LEAD RESIDUES IN TISSUES OF ANIMALS SLAUGHTERED AT GUSAU MODERN ABATTOIR, ZAMFARA STATE, NIGERIA

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A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY ZARIA

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FEBRUARY 2014

ATTESTATION

I hereby attest that this study entitled "Lead residues in tissues of animals slaughtered at Gusau modern abattoir, Zamfara State, Nigeria" was carried out by me in the Department of Community Medicine, Faculty of Medicine, Ahmadu Bello University, Zaria under the supervision of Prof I. Ajogi and Dr E.C. Okolocha. The information derived from the literature has been duly acknowledged in the text and the list of references provided. No part of this thesis has been previously submitted for a degree or diploma at any University.

JAFIYA Abubakar Aliyu	.....	.....
Name	Signature	Date

CERTIFICATION

I certify that this project entitled **"Lead residues in tissues of animals slaughtered at Gusau modern abattoir, Zamfara State, Nigeria"** by JAFIYA, Abubakar Aliyu meets the regulations governing the award of the degree of Master of Public Health of the Ahmadu Bello University, Zaria and is hereby approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to all the children of Zamfara State who lost their lives to lead poisoning and the Nigerian Field Epidemiology and Laboratory Training Programme for giving me the opportunity to undergo the training and this research in particular.

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LIST OF ACRONYMS

AAS	Atomic Absorption Spectrophotometer
ANOVA	Analysis of Variance
BAL	British Anti Lewisite
BLL	Blood lead level
CDC	Centres for Disease Control and Prevention
EC	European Commission
EDTA	Ethylene diamine tetra acetic acid
EPA	Environmental Protection Agency
EU	European Union
FAO	Food and Agriculture Organisation
FSIS	Food safety and inspection service
LGA	Local Government Area
MSF	Medecins sans Frontieres
NARICT	National research Institute for Chemical Technology
NFELTP	Nigeria Field Epidemiology and Laboratory Training Programme
OECD	Organisation for Economic Cooperation and Development
PPM	Parts per Million
PVC	Poly vinyl Chloride
SD	Standard Deviation
UNEP	United Nations Environmental Programme
WAD	West African Dwarf
WHO	World Health Organisation

SUMMARY

Lead is a bioaccumulative heavy metal usually found in nature combined with other elements to form lead compounds. Over 400 children were reported to have died as a result of lead poisoning outbreak in Zamfara State, Nigeria and about 2000 children are currently on treatment. The prevalence of lead residues in tissues of animals slaughtered at Gusau abattoir, Zamfara State was determined using Atomic Absorption Spectrophotometer. A total of 384 tissue samples were collected and their lead content determined. About 95% of the 384 animals were purchased from markets within Zamfara State and out of all the samples investigated 324(84.4%) had lead residues. The lead residues in 314(81.80%) of the animals were above the permissible limit of 0.1mg/kg recommended by World Health Organisation and European Commission. Lead residues were not detected in about 60(16.60%) of the animals sampled. There was no significant difference ($p>0.05$) observed in tissue accumulation of lead in animals based on difference in age, sex, species or breed of the animal. Gross contamination of the environment from where these animals were sourced could therefore be inferred.

KEY WORDS: Lead residues, Animal tissues, Atomic Absorption Spectrophotometer

CHAPTER ONE: INTRODUCTION

1.1 Background Information

Lead is a bluish soft metal with atomic number 82; atomic weight 207.19, specific gravity 11.34, melting point 327°C and boiling point 1740°C. It is the most common industrial metal that has become widespread in air, water, soil and food.[1] Metals are often characterized and distinguished from non-metals by their physical properties which include the ability to conduct heat, and an electrical resistance that is directly proportional to temperature, malleability, ductility and even luster.[2]

Heavy metals can be classified into four major groups based on their health importance.[3, 4] Copper, zinc, cobalt, chromium, manganese and iron are essential and also called micronutrients but are toxic when taken in excess of requirements.[4, 5] Barium, lithium and zirconium are non – essential. Tin and aluminium are less toxic whereas mercury, lead, cadmium and arsenic are highly toxic**.**

They are (lead, cadmium, mercury and arsenic) among the main toxic metals that remain in the environment permanently because they cannot be degraded and thus find their way into the food chain and ultimately into the tissues. They have direct physiologically toxic effects when stored or incorporated in living tissues.[6]

Heavy metals are kept under environmental pollutant category due to their toxic effects on plants, humans and food. Heavy metals such as lead, arsenic, cadmium and mercury are persistent, accumulate and are not metabolized in to other intermediate compounds and do not easily break down in environment.[1]

Poisoning by toxic chemicals can cause serious stock losses. Historically, lead and arsenic have been the most common causes of inorganic chemical poisoning in farm animals.[7] The increase in industrial and agricultural processes has resulted in increased concentrations of metals in the environment. These metals are taken in by

plants and consequently animals that graze on such contaminated plants and animals that drink from polluted water also accumulate such metals in their tissues.[8] Some heavy metals like arsenic, cadmium and lead have been reported to have no known bio-importance in human biochemistry and physiology and consumption even at very low concentrations can be toxic.[9, 10]

Several organisations have pointed out the need for monitoring heavy metal concentrations in the environment because of their persistence and accumulation in the biota.[11]

Lead is a metabolic poison and a neurotoxin that binds to essential enzymes and several other cellular components and inactivates them.[12] Toxic effects of lead are seen in haemopoeitic, nervous, gastrointestinal and renal systems.[6]

Lead poisoning is a medical condition caused by increased levels of the heavy metal lead in the body. Lead interferes with a variety of body processes and is toxic to many organs and tissues including the heart, bones, intestines, kidneys, reproductive and nervous systems. It interferes with the development of the nervous system and is therefore particularly toxic to children, causing potentially permanent learning and behavior disorders. Symptoms include abdominal pain, confusion, headache, anemia, irritability, and in severe cases seizures, coma, and death.[13] Toxicity of lead is closely related to age, sex, route of exposure, level of intake, solubility, metal oxidation stage, retention percentage and duration of exposure, frequency of intake, absorption rate and mechanisms and efficiency of excretion.[14]

In a survey of lead residue in kidney and liver of slaughtered cattle in Sokoto central abattoir, Nigeria, Bala *et al*[15] reported a prevalence rate of 100%. The presence of lead in the liver among different age groups was above the permissible limits of 0.1mg/kg set by the Food and Agricultural Organisation (FAO) but in the kidney the

concentration was within the permissible level in all age groups except for 0 – 2 years of age.

In another study of metal composition of livers and kidneys of cattle from Southern Nigeria, Iwegbue[16] reported levels of various metals were generally low and within international statutory safe limits.[16] However, Nwude *et al*[17] in a study of metal quantification in cattle: a case study of cattle slaughtered at Ota abattoir, Nigeria observed that the level of six metals quantified were higher than the WHO standards and gross contamination of cattle could be inferred; and the levels of metals in cattle parts could be used as biomarkers of metal pollution, though highly influenced by other factors.[17]

In a study of outbreak of fatal childhood lead poisoning related to artisanal gold mining in Zamfara State, Doyeema *et al*[18] reported that venous blood lead samples were obtained from 59% (204 of 345) of children < 5 years of age. All blood samples indicated lead poisoning, blood Lead level (BLL) ≥ 10 μg/dl. In 97% of children, BLLs were ≥ 45 μg/dl which is the CDC-recommended threshold for initiating chelation therapy.[19] Eighty-five percent of blood samples exceeded 65μg/dl, the maximum detection limit of the Lead Care II instrument.[18]

1.2 Problem Statement

Lead poisoning accounts for about 0.6% of global burden of diseases.[20] Lead has been impacting the health of humankind since the Romans began mining it 2500 years ago, and despite early knowledge of its harmful effects, exposure to lead from a wide variety of sources persists to this day.[21]

Lead bio-accumulates in many organs of the body after ingestion, it adversely affects many organs and systems which results in conditions such as anaemia, kidney damage, high blood pressure, impaired hearing and mental retardation[22] and elevated

levels can cause abortion in female animals and humans.[22] Consumption of carcass containing lead can cause lead poisoning as a result of bioaccumulation in body tissues, and this varies with individual and the duration of lead exposure.[23, 24]

In an assessment of metal levels in fresh milk from cows grazed around Challawa Industrial Estate, Kano, Nigeria, Ogabiela *et al*[25] reported that the concentrations were very high as the metals of samples exceeded the World Health Organisation permissible limits.[25] Another study by Okoye and Ugwu[26] on the impact of environmental cadmium, lead, copper and zinc on quality of goat meat in Nigeria reported high levels of cadmium, copper and zinc in the liver, kidney and muscles of goats.[26] However, lead levels determined were relatively within safe limits. Akan *et al*[27] in a study of heavy metals in the liver, kidney and meat of cattle, sheep, goat and chicken from Kasuwan Shanu, Maiduguri, Nigeria reported that the concentrations of all metals were within the tolerance limits with the exception of chromium and lead which were higher than standard limits.[27] Nwude *et al*[28] also reported varying levels of heavy metals in different seasons indicative of the effect of season as a factor in accumulation of heavy metals by animals.[28]

Environmental levels of lead have increased more than a thousand fold over the past three centuries as a result of human activity. The greatest increase occurred between the years 1950 and 2000 and reflected increasing world wide use of leaded gasoline. Lead is released into the air in the form of metal fumes or suspended particles from fuel combustion or smelting and disposal of wastes, however, most of the lead poisoning is from leaded gasoline.[6]

Dioka *et al*[29] and Kamala and Kumar[30] reported that some of these waste materials may contain some heavy metals such as lead and others that are dangerous to human and animal health.[29, 30]

Results of a recent study conducted in Macedonia indicate that Lead concentration in animal tissues is dependent on sampling locality, the organ and animal species. The concentrations of lead in the liver and kidney tissues taken from industrial area were higher as compared to other localities from which samples of tissues were taken for analysis.[31]

It is evident from available information that lead poisoning in man could result from consumption meat and milk of poisoned cattle, camel, sheep, goats and birds. Man can also be poisoned by lead through mining activities as is obtained in Zamfara State due to illegal, informal or unsafe mining of lead. Environmental poisoning is another risk for human especially from leaded petrol, diesel and even water.

The current study will provide information on lead poisoning in cattle, camel, sheep and goats as a risk for consumers of these various meats. This will serve as a guide to the public.

1.3 Justification of the Study

From a public health point of view, consumption of lead-contaminated animal products from lead-poisoned animals poses a food safety concern especially in children less than five years of age. Lead concentrations in the liver and kidneys are usually the highest and can be detected within few days before it is redistributed for storage in bones.

The primary route of lead exposure for humans is through ingestion of contaminated foods. The recent outbreak of lead poisoning and other heavy metals amongst local miners in Zamfara State calls for investigations of animals in that locality and other locations as they may have ingested the heavy metals. According to Doyeema *et al*[18] prevalence of lead poisoning is very high in Zamfara State. Over 400 children were reported to have died as a result of the lead poisoning outbreak in Zamfara State;

about 2000 children are currently on treatment. In 2010, WHO stated that over 4000 children are at risk of lead poisoning and this is entirely preventable.

The habitats of animals are continually being polluted with lead metal as a result of indiscriminate dumping of waste materials on the land and in water bodies, illegal mining of ores, painting of animal's houses, and the use of tetra ethyl lead as an anti-knocking additive to improve the quality of petrol in Nigeria and many other developing countries.

In Nigeria and Zamfara State in particular, most cattle are free grazing and drink water from ditches, streams, rivers and other possible contaminated water sources. They graze along roads, runways and other sites that might have been contaminated with toxic substances. Animals in the process could be liable to exposure to high levels of contaminants in the environment. These metals accumulate in the organs and other tissues which are sold for consumption by man. A primary source of lead exposure for human beings is through ingestion of contaminated foodstuff, consumption of contaminated animal products from lead – poisoned animals therefore poses a public health food safety concern especially among children less than five years. In view of the fact that there are very little or no available original data on lead residues in tissues of domestic and wild animals in the study site, this study will be undertaken in order to determine the levels of lead in meat of animals slaughtered at Gusau abattoir, Zamfara State.

1.4 Research Questions

1. Does the meat of animals slaughtered at Gusau abattoir contain lead residues?
2. Is the concentration of lead residues within or above the permissible limits?
3. Which animal species has the highest concentration of lead residues?
4. What are the risk factors for accumulating lead residues in animal tissues?

1.5 General and Specific Objectives

1.5.1 General Objective

The aim of this study is to determine the presence and levels of lead in meat of animals slaughtered at Gusau abattoir, Zamfara State, Nigeria.

1.5.2 Specific Objectives:

1. To estimate the prevalence of lead residues in meat of animals slaughtered at Gusau abattoir, Nigeria
2. To assess the effect of age and sex on concentration of lead in meat of different species of animals slaughtered at the abattoir
3. To compare the concentration of lead in meat of different animal species and in different breeds of cattle and sheep slaughtered at Gusau abattoir, Nigeria.

CHAPTER TWO: LITERATURE REVIEW

2.1 Heavy Metals

Heavy metals constitute a very heterogeneous group of elements widely varied in their chemical properties and biological functions. The term heavy metal is defined as commonly those metals, which have specific weights more than 5g cm^3.[1] Toxic metal is that which is neither essential nor has any beneficial effect. These metals stay permanently because they cannot be degraded from the environment; they pass into the food and from there make their way into the body tissues.[6]

Lead, cadmium, mercury and arsenic are the main toxic metals that accumulate in food chains and have a cumulative effect.[12, 32] Heavy metals such as copper, iron, chromium and nickel are essential since they play important roles in biological systems, whereas, cadmium and lead are non-essential metals as they are toxic even in trace amounts.[33]

There is an increasing concern about the health effects in humans due to continuous consumption of food contaminated with heavy metals and the extent of this contamination depends on several complex factors, one of which is the specific metabolic and homeostatic mechanisms operating in the type of food and tissue considered.[34] Metals are often characterised and distinguished from non metals by their physical properties, ability to conduct heat and an electrical resistance that is directly proportional to temperature, malleability, ductility and lustre.[2]

Exposure to metals can occur through a variety of routes. Metals can be inhaled as dust or fumes; they may be ingested involuntarily through food or drink.[35] The amount that is actually absorbed from the digestive tract can vary widely depending on the chemical form of the metal and the age and nutritional status of the individual. Once a metal is absorbed it distributes in tissue and organs. Excretion typically occurs

primarily through the kidneys and digestive tract, but metals tend to persist in some storage sites like the liver, bones and kidney for years or decades.[35] The toxicity of metals depends on a number of factors, the particular metal in question, dose absorbed and the age of person concerned. The occurrence of metal contaminants in tissues of organisms especially in excess of natural loads has become a problem of increasing concern. This situation has arisen as a result of rapid growth in human population, increased urbanisation, expansion of industrial activities, exploitation of natural resources, irrigation and other modern agricultural practices as well as the lack of enforcement of environmental regulations.[36]

Increase in industrial and agricultural processes have resulted in increased concentration of metals in the air, water and soil. These metals are taken in by plants and consequently accumulate in their tissues. Animals that graze on such contaminated plants and drink from polluted waters also accumulate such metals in their tissues.[8]

Meat and meat products form an important part of human diet as well as an important source of wide range of nutrients, but they may also carry certain toxic substances. Although the level of these toxic substances is generally low in muscles, offal such as liver and kidney showed higher concentrations of toxic substances than most other foods.[37] The levels of heavy metals in certain food commodities relate directly to natural local geochemical environments. Since farm animals commonly consume locally produced feeds as major portion of their ration, their body burden of metals may reflect the locality's heavy metal status.[32] Therefore, it is essential to monitor the tissue residues of metals in meat animals to protect the health of humans as well as animals.

Heavy metals have largest availability in soil and aquatic ecosystem and to relatively smaller proportion in atmosphere at particular vapours. Heavy metals pollution can originate from natural and anthropogenic sources. The toxicity of metals depends on a number of factors, the particular metal in question, dose absorbed and the age of person concerned sources. Activities such as mining, smelting operation and agriculture have contaminated extensive areas of the world.[1]

Amongst toxic heavy metals, lead ranks as one of the most serious environmental poisons all over the world. Exposure to lead in the home and the workplace results in health hazards to many adults and children causing economic damage, which is due to the lack of awareness of the ill effects of lead.[38]

2.2 Lead

Lead is a heavy metal with a bluish-gray colour. It has a low melting point; it is easily moulded and shaped and occurs naturally in the earth's crust.[1, 39] It is rarely found naturally as a metal, it is usually combined with two or more other elements to form lead compounds.[39, 40] Lead is a heavy soft metal and occurs in nature as oxides or salts, it is one of the hazardous and cumulative environmental pollutants.[41]

Lead is a very soft, dense, ductile metal; it is very stable and resistant to corrosion, although acidic water may leach out of pipes, fittings, and solder. It does not conduct electricity. Lead is an effective shield against radiation. Because of these properties and also because it is relatively easy to mine and work with, lead has been used for many purposes for thousands of years. Ancient Romans used lead for plumbing, among other uses. In modern times, lead was added to paint and gasoline to improve their performance but was eliminated recently due to health concerns.

2.3 Sources of Lead.

Lead occurs naturally in the environment; however, most of the high levels found throughout the environment come from human activities. Lead can enter the environment through releases from mining lead and other metals and from factories that make use of lead.[39]

2.3.1 Natural Sources

Lead occurs naturally in low concentrations in all rocks, soils and dusts, usually ranging from 2 to 200 parts per million. The total amount of lead in the earth's crust is estimated to be 3.1 x 1014 tonnes. Some soils have relatively high concentrations of lead, where the underlying parent rock has significant lead content. Lead contents of waters are generally low, but significant amounts of lead-rich dusts and vapours are carried in the air, from windblown materials and volcanoes. However, these natural emissions are small in comparison with those resulting from human activity.

2.3.2 Anthropogenic Sources of Lead

2.3.2.1 *Production of lead* – Mining, smelting and refining of lead and other metals have in former times caused large emissions. Most of this is solid waste material, but sizeable emissions have also occurred to the atmosphere and to water. Modern techniques in developed countries have minimized emissions to meet statutory requirements, including employment of best available technology.

2.3.2.2 *Use of lead* – Mobile sources (i.e. vehicles running on leaded petrol) continue to be a major contributor of lead to atmosphere in some countries, and this gives rise to elevated lead levels in soils, dusts and surface waters. Emissions are declining in many countries with the phasing out of leaded petrol, but lead deposited from petrol in the past remains in the environment. Residues from leaded paints, though now not

used except for a few specialized outdoor applications, still continue to present a significant source of lead in house dusts and garden soils.

2.3.2.3 *End-of-life of lead products* – Most of the lead used at present is in products, such as batteries and lead sheet, which are largely recycled. Emissions can occur from such products when disposed improperly.

2.3.2.4 *Lead in the waste stream: landfill, incineration and compost* – Many lead containing products (such as leaded solder, glass, PVC, and small lead items) are disposed of as waste. Lead in most forms is fairly inert, and if buried in a modern well-maintained landfill, any releases should be very small. However, in the long term, some small losses of lead and other metals can be expected to occur.[39]

2.3.3 Other Sources of Lead

Coal and oil combustion results in the emission of small amounts of lead, along with many other metals. Sewage sludge often contains lead and other metals, from various sources. Application of sludge to land continues to be a source of lead input at low levels to agricultural soils. The WHO estimated that the sources of lead exposure in children are dust and soil (45%), food (47%), water (6%) and air (1%), respectively. Dietary Pb exposure has gradually decreased with increased food security and effective control measurements, and direct exposure to dust has become more dominant, especially for children with hand-to-mouth activity

Ingested residues of lead ammunition are a recently identified pathway of lead exposure to human consumers of gun-killed game animals. An analysis of North Dakota residents showed that recent (< 1 month) consumers of game meat had higher covariate-adjusted blood lead concentrations than those with a longer interval (> 6 months) since last consumption.[42]

Lead is commonly found in soil especially near roadways, older houses, old orchards, mining areas, industrial sites, near power plants, incinerators, landfills and hazardous waste sites.[39, 43] Animals grazing in pastures bordering highways of countries where leaded gasoline is still used have higher background lead concentrations. Some waste materials may also contain heavy metals such as lead and others that are dangerous to human and animal health.

2.4 Toxico-dynamics of Lead

According to Siddiqui and Gayatri[40] the permissible limits of lead in ambient air is 0.75 mg/m³ for sensitive areas, 1.0 mg/m³ for residential areas, 1.5 mg/m³ for industrial areas and in water 0.05 mg/L for drinking water while for effluents: 0.10 mg/L for discharge of industrial effluents in inland surface water. These are generally in line with international standards. The acute oral lethal dose of lead in various animal species has been considered as 50 to 400mg/kg in calves, 600 to 800mg/kg in cattle, 160 to 600mg/kg in birds, 30 to 40gm in sheep and 10 to 20g in swine. However, according to Needleman[44] medical science has since concluded that virtually no level of lead exposure can be considered harmless in consideration of its many sub lethal, debilitating, and often irreversible effects.

2.5 Lead Poisoning

Lead poisoning is a medical condition caused by increased levels of the heavy metal lead in the body. Lead interferes with a variety of body processes and is toxic to many organs and tissues including the heart, bones, intestines, kidneys, and reproductive and nervous systems. It interferes with the development of the nervous system and is therefore particularly toxic to children, causing potentially permanent learning and behavior disorders. Symptoms include abdominal pain, confusion, headache, anemia, irritability, and in severe cases seizures, coma, and death. Toxicity of lead is closely

related to age, sex, route of exposure, level of intake, solubility, metal oxidation stage, retention percentage and duration of exposure, frequency of intake, absorption rate and mechanisms and efficiency of excretion.[14]

Patterns and sources of exposure to lead, prevalence rates of lead poisoning and the severity of outcomes vary greatly from country to country and from place to place within countries.[45] Children are vulnerable to the effect of lead exposure because they absorb several times the percentage ingested compared to adults and because their brain is not fully developed, even a brief exposure may influence developmental processes.[46]

2.6 Epidemiology of Lead Poisoning

Lead is ubiquitous in the environment, persists indefinitely, and can be found at low levels in almost all living organism. Lead is found in the soil, plants and grains grown on contaminated soil, and tissues of animals that eat contaminated plants and feed grains. Because of widespread environmental exposure, low levels of lead can be demonstrated in tissues of clinically normal birds and animals.[47]

For centuries, lead has been mined and used in industry and in household products. Modern industrialization, with the introduction of lead in mass-produced plumbing, solder used in food cans, paint, ceramic ware, and countless other products resulted in a marked rise in population exposures in the 20th century.[35]

Between the early 1920's and 1986, leaded petrol was used in every country in the world. The global phase-out of lead from petrol will not only reduce exposure to lead poisoning, it will also reduce some contributors to global warming.[48]

The dominant source of worldwide dispersion of lead into the environment (and into people) for the past 50 years has clearly been the use of lead organic compounds as antiknock motor vehicle fuel additives. Since leaded gasoline was introduced in 1923,

its combustion and resulting contamination of the atmosphere has increased background levels everywhere, including the ice cap covering Northern Greenland where there is no industry and few cars and people. Although a worldwide phase-out of leaded gasoline is in progress, it is still being used all over the world.[35]

The current annual worldwide production of lead is approximately 5.4 million tons and continues to rise. Sixty percent of lead is used for the manufacturing of batteries (automobile batteries, in particular), while the remainder is used in the production of pigments, glazes, solder, plastics, cable sheathing, ammunition, weights, gasoline additive, and a variety of other products. Such industries continue to pose a significant risk to workers, as well as surrounding communities.[35]

In response to these risks, many developed countries over the last 25 years have implemented regulatory action that has effectively decreased actual exposures to the general population. However, exposures remain high or are increasing in many developing countries through a rapid increase in vehicles combusting leaded gasoline and polluting industries (some of which have been "exported" by corporations in developed countries seeking relief from regulations). Moreover, some segments of the population in developed countries (such as the U.S.) remain at high risk of exposure because of the persistence of lead paint, lead plumbing, and lead-contaminated soil and dust, particularly in areas of old urban housing.[35]

Chan *et al*[49] conducted a cross-sectional study where they recruited 17 lead workers and 13 comparison non-lead workers households. Companies and eligible employees were contacted using mail-out packs. Children were aged between 12 and 72 months. Data collection involved administration of a questionnaire and collection of dust, soil, water, paint scraping samples, and blood from the children for the determination of lead and ferritin levels. Children of lead workers are at higher risk of lead absorption.

Poor work hygiene practices of lead workers suggest an association with elevated lead levels in their children. A number of other predictors were suggested by this study but the small numbers of participants made it difficult to detect statistically significant differences between subgroups.

It is currently estimated that some 890,000 United States of America children have BLLs 10 µg/dl.[50] In developed countries, people with low levels of education living in poorer areas have high risk for elevated lead in their body.[51] In the United States, the groups of people at risk for lead exposure are the impoverished, city dwellers and immigrants.[52]

African American children and those living in old houses that are painted with lead paint have also been found to be at risk for high blood lead levels in the United States. Low income people often live in old housing with lead paint, which may begin to peel, exposing the occupants to high levels of lead containing dust.

Alcohol consumption and tobacco smoking are risk factors for elevated lead exposure, possibly because of contamination of tobacco leaves with lead containing pesticides.[53] Calcium and iron deficiencies, old age, disease of organs usually targeted by lead (such as the brain, kidneys etc) and possibly genetic susceptibility are also risk factors in adults to lead toxicity.[24] Differences in vulnerability to lead induced neurological damage in males and females have also been observed, but some studies have found males to be at greater risk, while others have found females to be at greater risk.[54] However, according to Rossi et al[55] in adults of all ages, men have higher blood lead levels than women because of occupational hazard.

Children and young animals are more sensitive to elevated blood lead levels than adults. Children between the ages of one to three years tend to have the highest blood

lead levels, possibly because at that age they begin to walk and explore their environment and use their mouth in exploring.[54]

In China lead poisoning in children may be widespread as a result of rapid industrialization and the use of leaded petrol.[56] Children residing in industrial areas and areas with high traffic had average blood lead levels of 21.8-67.9µg/dl.[56] The proportion of blood lead levels >10µg/dl ranged from 64.9% to 99.5% and about 50% of children living in non-industrialized areas had blood lead levels > 10µg/dl.[56]

In a study in India of randomly selected 2031 children and adults in five cities with high population densities and where leaded petrol has contributed to the environmental lead levels. Approximately 51% had lead levels >10µg/dl and 13% had blood lead levels >20µg/dl.[57] The proportion of children with levels ≥10µg/dl ranged from 40% in Bangalore to 62% in Mumbai.[58]

African children may be particularly predisposed to environmental lead exposure because of their lifestyle and socio-economic factors. The true picture of childhood lead poisoning in Africa remains unclear. In most African countries, petrol sold contains 0.5-0.8g/l lead, which may be among the highest levels in the world.[59] Average atmospheric lead concentrations reach 0.5-3.0µg/m³ and exceed 1000µg/g in dust and soils in urban and rural areas and near mining centres.

In a study conducted in Cape Province, South Africa over 90% of the children in some urban and rural communities had blood lead levels ≥10µg/dl. About 13% of mixed race children, not white children had blood lead levels ≥25µg/dl.[60] Levels of lead in blood, air and dust samples taken from schools close to roads carrying heavy traffic were higher than those from schools further away.[60, 61]

The habitats of animals are continually being polluted with lead metal as a result of indiscriminate dumping of waste materials on the land and in water bodies, illegal

mining of ores, painting of animal's houses, and the use of tetra ethyl lead as an anti-knocking additive to improve the quality of petrol in Nigeria and many other developing countries.

In Nigeria, most cattle are free grazing and drink water from ditches, streams, rivers and other possible contaminated water sources. They graze along roads, runways and other sites that might have been contaminated with toxic substances. Animals in the process could be liable to exposure to high levels of contaminants in the environment. These metals accumulate in the organs and other tissues. The muscles and other organs including intestines are sold in the market to the populace for consumption. A primary source of lead exposure for human beings is through ingestion of contaminated foodstuff, consumption of contaminated animal products from lead – poisoned animals therefore poses a public health food safety concern especially among children less than five years.[62]

2.7 Lead Poisoning in Zamfara State

Although farming is the major livelihood in Zamfara State, gold-ore–processing increasingly constitutes an important income source among selected areas. During routine meningitis surveillance in Zamfara State conducted during February–April 2010, Medecins sans Frontieres (MSF) and local public health officials identified more than 200 children aged <5 years with convulsions during the previous 3 months among 4 villages. About 40 of these children were reported to have died. Environmental causes were suspected because of a recent increase in gold-ore–processing activities in the region.

Diagnostic tests on 8 symptomatic children revealed blood lead levels (BLLs) of 168–370 µg/dl, levels known to be fatal in children. The unprecedented level of morbidity and mortality raised suspicion of other concomitant diseases such as

malaria and bacterial infections; however, laboratory tests failed to demonstrate microorganisms in the majority of patients and the illnesses did not respond to anti malarial and empiric antibiotics. During May 2010, the Nigerian Federal Ministry of Health assembled a multidisciplinary team consisting of representatives from the Nigerian Field Epidemiology and Laboratory Training Program (NFELTP), Zamfara State Ministry of Health, Centre for Disease Control and Prevention, and the World Health Organization to join MSF in investigating the outbreak.[63]

During May–June 2010, the team surveyed the 2 most-affected villages and confirmed lead poisoning as the cause of the outbreak.[18, 63] Among these 2 villages, 25% of children aged <5 years had died during the previous 12 months and 82% had experienced convulsions before death. All of the 204 children aged <5 years who were tested had BLLs ≥10 μg/dl, and 97% had BLLs ≥45 μg/dl. Lead-rich gold-ore was identified in both villages. Gold-ore–processing activities had begun during the previous 12 months inside a majority of family compounds. Two-thirds of households reported processing gold-ore inside family compounds, and soil-lead levels in 85% of family compounds exceeded the U.S. Environmental Protection Agency (EPA) soil-lead standard (400 parts per million [ppm] for areas of bare soil where children play.

Factors associated with child mortality in the 2 surveyed villages were the child's age, maternal participation in ore processing, and environmental factors such as primary water source type and soil-lead level of the family compound.[18] The investigation concluded that 118 child fatalities were strongly associated with gold-ore–processing.

Animals are very good indicators of environmental pollution, as they inhabit the same space as humans and are exposed to the action of the same pollutants, for that reason, it is appropriate and advantageous to evaluate the negative impact of the polluted

environment by heavy metals, and their influences load on human health by parallel evaluation of their load on animals.[64]

2.8 Lethal Levels of Lead in Animals

According to Siddiqui and Gayatri[40] lethal levels of lead occur when:

Cattle: Intakes of greater than 6 mg/kg body weight can lead to chronic poisoning and intakes greater than 10 mg/kg body weight may cause acute lead poisoning.

Sheep: occurs only in lambs and symptoms of poisoning appear at intakes greater than 4.5 mg/kg body weight.

Pigs, goats and rabbits: are more resistant than sheep or cows. Very minor signs of poisoning occur at intakes of 60 mg/kg body weight. This is equal to blood concentrations of 130µ/dl.

Horses-Respiratory "roaring" occurs at intakes of 6.4 mg/kg body weight. Signs of anemia occur at intakes of 7.4 mg/kg.

Birds: Poultry can withstand dietary intakes of 100 mg/kg feed with no symptoms. Levels of 500 mg/kg induced serious poisoning.

Dogs and Cats: Nervous symptoms of poisoning appear at intakes of 5 mg/kg body weight/day.

2.9 Traditional Livestock Breeds used as Food Animals

According to the Federal Ministry of Agriculture[65], 80% of goats, 70% of sheep and 85% cattle are produced in the northern regions, while 80% of pigs and 85% of poultry are produced in the south. The traditional system of management of livestock has remained the most practised in the country.

Roger[66], 1999 in a working paper titled "Traditional livestock breeds: geographical distribution and dynamics in relation to the ecology of West Africa" described livestock breeds in Nigeria as follows:

2.9.1 Cattle

Nigeria had a mean (i.e. averaged between wet and dry seasons) cattle population of some 13.9 million in 1990, of which 11.5 million were kept in pastoral systems and 2.4 million in villages. These were predominantly zebu, but included muturu, keteku, ndama and kuri. Country-wide, the mean density of cattle is approximately 15/km², or 6.6 hectare/head. Cattle numbers increase steadily with declining rainfall, so that much of the south has low cattle densities and most of the population is in the north. There is some seasonal change in the relative proportions of cattle in the various ecozones. Approximately 45% of the national herd stays within the sub-humid zone throughout the year, with almost all of the remainder in the semi-arid or arid zones. In both seasons, there are several hundred thousand cattle in and around Lake Chad.

The Zebu are divided into six distinct resident breeds as well as animals that are of doubtful breed status or are only seen as trade stock. These breeds are of uneven numerical importance, with three breeds constituting 90% of the zebu. Zebus, in turn represent the great majority of cattle with perhaps 115,000 muturu and statistically insignificant numbers of other breeds.[66]

2.9.1.1 *Bunaji/White Fulani*

Bunaji or White Fulani cattle is a white, black-eared and medium-horned breed, and is the most numerous and widespread of all Nigerian cattle breeds. It is estimated that they represent some 37% of the national herd. They are found from Lagos to Sokoto, Katsina and Kano States and spread across the Nigerian Middle Belt. The only areas from which they are significantly absent are Borno, where Rahaji and Wadara predominate, and in the south-east, where there are no resident zebu.[66]

2.9.1.*2 Sokoto Gudali*

The Sokoto Gudali is a uniform cream, light grey or dun, the dewlap and skin folds are highly developed and the horns almost absent. Although the Sokoto Gudali stereotypically occurs mainly in the northwest of Nigeria, in reality it is now distributed widely throughout the country, it is estimated that they represent some 32% of the national herd.

2.9.1.3 *Rahaji*

The Rahaji is one of the largest zebu breeds and is distinguished by its deep burgundy-coloured coat, pendulous ears and long, thick horns. It is the third most numerous breed of cattle in Nigeria, some 22% of the national herd. The Rahaji is adapted to arid and semi-arid regions and rarely goes further south than Kaduna in the wet season, except for the isolated population on the Mambila Plateau in the south-east.[66]

2.9.1.4 *Wadara*

Wadara cattle are medium-sized, lightly built cattle, and are usually dark red, black, pied or brown. They are short-horned and have a small erect hump, representing some 6.6% of the national herd. Wadara cattle are the 'indigenous' cattle of Borno and are referred to by the Koyam and related pastoralists as 'our' cattle.

2.9.1.5 *Adamawa Gudali*

The Adamawa Gudali resembles the Bunaji in conformation. It is medium to large sized, with Medium-length horns, and usually pied, or with a white, black, red or brown coat. It has thick, crescent-shaped horns, a pendulous hump, and a short head and muzzle. The pendulous hump is the feature that most reliably distinguishes it from the Bunaji. Adamawa Gudali represents about 2% of the national herd.

2.9.2 Sheep

Sheep are kept everywhere in Nigeria, with a broad distinction between their importance and ubiquity in the north, and the more dispersed populations of the humid zone. Sheep and goats are seen as having secondary importance in relation to crops. There are generally considered to be four breeds or races of sheep native to Nigeria, the Balami, Uda, Yankasa and West African Dwarf.

2.9.2.1 *Balami*

The Balami is the largest bodied native sheep in Nigeria. As a pastoral animal it is confined to the semi-arid north, but it is favoured as a stall-fed breed by Muslims throughout the Nigerian Middle belt. It is white and hairy with pendulous ears and a long thin tail; rams have a throat ruff and are horned but ewes are normally polled. Another feature that makes the Balami distinctly recognisable is its Roman nose, a large bulbous nose that distinguishes it from the Yankasa.[66]

2.9.2.2 *Uda*

The Uda is slightly smaller-bodied than the Balami, although their size ranges overlap. It is easily recognized by a distinctive coat colour pattern; entirely brown or black forequarters and white behind. Uda sheep give their name to a Fulfulde clan, the Uda'en, who herd large flocks of this breed between Niger and the northern reaches of the Nigerian Middle Belt. Studies on Nigerian Uda are lacking.

2.9.2.3 *Yankasa*

The Yankasa breed has been the most extensively studied in Nigeria. The body colour is white with black patches around the eyes and sometimes on the feet. The muzzle and ears are usually black too. Rams have curved horns and a hairy white mane, and ewes are polled. Yankasa sheep have been recorded in all parts of Nigeria, though the

populations attenuate towards the northern border and the sea-coast. Some tentative studies have been made of its ecological adaptations. Yankasa sheep do not need daily watering in the wet season and watering once a day suffices in the dry season.[66]

2.9.2.4 West African Dwarf

The West African Dwarf is a small-bodied, compact breed which may be all white, black, brown, or spotted black or brown on a white coat. Its variation in colour and patchy distribution make it difficult to distinguish clearly from the Yankasa. Different types exist, mentioning the 'Pagan' variety on the Jos Plateau, and the 'Umuahia' variety near the Confluence, but there is no published account of such varieties.

2.9.3 Goat

2.9.3.1 *Sahelian Goat*

The Sahelian or Desert goat is found along the northern border of Nigeria, particularly in Borno, where it is often known as 'Balami', although this name has not been adopted as it would lead to confusion with the better-known sheep race, 'Sahel', which seems appropriate, as this race is distributed from Senegal to Sudan. In Nigeria, the Sahel goat is generally the variety preferred by pastoralists. Sahel goats are very similar in appearance to the sheep with which they are often herded. The coat is white or dappled, the ears are pendulous and the legs are notably longer than other breeds.

2.9.3.2 *Sokoto Red Goat*

The Sokoto Red, Kano Brown or Maradi goat is probably the most widespread and well-known type in Nigeria 1975. It is the usual village goat in the northern two-thirds of the country although it is less common with transhumant pastoralists. The distribution of Sokoto Red goats in Nigeria spread south and east from Sokoto

through the savannah belts giving rise to the Kano Brown and, further east, to the Sahel types of Borno State.[66]

2.9.3.3 *West African Dwarf Goat*

The West African Dwarf (WAD) goat is found in 'many local types' no published account differentiates them. Although they are stereotypically said to be native to the forest belts, their presence in Borno State and in adjacent Republics of Cameroon and Chad suggests that they were far more widespread until recently. Indeed, like muturu cattle, they may once have been the main race of goat over most of Nigeria. WAD goats have been driven to remote areas in the savannahs. The WAD is usually black, although patched, pied, and occasionally all-white animals can be seen, even on the coast. WAD is a proportionate dwarf, the distorted forms and extremely short legs do suggest achondroplasy. This small size is probably an adaptation to the goats' environment though the nature of the selective force is unknown. The WAD goats in the semi-arid zone resemble Sokoto Red goats in their body proportions. The WAD goat is believed to be trypano-tolerant because it thrives in tsetse areas, but there have been no critical studies of this belief.

2.9.4 Camels

Degradation of vegetation and the spread of thorns and woody plants give stock that can digest these plants a comparative advantage. Camels, like goats, are specialized in eating browse and can ingest foliage from thorn trees and other armed plants that are virtually unavailable to other domestic species. Their greater height also gives them an advantage in terms of the types of tree and foliage they can browse. Their ability to manage without water for several days makes them ideal for work in arid environments and degraded regions of the semi-arid zone. However, camel meat and milk are not popular with consumers and there is a broad tendency for livestock

producers in the Sahel to herd cattle wherever the pasture and water resources permit.[66] Camels are commonly thought of as being confined to the northern borders of Nigeria and this is still largely true of breeding herds. Although individual farmers may breed camels on a small scale, relatively few breeding herds spend the entire year in Nigeria; most cross into the Niger Republic for 3–4 months at the height of the wet season. Sokoto and Borno States are the main focus for such transhumant herds, though they also transit through Kano and Katsina. By contrast, working bull camels are being used further south every year. Male camels are brought into Sokoto and northern Borno as work and transport animals, and are being brought further and further south into the centre of the country as portage stock. There seems little doubt that this rather dramatic change is being driven by the changes in the environment. As human population has expanded, land between farms available as a grazing resource has decreased. The cattle population has also grown, putting ever greater pressure on pastures. In many areas of the semi-arid zone, only browse plants remain and some of these are unavailable to any species except camels. Pressure on water-points has made watering large herds of cattle an expensive and time-consuming proposition. There is no reason to think that any of these trends will reverse in the next few years and it is therefore likely that camels will become still more common, especially as work animals in villages but also with pastoral communities. This places clear responsibility with the Nigerian authorities responsible for livestock to take a more active role in both allocating veterinary resources and planning extension targeted to camel-users.

2.10 Lead Poisoning in Animals.

Free ranging animals as in the case of traditional management of livestock in Nigeria can be good indicators of the general environmental status. Cattle and other ruminants

that graze on such environment and drink water from ponds, streams, rivers and other contaminated sources may bio accumulate these metal in their organs and other tissues. When such animals are slaughtered for human consumption, the metals accumulate in human tissues and organs.[67]

Lead poisoning occurs commonly in farm animals, most especially young cattle, sheep and horses. In cattle, lead poisoning is usually due to accidental ingestion of a toxic quantity over a short period of time. Lead is a common cause of toxicity in cattle; the relatively high frequency of ingestion in cattle is associated with their natural curiosity, propensity to lick and lack of oral discrimination. Young cattle are most commonly affected.[43] It has been estimated that 150,000 cattle worldwide are exposed annually to toxic levels of lead and that at least 20,000 acute deaths occur.[68]

Cattle are the most susceptible livestock, with calves the most likely victims. However, lead poisoning can occur in all domestic animals including horses, birds/poultry and dogs. Pigs are the least susceptible. Lead poisoning is most common among calves because they are curious feeders, and both milk and milk substitutes increase the amount of lead absorbed by calves. Sucking animals can also receive lead in their milk.[40]

Lead is one of the most frequently reported causes of poisoning in farm animals especially cattle.[69] The concentration of lead residues in tissues of farm animals depends on the route of entering and exposure to the environmental pollutants (air, water and plants) for long period. Most orally ingested lead is deposited in the skeleton.[70] Initially, lead is deposited in the bone until a possible threshold is reached, then it is deposited in other tissues especially the kidneys. The lead particles when ingested or inhaled pass to the blood stream and about 82% is excreted in faeces and urine, only about 0.5% is excreted with milk and the rest about 17.5% remains in

tissues and body organs.[69] However, Fragenberg (1986) cited in Hanan and Rikam[71] found that administration of very high doses of lead to animals result in highest accumulation in the kidney, then the liver, bone marrow and the heart muscles, whereas chronic administration of low doses of lead resulted in accumulation particularly in bone marrow, kidney and skeletal muscles in most species.

Absorbed lead enters the blood and soft tissues and eventually redistributes to the bone. The degree of absorption and retention is influenced by dietary factors such as calcium or iron levels.[40]

In ruminants, there is a tendency for metallic lead particles to settle in the reticulum; poisoning results from the gradual conversion of lead particles to soluble lead acetate due to acidity of the fore stomachs.[72] It has been reported that young calves are more susceptible to lead poisoning because of their innate curiosity, active calcium absorption mechanism and the fact that milk and milk replacer diets promote lead absorption.[73] In a study of evaluation of lead accumulation in cattle raised in area contaminated with lead, it was observed that tissue accumulation in animals was related to concentrations of lead in the environment.[67]

Cadmium and lead are bioaccumulative metals; therefore, animals with longer life spans have high concentrations of these metals in their tissues. As a result of this bioaccumulation, the consumption of meat from older animals could represent an increased risk for ingestion of Cadmium and lead. This bioaccumulation factor is demonstrated by results of the 1985-1986 Food Safety and Inspection Service (FSIS) study in which young chickens had lower levels and lower frequencies of detection for Cadmium and lead than mature chickens.[74]

2.11 Clinical Signs of Lead Poisoning in Animals

Clinical signs of lead poisoning in cattle may be acute or sub acute because of the differences in the dose of lead consumed and the resulting severity of symptoms.

2.11.1 Acute

In acute poisoning, animals are often found dead without any signs of illness. Affected animals may demonstrate staggering, muscle tremors of head and neck, twitching of the face and ears, clamping of the jaws, blindness, aggression, head pressing and convulsions.

2.11.2 Sub-acute

Sub acute lead poisoning is more common with animals showing symptoms associated with cerebral oedema including blindness with diminished or absent palpebral reflex, incoordination, staggering, anorexia, teeth grinding and rumen stasis. Cattle may initially show constipation that progress to diarrhoea. Mid to late gestational abortion has been reported.

2.11.3 Chronic

Chronic lead poisoning from long term low level exposure may potentially result in anaemia and decreased haemoglobin synthesis, but this is rare in cattle.[4]

Toxicosis can occur in cattle after ingestion of toxic amounts of lead from a variety of sources such as auto batteries, discarded crankcase oil, paint, solder, greases, oil well pipe dopes, asphalt, and roofing material. Clinical signs of lead toxicosis in the bovine include depression, blindness, diarrhea, rumen atony, salivation, facial tremors, and dyspnoea. These signs may progress to recumbency, “chewing gum” seizures, and death within 24 hours to 10 days of exposure.[75]

2.12 Lesions in Animals

Animals that die from acute lead poisoning may have few observable gross lesions. Oil or flakes of paint or battery may be evident in the gastrointestinal tract. The caustic action of lead salts causes gastroenteritis. In the nervous system, edema, congestion of the cerebral cortex and flattening of the cortical gyri are present. Histologically, endothelial swelling, laminar cortical necrosis, and edema of the white matter may be evident. Tubular necrosis and degeneration and intranuclear acid-fast inclusion bodies may be seen in the kidneys. Osteoporosis has been described in lambs. Placentitis and accumulation of lead in the fetus may result in abortion.[75]

2.13 Lead Poisoning in Children

Childhood lead poisoning is a major, preventable environmental health problem in the United States. Blood lead levels (BLLs) as low as 10µg/dl is associated with harmful effects on children's ability to learn. Very high BLLs (70 µg/dl) can cause devastating health consequences, including seizures, coma, and death. It is currently estimated that some 890,000 U.S. children have BLLs 10 µg/dl.[50]

Children can be exposed to lead in many ways. Sources of exposure include lead-based paint and industrial sites and smelters that use or produce lead-containing materials. Lead-contaminated dust, soil, and water; lead containing materials used in parental occupations or hobbies; and lead-containing ceramic ware and traditional remedies all contribute to childhood lead exposure. Lead-contaminated house dust, ingested in the course of normal hand-to-mouth activity, is of major significance. House dust is most often contaminated by lead-based paint in the home, when such paint is peeling, deteriorating, or scattered about during home renovation or preparation of painted surfaces for repainting.[50]

Experiments using adult volunteers showed that for adults who have just eaten, the amount of lead that got in to the blood from the stomach was only 6% of the total amount taken in. In adults who had not eaten for a day, about 60-80% of the lead from stomach got in to their blood. In general, if adults and children swallow the same amount of lead, a bigger proportion of the amount swallowed will enter the blood in children than in adults. Children absorb about 50% of ingested lead.[39]

Lead has been incriminated as the causal agent in permanent mental retardation in children and has been shown to decrease bacterial resistance in mice.[32] Children are more sensitive to the health effects of lead than adults. Lead affects children in different ways depending on how much lead a child swallows. Anaemia, kidney damage, colic, muscle weakness, brain damage which can lead to coma and death are some of the health effects.

Once lead gets into the body, it travels in the blood to the soft tissues and organs such as the liver, kidney, lungs, brain, spleen, muscles and heart. After several weeks most of the lead move into bone and teeth, in adults about 94% of the total amount of lead in the body is contained in the bones and teeth, about 73% of lead in children's bodies is stored in their bones. However, some lead can leave the bones and re-enter the blood stream and organs under certain circumstances e.g during pregnancy, periods of breast feeding, after a bone is broken or during advancing age. Under conditions of continued exposure not all the lead that enters the body will be eliminated and this may result in accumulation of lead in body tissues especially the bone.[39]

Lead is considered to be one of the major environmental pollutants; it continued to pose health hazards to animals and man in Nigeria and other parts of the world and has been incriminated as a cause of accidental poisoning in domestic animals more than any other substances.[76]

2.14 Diagnosis of Lead Poisoning in Animals

The potential for lead residues within exposed but asymptomatic cattle should be considered. Sometimes herd outbreaks of toxicity after herd exposure to a lead source do occur. Veterinarians commonly send blood and tissue samples to confirm diagnosis in individual animals with clinical signs, however, they do not routinely screen asymptomatic animals within these herds for evidence of exposure.[43]

The main tool in the diagnosis of lead poisoning and assessing its severity is analysis of blood lead level.[77] Blood lead levels are mainly an indicator of recent or current lead exposure and not of total body burden.[78] The best measure to determine total body burden of cumulative exposure is non invasive X-ray fluorescence.[23] However, this method is not readily available and mainly used for research purposes.[79] Another sign of elevated lead levels on radiographs is the presence of radio-dense lines called lead lines at metaphysis of long bones in growing children especially around the knees.[77] X-rays may also reveal lead-containing foreign materials such as paint chips in the gastrointestinal tract.[24, 77]

Faecal content measured over a course of some few days may also be used as an accurate way to estimate the overall amount of lead intake. This type of measurement may serve as a useful tool to see the extent of oral lead exposure from diet and environmental sources of lead.[80]

Other methods that can be used in diagnosis of lead poisoning include: rapid test kits, atomic absorption spectrophotometer, radio immune assays and enzyme linked immunoabsorbent assay.

Conditions that present similar signs to lead poisoning include carpal tunnel syndrome, Guillain-Barre syndrome, renal colic, appendicitis, encephalitis in adults and viral gastroenteritis in children. Other differential diagnoses in children include

constipation, abdominal colic, iron deficiency, subdural hematoma, neoplasm of the central nervous system, emotional and behavioural disorders and mental retardation.[77]

2.15 Treatment of Lead Poisoning

According to Jennifer[81] treatment of lead poisoning can be accomplished through:

2.15.1 Decreasing exposure: The most successful management occurs due to the removal of the lead risk from the environment and, ultimately, the child. Upon finding an elevated blood lead level, the local health department should be notified, and a home risk assessment should be performed. Once the source of lead is found in the home, soil, or workplace every effort should be made to remove this source. This may be accomplished by home lead paint abatement (by license and trained professionals with the family, preferably, out of the home), home dust reduction techniques, decreasing bare soil available to children, and nutritional evaluation and counselling. As noted above, those children with iron deficiency should be treated as anaemia may be worse with high lead and low iron. In addition, a diet sufficient in trace elements including calcium and vitamin C should be encouraged.

2.15.2 Chelation Therapy: Once lead has entered the body, especially bone, it is very difficult to remove. Accordingly, prevention is the mainstay of treatment. However, chelation therapy may be used to decrease the blood lead concentrations acutely. The final component of treatment is chelation therapy. Chelating agents bind metals at two or more sites. Ideally, the chelated metal would be excreted; however, the lead-chelate complex may persist in tissues where the binding occurred or be redistributed to other tissues. An optimal chelating drug should increase lead excretion, be administered easily, and be affordable and safe. Lead removal should halt further toxicity and reverse previous effects.[82]

Several chelating agents are effective in lead excretion, but the chelator of choice depends on the blood lead concentration, the patient's symptoms and the environmental lead burden. Symptomatic patients should be hospitalized and chelation therapy with Edetate Calcium Disodium ($CaNa_2EDTA$). $CaNa_2EDTA$ is an intravenous formulation that has been shown to be effective with British AntiLewisite (BAL, Dimercaprol) for removal of lead in patients with encephalopathy. Edetate calcium disodium, used alone, may aggravate symptoms in patients with very high blood lead levels. When clinical symptoms consistent with lead poisoning or when blood lead levels are greater than 70µg/dl. It is recommended that edentate calcium disodium be used in conjunction with dimercaprol. British-Anti-Lewisite (BAL) or dimercaprol is a small molecule drug which will cross into cells and may prevent the worsening of clinical and biochemical status on the first day of EDTA therapy.[83]

Studies have shown that the consumption of certain nutrients in the diet including minerals such as Ca, P, Fe and Zn and vitamins such as vitamin C, E and thiamine can reduce absorption of dietary lead in children.[84] There is ample evidence that vitamins, essential minerals and trace elements play a preventive role in reducing lead poisoning in humans[85] and animals.[86] Treatment for acute lead poisoning is seldom effective. The disease has usually progressed too far to be treated once clinical signs are seen.

Treatment only stops or lessens the clinical signs of lead poisoning and must begin early if an animal is to be saved.

1. Calcium - disodium EDTA: - For large animals, slow I/V injection of 6.6% solution at 70 mg/kg/day divided in 2 - 3 doses for 3-5 days. The injection should be repeated after a gap of two days.

2. Emetics, Saline purgatives and sedatives or hypnotics should also accompany such treatments.

2.16 Prevention of Lead Poisoning

Among the many international conventions that have acknowledged the importance of exposure to lead as a key public health issue are the following:

1) The 1989 Convention on the Rights of the Child.

2) Agenda 21 adopted by the United Nations Conference on Environment and Development in 1992.

3) The 1997 Declaration on the Environment by the Leaders of the Eight (on Children's Environmental Health).

4) The OECD Declaration on Lead Risk Reduction

According to Centres for Disease control and Prevention[87] public health measures should continue to be directed to the reduction and prevention of exposure to lead by reducing the use of the metal and its compounds and by minimizing lead-containing emissions that result in human exposures. This can be achieved by:

I. Phasing out lead additives in fuels and removing lead from petrol as soon as is practicable.
II. Safe mining practice
III. Reducing and phasing out the use of lead-based paints.
IV. Eliminating the use of lead in food containers.
V. Identifying, reducing and eliminating lead used in traditional medicines and cosmetics.
VI. Minimizing dissolving of lead in water treatment and water distribution systems.
VII. Improving control over exposure to lead in workplaces.

VIII. Improving identification of populations at high risk of exposure on the basis of monitoring systems.

IX. Improving procedures of health risk assessment.

X. Improving promotion of understanding and awareness of exposure to lead.

XI. Increasing emphasis on adequate nutrition, health care and attention to socio-economic conditions that may exacerbate the effects of lead.

XII. Developing international monitoring and analytical quality control programmes

2.17 Public Health Implications of Lead Poisoning

Lead is associated with a wide range of toxicity in children across a very broad band of exposures, down to the lowest blood lead concentrations yet studied, both in animals and humans. These toxic effects extend from acute, clinically obvious, symptomatic poisoning at high levels of exposure down to subclinical (but still very damaging) effects at lower levels. Lead poisoning can affect virtually every organ system in the body. The principal organs affected are the central and peripheral nervous system and the cardiovascular, gastrointestinal, renal, endocrine, immune and haematological systems.[45]

Blood lead levels as low as 2μg/dl may not cause distinctive symptoms but are associated with decreased intelligence and slower neurobehavioral development in the form of cognitive and language deficits. Many other effects can begin to occur at these low blood levels. Recent studies suggest that lead absorption is harmful at any concentration and that no safe level of lead exposure exists.[88]

Intense, acute, high-dose exposure to lead can cause symptomatic poisoning in children. It is characterized by colic, constipation, fatigue, anaemia and neurological

features that can vary from poor concentration to stupor. In the most severe cases, a potentially fatal acute encephalopathy with ataxia, coma and convulsions can occur. In many instances, children who survive acute lead poisoning have permanent and clinically apparent deficits in their neuro developmental function.[89]

Subclinical toxicity denotes relatively low-dose exposure to lead at blood lead levels previously thought to be safe can cause harmful effects not evident in a standard clinical examination. Although they are not clinically obvious, the subclinical toxic effects of lead can be very damaging. The premise underlying the concept of subclinical toxicity is that there is a dose-related continuum of toxic effects in which clinically apparent effects have their asymptomatic (but still very real) counterparts.[90]

Anaemia is the classic clinical manifestation of lead toxicity in erythrocytes. The severity and prevalence of lead-induced anaemia correlate directly with the blood lead concentration. Younger and iron deficient children are at higher risk of lead-induced clinical anaemia. The anaemia induced by lead is caused primarily by impairment of haeme biosynthesis, but an increased rate of erythrocyte destruction may also occur.[91]

In the peripheral nervous system, the motor axons are the principal target of lead toxicity. Lead-induced pathological changes in these fibres include segmental demyelination and axonal degeneration. Extensor muscle palsy with wrist and ankle drop has been recognized since the time of Hippocrates as the classic clinical sign of the peripheral neurological toxicity of lead; however, this generally only occurs with chronic lead poisoning and is rare in acute exposure to lead. In the central nervous system, lead causes asymptomatic impairment of neurobehavioural function in children at doses insufficient to produce clinical encephalopathy.[92]

In pregnancy, lead that has been stored in the mother's skeleton in the past years is released into the circulation under the metabolic stress of pregnancy. Throughout

pregnancy, lead readily crosses from the maternal to the infant circulation, and the blood lead concentration of the infant becomes virtually identical to that of the mother.[82]

Once in the infant, lead can penetrate the immature blood–brain barrier to enter the developing brain. The developing human brain is particularly susceptible to lead, even at very low levels of exposure. The developing human brain undergoes rapid growth, development and differentiation, and lead can interfere with these extraordinarily complex and delicate processes. The brain damage caused by chronic, low-level exposure to lead are irreversible and untreatable.[93] Exposure to lead early in life can re-programme genes, which can lead to altered gene expression and an associated increased risk of disease later in life.[94] Early exposure to lead can also reduce an individual's capacity to successfully weather other neurological abuse later in life.

In kidneys, lead causes proximal tubular injury with a characteristic pathology of proximal tubule nuclear inclusion bodies that progress to tubulo-interstitial disease and fibrosis. Lead accumulation in the proximal tubule leads to hyperuricaemia and gout – presumably by inhibiting uric acid secretion – and also to diminished renal clearance, tubular reabsorption and glomerular filtration rate.[95]

The hypertensive effects of lead have been confirmed in experimental animal models. Beyond hypertension, studies in general populations have identified a positive relationship between exposure to lead and clinical cardiovascular events (mortality due to cardiovascular disease, coronary heart disease and stroke; and peripheral arterial disease), but the number of studies examining these effects is relatively small. In some studies, these relationships were observed at blood lead levels lower than 5μg/dl.[96]

Exposure to environmental lead is clearly a major public health hazard of global dimensions. As measures to control the transfer of lead to the environment are implemented in most developed countries through, for example, the phasing out of lead in fuel, paints and other consumer products, and tighter control of industrial emissions, environmental exposure to lead can, in general, be expected to continue to decline. However, because of rapid industrialization and the persistence of lead in the environment, exposure is likely to remain a significant public health problem in most developing countries for many years.

Much work needs to be done to identify and treat children with elevated blood lead levels and reduce lead exposure in the community. Screening, monitoring, intervention and evaluation are critical for the development of rational, cost-effective and science-based public health policies aimed at achieving these goals.

CHAPTER THREE: METHODOLOGY

3.1 Area of Study

Zamfara State is one of the 36 States of the Federal Republic of Nigeria situated in the north western part of the country and occupies about 39,762km². Gusau is the capital of Zamfara State; the State is made up of 14 Local Government Areas, 62 Districts and 147 political wards. It shares boundaries with Katsina, Sokoto and Kebbi States of Nigeria and an international boundary with Niger republic to the north (Fig 3.1). The total population of the State is estimated to be approximately 3.7million of which about 20% are estimated to be children less than five years of age. Farming is the major source of livelihood with more than 80% of the people participating in agricultural activities. The State is mainly populated by hausas and fulanis. The climate of Zamfara State is warm tropical, with temperatures rising up to 38°C between March and June. The rainy season typically lasts from July to September, while the cold season (harmattan) lasts from December to February.

Gusau abattoir is the main abattoir in the State. Cattle, sheep, goats and camels are the animals that are slaughtered for human consumption in the abattoir with an average daily slaughter figure of about 40 heads of cattle, 6 camels, 5 goats and 25 sheep.

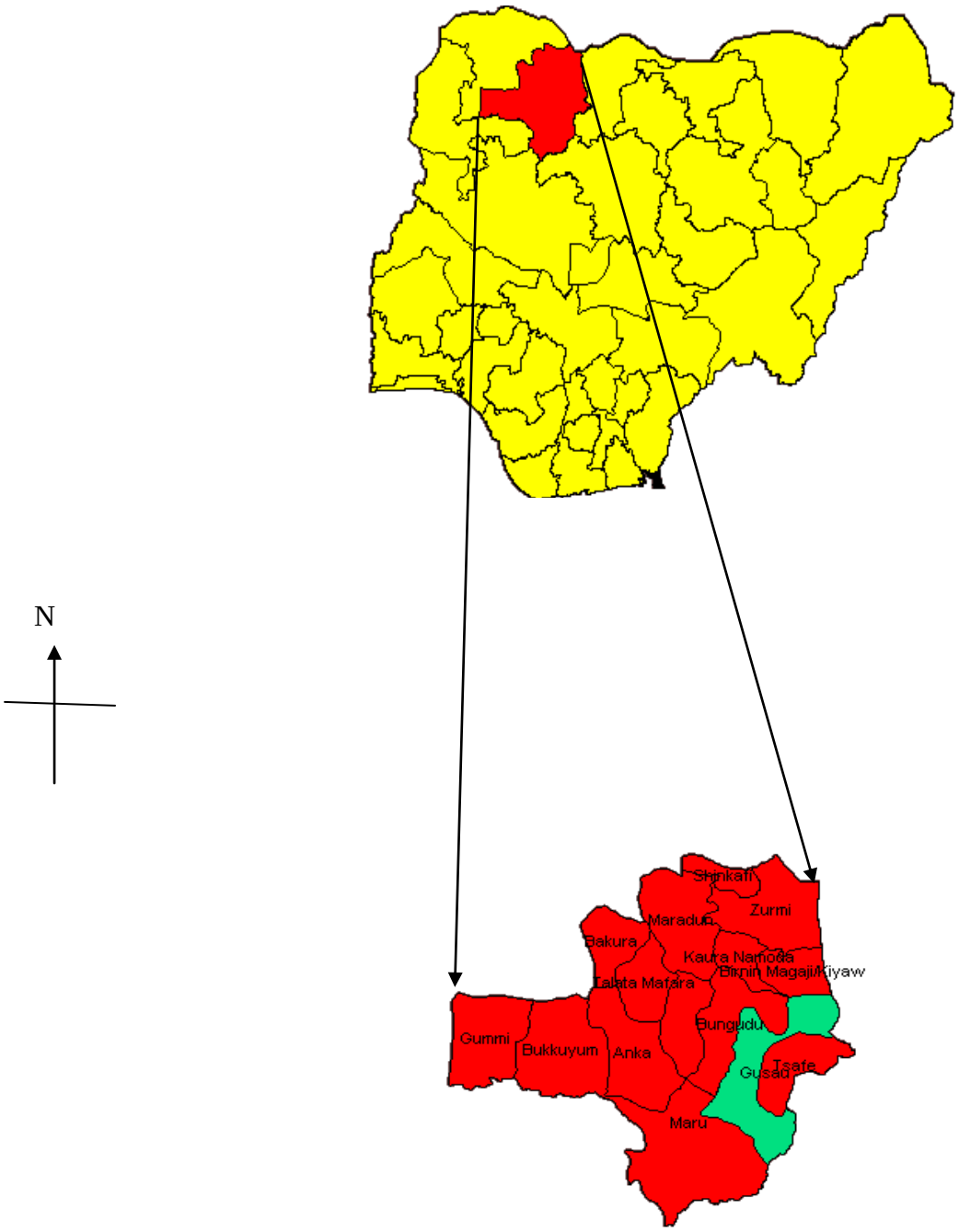


Figure 1: Map of Nigeria showing the position of Zamfara State and Gusau LGA in Zamfara State highlighted in green colour.

Source: Health Mapper WHO

3.2 Study Design

The study was cross-sectional type of study and it was abattoir - based. It covered a period of fifteen weeks (November, 2012 to February, 2013) of sample collection and analyses.

3.3 Study Population

All animals slaughtered at Gusau abattoir, Zamfara State from November, 2012 to February, 2013.

3.3.1 Inclusion Criteria

Only animals slaughtered within the abattoir

3.3.2 Exclusion Criteria

Any animal slaughtered outside the abattoir

3.4 Sample Size Determination

Lwanga and Lemeshow[97]

$$\mathbf{N} = \frac{Z\alpha^2 P (1 - P)}{d^2}$$

Where,

N = desired sample size

$Z\alpha^2$ = the standard normal deviation usually set at 1.96 which corresponds to the 95% confidence

P= Proportion of outcome of interest obtained from a previous study.

d = the degree of precision

Where,

$Z\alpha = 1.96$

P = 50% prevalence of lead poisoning

d = 0.05%

Therefore,

$$N = \frac{1.96^2 * 0.5(1 - 0.5)}{0.05^2}$$

N = 384

A total of 384 animals were sampled for this study. The numbers of specimens collected from different animal species were based on the daily average slaughter figure (proportionate allocation based on slaughter figures). Therefore, a total of 227, 111, 26 and 20 samples were collected from cattle, sheep, camels and goats respectively.

Table 1: Proportionate Allocation of Samples Based on Slaughter Figures at Gusau Abattoir Zamfara State. (November 2012 - February 2013)

Species	Slaughter Figure (Daily)	Proportion (%)	No. Animals to be Sampled
Camels	5	6.58	26
Cattle	45	59.21	227
Goats	4	5.26	20
Sheep	22	28.94	111
Total	**76**	**100**	**384**

3.5 Sampling Technique

Systematic sampling technique was used. Out of every five animals of different species slaughtered, one sample is collected to get the determined sample size based on slaughter figures.

3.6 Sample Collection

A fresh sample of muscle from the neck was collected from each of the animal randomly selected and sampled at the abattoir. The samples were collected in labelled polyethylene bags. The samples were stored in deep freezers before being transported to the laboratory for analysis. Demographic data (breed, age, sex) and other relevant information about the source of the animal were obtained at ante-mortem inspection prior to slaughter using a structured questionnaire (Appendix 1). The study was carried out between the Months of November, 2012 to February, 2013.

3.7 Sample Preparation for Laboratory Analysis

The Chemistry Laboratory of the National Research Institute for Chemical Technology (NARICT) Zaria Nigeria was used for sample preparation and analyses.

3.7.1 Sample Digestion

The samples were dried at 45°C for 2 hours using an oven. After drying individual samples were crushed into fine powder using a pestle and mortar. About 1gm of the fine powder sample was weighed into porcelain crucible and ignited in a muffle furnace at 550° C for about two hours[15, 31]. The samples were then removed from the furnace and allowed to cool in desiccators and weighed again. The difference between the weight of the crucible and ash and the weight of the crucible alone was used to calculate the percentage ash content of the sample. Thereafter, 5ml of IM trioxonitrate (v) acid ($HNO_{3)}$ solution was added to the left-over ash and evaporated to dryness on a

hot plate and returned to the furnace for heating again at 400°C for 16-20 minutes until perfect greyish-white ash was obtained. To the cooled ash 15ml hydrochloric acid (HCl) was then added to the ash to dissolve it and the solution was filtered into 100ml volumetric flasks.

3.7.2 Spectrophotometry Techniques for Lead

Determination of lead residue was done under specified condition according to the manufacturer's instructions. Reagent blank was used for zeroing while taking the readings of samples containing the lead. The sample solution was aspirated into the flame and its absorbance reading was recorded. Calibration curve for the absorbance readings of the standard solutions for the lead was plotted. The concentration of lead in each sample was determined using calibration curve.[15, 25, 98] Results of each sample will be presented in parts per million (PPM) per litre and this will be converted appropriately to mg of lead per kilogram of meat sample.

3.8 Data Analyses

All qualitative (species, breed, sex, LGA of purchase, length of stay in Zamfara) and quantitative information collected were entered and analysed using Epi info version 3.5.3. Data collected were presented as milligram of lead per kilogram of meat sample. The presence or absence of lead was used to arrive at the prevalence of lead poisoning in animals slaughtered at Gusau abattoir. The lead levels in each animal were quantified. Exposure and outcome variables were statistically tested using the chi square test.

3.9 Ethical Considerations

Ethical Approval was obtained from the Ahmadu Bello University Teaching Hospital Zaria Ethical Committee (Appendix 2)

Approval was also obtained from the Ministry of Animal Health and Livestock Development, Zamfara State for the use of the abattoir as the study site (Appendix 3).

Informed consent of individual butchers was obtained before samples were collected from their animals.

Confidentiality of information was assured and maintained.

3.10 Limitations

1. The desired sample size for goats and sheep could not be achieved due to low slaughter figures of these species

2. Only about 13% of butchers could answer questions on the duration of stay of their animals in Zamfara State.

CHAPTER FOUR: RESULTS

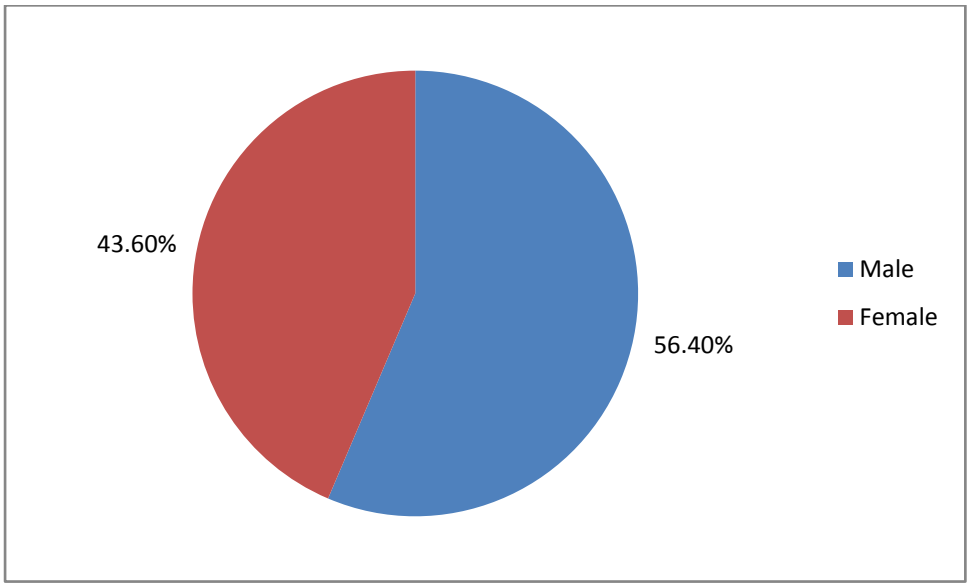


Figure 2: Sex distribution of animals slaughtered at Gusau abattoir

Out of 384 animals sampled for the study 216 (56.4%) were males whereas, 167 (43.6%) were females (Figure 2). Lead residues were present in 142(85.02%) female animals and in 181(83.79%) males.

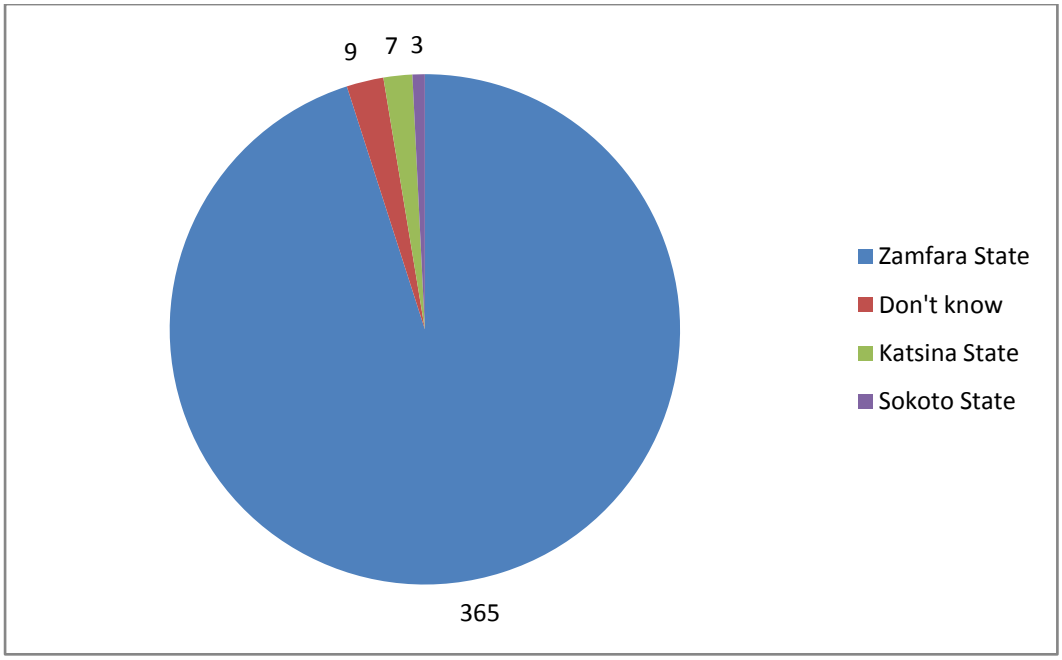


Figure 3: Source of animals slaughtered at Gusau abattoir

Of the 384 animals sampled and tested 324(84.4%) had lead in their tissues and out of these 309(95.4%) bought their animals from markets within Zamfara State, 7(2.1%) from Katsina State, 3(0.9%) Sokoto State and 9(2.8%) do not know the source of the animal (Figure 3).

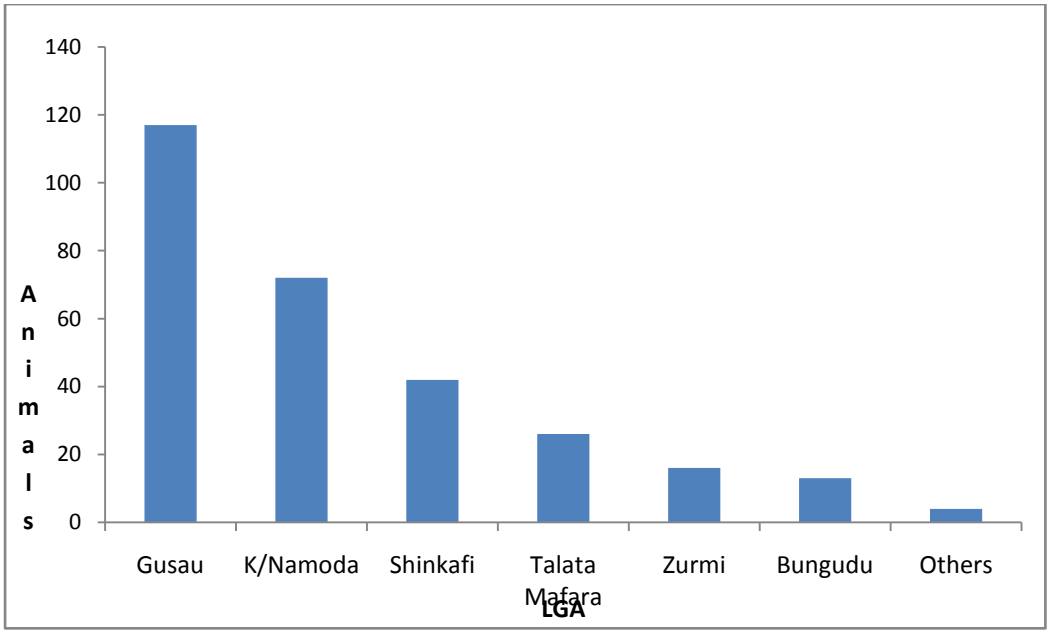


Figure 4: Distribution of animals slaughtered at Gusau abattoir by LGA of purchase in Zamfara State

Out of the 309 animals sourced from Zamfara State 117(37.9%) were from markets in Gusau LGA, 72(23.3%) from Kaura Namoda, 42(13.6%) from Shinkafi, 26(8.4%) from Talata Mafara, 16(5.2%) from Zurmi, 13(4.8%) from Bungudu and 4(1.2%) from Anka, Bukkuyum and Tsafe LGAs (Figure 4).

Table 2: Prevalence of lead residues in tissues of animals slaughtered at Gusau abattoir

Pb residue	Frequency	Percent
Present	324	84.4
Absent	60	15.6
Total	384	100

Out of 384 animals slaughtered at Gusau abattoir 324(84.4%) had residues in their tissues and 60(15.6%) had no lead in their tissues.

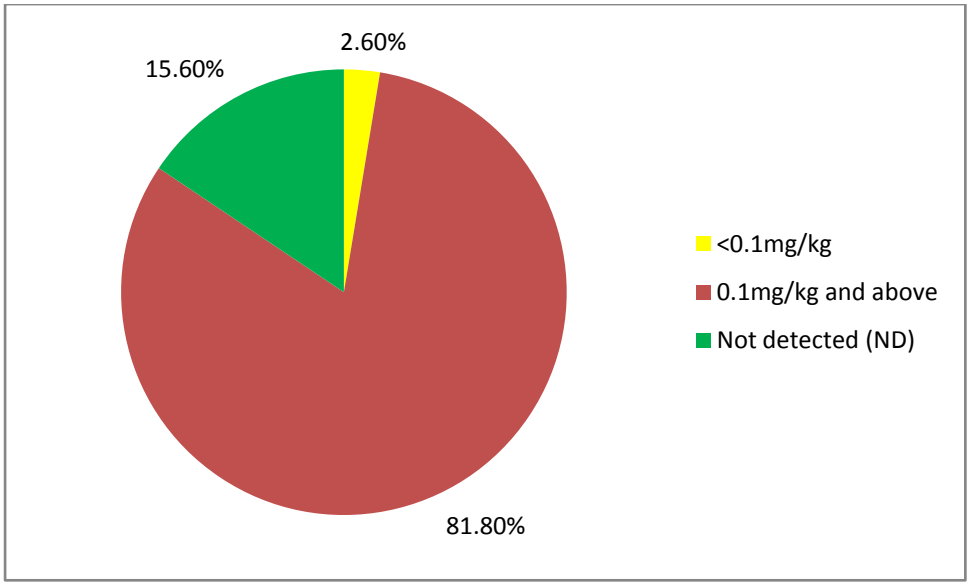


Figure 5: Chart indicating the three levels of lead residues found in all species slaughtered at Gusau abattoir

Of those that tested positive for lead, 8(2.6%) were within the FAO and EC permissible limits of 0.1mg/kg and 316(81.80%) of samples were found to be above the permissible limits. (Figure 5)

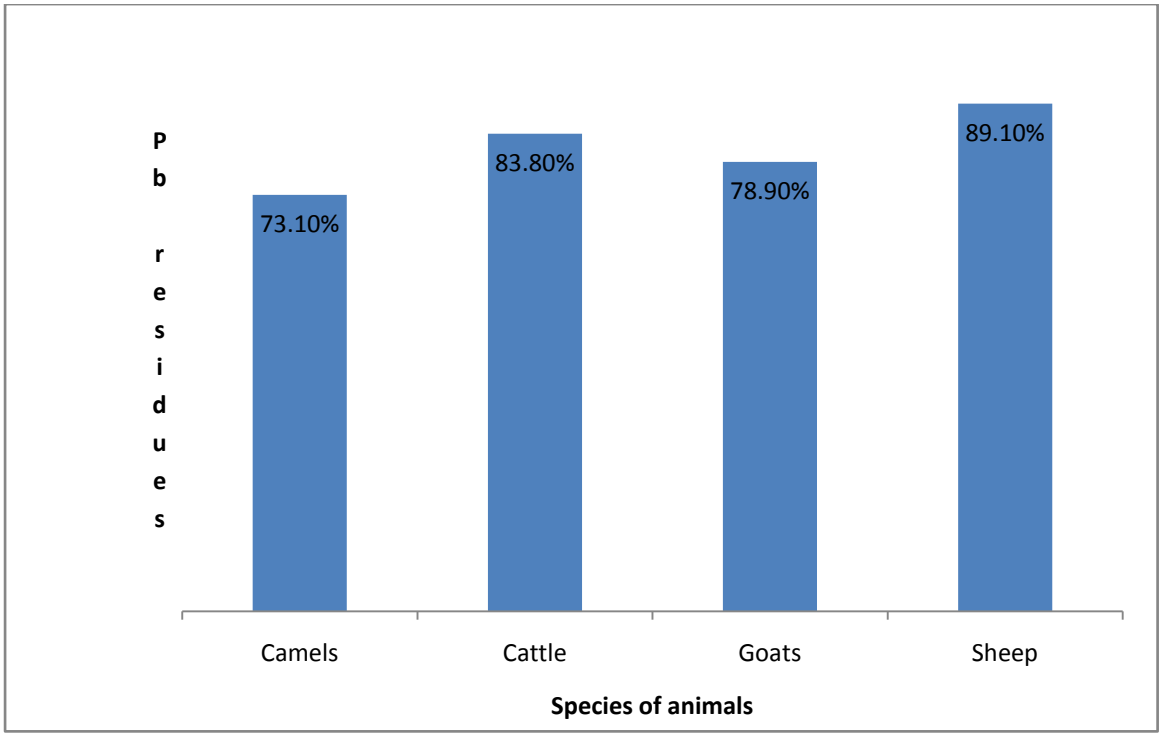


Figure 6: Prevalence of lead residues in different animal species slaughtered at Gusau abattoir.

Prevalence of lead residues in animal tissues was highest in sheep (89.10%) and lowest in camels (73.10%)

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Table 3: Mean concentration of lead (mg/kg) in different species of animals slaughtered at Gusau abattoir

Species	No. of Animals	Mean conc. of lead (mg/kg)	Standard Deviation	P value = 0.1004
Camels	26	1.039	1.04	
Cattle	229	1.039	0.92	
Goats	19	1.573	1.25	
Sheep	110	1.087	0.74	

There was no statistical difference in the mean concentration of lead residues between the different species of animals slaughtered at Gusau abattoir.

p value > 0.05.

Table 4: Mean concentration of lead (mg/kg) in goats of different ages slaughtered at Gusau abattoir

Age	Number of Animals	Mean conc. Pb mg/kg	Standard deviation	P value = 0.5734
< 1 year	3	2.2167	1.1609	
1 year	2	0.5115	0.7234	
1.5 years	5	1.3008	0,9871	
2 years	5	2.0192	1.770	
2.5 years	4	1.4020	1.0869	

p value > 0.05 – No significant difference in lead residue accumulation between different ages of goats.

Table 5: Mean concentration of lead (mg/kg) of different ages in camels slaughtered at Gusau abattoir

Age	Number of Animals	Mean Conc. Pb mg/kg	Standard deviation	P value = 0.4537
< 1 year	1	1.705	0	
3 years	2	0.021	0.0297	
4 years	2	0.426	0.6025	
5 years	2	1.620	2.2910	
6 years	4	1.0943	1.410	
7 years	7	1.181	0.919	
8 years	5	1.093	0.729	
9 years	1	0.042	0	
10 years	1	2.670	0	

P value > 0.05 - No significant difference in lead residue accumulation between camels of different ages

Table 6: Mean concentration of lead (mg/kg) of different ages of sheep slaughtered at Gusau abattoir

Age	Number of Animals	Mean Conc. Pb mg/kg	Standard deviation	P value = 0.123
< 1 year	3	0.6667	1.1066	
1 year	5	1.0028	0.6698	
1.5 years	23	1.0189	0.7108	
2 years	33	1.0932	0.6620	
2.5 years	18	1.0738	0.6106	
3 years	17	1.2486	0.8048	
3.5 years	5	0.3936	0.5115	
4 years	5	1.8950	1.1359	
4.5 years	1	1.0560	0	

P value > 0.05 - No significant difference in lead residue accumulation between sheep of different ages

Table 7: Mean concentration of lead (mg/kg) of different ages of cattle slaughtered at Gusau abattoir

Age	Number of animals	Mean conc. Pb (mg/kg)	Standard deviation	P value = 0.4537
<1 year	1	2.103	0	
1 year	10	1.317	1.2425	
2 years	19	0.7839	0.6698	
3 years	19	1.0846	0.9326	
4 years	42	1.1952	0.9778	
5 years	65	1.0124	0.8572	
6 years	49	0.9230	0.9267	
7 years	20	1.1977	0.9869	
8 years	4	0.5033	0.5639	

P value> 0.05 - No significant difference in lead residue accumulation between cattle of different ages

Table 8: Prevalence of lead residues in different breeds of cattle and sheep slaughtered at Gusau abattoir

Specie	Breed	Frequency	Pb present	Percent
Cattle	Red Bororo	53	46	86.79
Cattle	Sokoto Gudali	80	67	83.75
Cattle	White Fulani	97	79	81.44
Sheep	Yankasa	84	75	89.28
Sheep	Balami	1	0	0
Sheep	Uda	25	23	92

Uda breed had the highest prevalence (92%) in sheep whereas in cattle the Red Bororo breed had the highest prevalence (86.79%)

Table 9: Association between length of stay in Zamfara and tissues lead residues in animals slaughtered at Gusau abattoir

Exposure	Pb residue		Total	OR [95% CI]	P value = 0.4951
	Pb +	Pb -			
>2 months	39	5	44	**1.95**	
<2 months	4	1	5		
Total	**43**	**6**	**49**		

P value > 0.05 – There is no significant association between the length of stay in Zamfara State (> 2 months or < 2 months) and lead residue accumulation in animal tissues.

CHAPTER FIVE: DISCUSSION

This study shows that the prevalence rate of lead residues in muscle tissues of animals slaughtered at Gusau abattoir is 84.4% (324 out of the 384) samples tested. This rate is lower compared to 100% reported by Bala *et al*[15] who studied lead in liver and kidney of slaughtered cattle in Sokoto abattoir. The liver is an organ where detoxification takes place and as such more of the lead from blood and other tissue will be mobilised and taken to the liver through circulation for detoxification to take place and the kidneys are also meant for excretion, therefore the metal composition of these organs is expected to be higher as compared to that of the muscle tissues. This appears to be the reason for the difference.

The result obtained from this study is similar to the one reported by Nwude *et al*[28] who found lead residues in 93% of cattle sampled from the South Eastern Nigeria. However, the result obtained in this study is higher than results obtained by Fathy *et al*[37] in beef carcasses in Beni - Suef abattoir in Egypt. Animals commonly consume locally produced feeds as major portion of their ration; their body burden of metals may reflect the locality's heavy metal status.[32]

The concentration of lead residues in 81.80% of samples tested was higher than the permissible limit of 0.1mg/kg for muscle tissue recommended by the FAO and EU Commission. This result is similar to the result reported by Mariam *et al*[99] who found lead residues above the permissible limit of 0.1mg/kg in all the muscle samples of cattle analysed in Punjab, Lahore.

The highest mean concentration of lead of 2.670mg/kg in camels, 2. 2167mg/kg in goats, 2.103mg/kg in cattle and 1.895mg/kg in sheep, are similar to the one obtained by Snezana Stavreva-Veselinovska and Jordan Zivanovic[31] in a study of heavy metals in cattle reared in the vicinity of a metallurgic industry but it is higher than the results

obtained in Sokoto by Bala *et al*[15] who reported 0.6140mg/kg in cattle. The observed difference could be as a result of indiscriminate mining activities practiced in Zamfara State. However, Nwude *et al*[28] reported highest concentration of 4.98mg/kg from South Eastern Nigeria which is higher that the result obtained in this study. This may be as a result of exhaust fumes inhaled by these animals in the course of transportation from the Northern part of Nigeria to the South. Another reason could be because of the industrialised nature of the Southern States of Nigeria as compared to the North that have few industries.

The highest mean concentration of lead in goats and cattle was observed in age group less than one year old whereas in sheep and camels it was observed in age group four and ten years old respectively. This result agrees with reports of Blakley and Brockman[72] who stated that cattle of all ages are affected by lead but young ones are more susceptible to lead because of innate curiosity and active calcium absorption mechanism. The result is also in line with the findings made by Doritza *et al*[74] that cadmium and lead are bioaccumulative metals; therefore, animals with longer life spans have high concentrations of these metals in their tissues.

The results from this study indicate that, of all the species of animals slaughtered at Gusau abattoir, the prevalence of lead residues is highest in sheep (89.10%) and cattle (83.90) as compared to others and lowest in camels (73.10%) and goats (78.90%). Generally, there are no significant differences in the prevalence of lead residues in all the four species of animals slaughtered at Gusau abattoir. The low prevalence in camels as compared to other species could possibly be because of their greater height which gives them an advantage in terms of the types of tree and foliage they browse. The prevalence in goats is slightly lower than the results obtained by Okoye and

Ugwu[26] who reported 61% prevalence of lead residues in muscles of goats in Nsukka, Nigeria.

The mean lead concentration in all species indicates that there are no significant differences in lead accumulation in male and female animals. This suggests that animals of both sexes are equally susceptible to lead residue accumulation. This is in agreement with results obtained by Bala *et al.*[15] Similarly, there is no significant difference in tissue lead residue accumulation between the different breeds of cattle and sheep slaughtered at Gusau abattoir.

The bone is considered to be a sink for lead and it may contain 90-98% of the total body burden of lead. When bone and blood from the affected animals are used as bone and blood meal in animal feed, the lead content may bio-accumulate in tissues of the animals fed with such feeds.[23, 24] Lead is also excreted from the faeces of affected animals in high amount (90%), when such faeces are used as manure on the land for growth of pasture and crops for animal and human consumption. The lead in the manure will contaminate the plants[100] and when such plants are consumed by animals and man, it may cause lead residue accumulation.

Cattle and other animals serve as bio-indicators of environmental contamination with heavy metals.[67] The presence of lead in the tested samples of animal tissues serves as an indication that the environment where these animals grazed before they were purchased for slaughtering was contaminated with lead. Consumption of meat of these animals may pose a serious health problem to man especially children <5 years old as a result of bioaccumulation of lead in the body tissues. This however varies among individuals and depends on duration of exposure.[24]

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This study has established

1. The presence of lead residues in 324 (84.4%) of the tissues sampled and tested from animals slaughtered at Gusau abattoir, Nigeria.
2. The concentration of lead residues was found to be higher than the permissible limit of 0.1mg/kg recommended by FAO and EU in 81.80% of animals tested
3. That the effect of age, sex, species and breed of animals on lead residue accumulation in slaughtered animals in Gusau abattoir were not statistically significant.
4. That the length of stay of animals in Zamfara State is not statistically significant as a risk factor for lead residue accumulation

6.2 Recommendations

1. Environmental impact assessment should be conducted by the Government to determine the level of contamination of soil, water, grasses and crops where animals are reared for human consumption.

2. Artisanal gold miners should be educated and enlightened on safe mining practices.

3. There is need to educate the general public through the media (TV, Radio, Pamphlets, Newspapers, Drama) on ways of disposing lead materials to avoid contamination of the environment and water bodies.

4. Further research is required to determine the presence of lead residues in other organs and tissues and also in animals slaughtered in other abattoirs and slaughter slabs across entire Zamfara State.

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APPENDIX 1

EPIDEMIOLOGY OF LEAD POISONING IN ANIMALS SLAUGHTERED AT GUSAU ABATTOIR

QUESTIONNAIRE

Questionnaire Number……..

NAME (Optional)…….

1. Animal's information.

a. Sex…… b. Breed……. c. Age……

2. Where have you gotten your animal from?

a. Zamfara State LGA…… b. Other States State……..

c. Outside Nigeria Country…… d. Don't know…….

3. For how long has the animal been in Zamfara State?

a. < 2 months. b. > 2 months c. Don't Know

4. Select the animal production system

a. Free range b. With the Fulani's c. Semi intensive d. Intensive e. Don't know

APPENDIX 2

Ahmadu Bello University Teaching Hospital

P.M.B. 06, Shika - Zaria, Kaduna State, Nigeria. 069-876305

website: www.abuth.org abuthshika@yahoo.com Abuthshika@gmail.com

Chairman of Board:

Chief Medical Director: **DR. LAWAL KHALID,** ***MBBS, FMCS, FWACS, FRCS(ED) mni***

Chairman, Medical Advisory Committee: **DR. ABDULLAHI MOHAMMED,** ***MBBS, FWACP FICS***

Director of Administration: **BARR. ISHAK BELLO,** ***LL.B, BL, LL.M, PGDM, AHAN, FCAI***

Our Ref: ABUTH/HREC/TRG/36 7th March, 2013

Dr. Abubakar Aliyu Jafiya,
Comm. Medicine Department,
A.B.U. Zaria.

ETHICAL CLEARANCE.

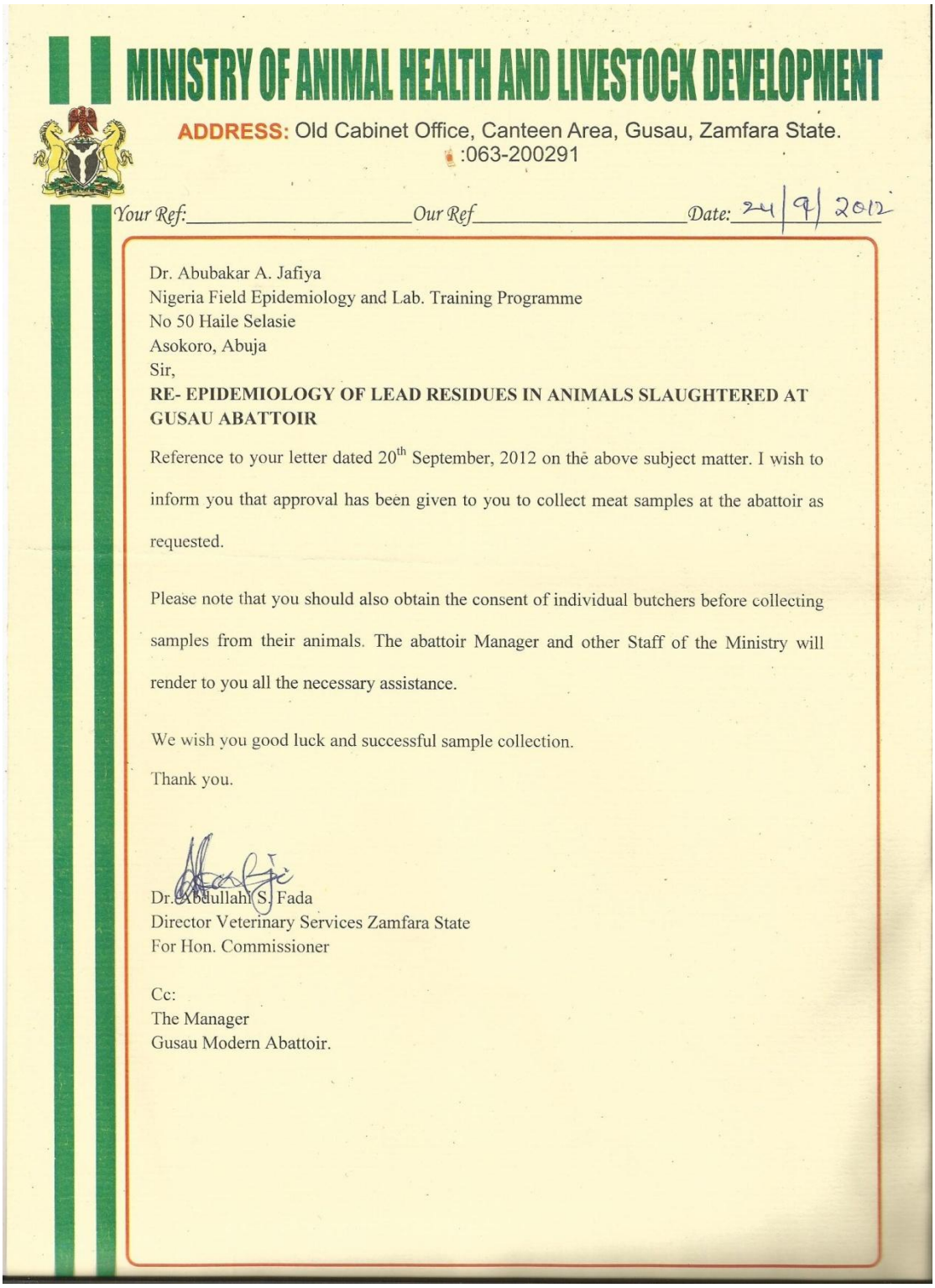
Your application for ethical clearance on the research proposal titled: - **"Prevalence of lead poisoning in cattle slaughtered at Gusau abattoir. Zamfara State."** refers.

This is to convey ethical approval for you to commence the study. The ABUTH Scientific and Health Research Committee require an annual update from the Principal Investigator.

Thank you.

PROF. J.U OKPAPI
CHAIRMAN, ABUTH HREC

APPENDIX 3



MINISTRY OF ANIMAL HEALTH AND LIVESTOCK DEVELOPMENT

ADDRESS: Old Cabinet Office, Canteen Area, Gusau, Zamfara State.
:063-200291

Your Ref:_____ Our Ref_____ Date: 24/9/2012

Dr. Abubakar A. Jafiya
Nigeria Field Epidemiology and Lab. Training Programme
No 50 Haile Selasie
Asokoro, Abuja
Sir,

RE- EPIDEMIOLOGY OF LEAD RESIDUES IN ANIMALS SLAUGHTERED AT GUSAU ABATTOIR

Reference to your letter dated 20th September, 2012 on the above subject matter. I wish to inform you that approval has been given to you to collect meat samples at the abattoir as requested.

Please note that you should also obtain the consent of individual butchers before collecting samples from their animals. The abattoir Manager and other Staff of the Ministry will render to you all the necessary assistance.

We wish you good luck and successful sample collection.

Thank you.

Dr. Abdullahi S. Fada
Director Veterinary Services Zamfara State
For Hon. Commissioner

Cc:
The Manager
Gusau Modern Abattoir.