SURVEY OF LEAD POISONING IN SMALL RUMINANTS AND DUCKS IN ANKA LOCAL GOVERNMENT AREA OF ZAMFARA STATE, NIGERIA

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SURVEY OF LEAD POISONING IN SMALL RUMINANTS AND DUCKS IN ANKA LOCAL GOVERNMENT AREA OF ZAMFARA STATE, NIGERIA

BY

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AUGUST, 2014

DECLARATION

I declare that, the work in this Thesis entitled "**A Survey of Lead Poisoning in Small Ruminants and Ducks in Anka Local Government Area of Zamfara State, Nigeria**" has been carried out by me in Department of Veterinary Public Health and Preventive Medicine. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at this or any other institution.

_____	_____	_____
Name of Student	Signature	Date

CERTIFICATION

This thesis entitled "A SURVEY OF LEAD POISONING IN SMALL RUMINANTS AND DUCKS IN ANKA LOCAL GOVERNMENT AREA OF ZAMFARA STATE, NIGERIA" by Nabilah DALHATU meets the regulations governing the award of the degree of Masters of Science in Veterinary Public Health and Preventive Medicine of the Ahmadu Bello University Zaria, and is approved for its contribution to knowledge and literacy presentation.

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DEDICATION

This research work is dedicated to my lovely and amazing parents Alhaji Dalhatu Sule and Hajiya Nafisatu Adamu.

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ABSTRACT

Lead poisoning was reported in Anka and Bukkuyum Local Government Area of Zamfara State in 2010 where over 400 children were reported dead. Based on the above information, a study was carried out to demonstrate the occurrence and concentrations of lead in the blood of animals in some affected villages, as well as increase the understanding of the involvement of domestic animals in the outbreak of poisoning in Anka Local Government Area. A total of 533 blood samples were collected from small ruminants (515) and ducks (18) which were analysed for presence and levels of lead using Lead Care II analyser. A structured questionnaire was also administered to one member each of 90 households in Abare (24), Sunke (26), Dareta (19) and Bagegga (21) to determine the relationship between species, location and management practices on blood lead levels and determine which animal(s) could be used as early warning of poisoning in humans in the study area. The questionnaire was also used to determine the level of awareness of household members on lead poisoning in humans and animals. Soil samples were evaluated for lead using Field-portable X-ray fluorescence (FPXRF) machine. Levels of lead were assessed using the World Health Organisation classification of lead poisoning as blood lead level above 5µg/dl and soil samples with greater than 400ppm of lead were considered as contaminated. Out of 296 goats and 219 sheep that were sampled, 216 (71.9%) and 138 (63.0%) were poisoned respectively. Majority of the ducks had high blood lead levels of greater than 65µg/dl. Goats proportionally had higher levels compared to sheep. Ducks had the highest morbidity and mortality, followed by sheep and goats. The pattern of poisoning in man and animals were similar. Only 20% of the respondents could not link lead poisoning to the mining activity in the area and 91% of the respondents live more than 1km away from the mining site. Bagegga had the highest number of positive samples for blood (82.7%) and soil (80.8%) lead. In all, 52% of soil samples taken from the households were contaminated. Lead poisoning was found

in animals in all the communities of Anka LGA, associated with heavy soil contamination which is related to the human cases of lead poisoning. Massive death of ducks due to high levels of lead found in their blood and also that found in goats are good indicators of a potential epidemic of lead poisoning in humans.

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CHAPTER ONE

INTRODUCTION

1.0 Background of the Study

The environment can be defined as all the physical, biological and chemical factors external to the human host as well as those factors impacting related behaviour (WHO, 2002). Chemicals could come in different forms, some of which are beneficial to man and animals while others are harmful. These harmful effects could be acute or chronic depending on the chemical involved, route of exposure, duration of exposure and dosage. An example of chemicals that have impact on both man, animals and the environment are the heavy metals.

Heavy or toxic metals are trace metals that are at least five times denser than water. As such, they are stable elements and bio-accumulative. Interestingly, small amounts of these elements are common in our environment and diet and are actually necessary for good health, but large amounts of any of them may cause acute or chronic toxicity (Ryan, 2003). Allergies are not uncommon and repeated long-term contact with some metals or their compounds may even cause cancer (International Occupational Safety and Health Information Centre (IOSHIC), 1999). If unrecognized or inappropriately handed, toxicity can result in significant illness and reduced quality of life (Ferner, 2001). Heavy metals are taken into the body via inhalation, ingestion, and skin absorption (OSHA, 1991). If heavy metals enter and accumulate in the body tissue faster than the body's detoxification pathways can dispose of them, a gradual build up of these toxins will occur. High-concentration exposure is not necessary to produce a state of toxicity in the body tissues and, over time, can reach toxic concentration levels (Landrigan and Todd, 1994).

Heavy metals include antimony, arsenic, bismuth, cadmium, cerium, chromium, cobalt, copper, gallium, gold, iron, lead, manganese, mercury, nickel, platinum, silver, tellurium, thallium, tin, uranium, vanadium, and zinc (Glanze, 1996).

Lead is a naturally occurring bluish-gray metal found in small amounts in the earth's crust. It has no special taste or smell. It can be found in all parts of our environment (Singh, 2005). Most of it comes from human activities like mining, manufacturing and the burning of fossil fuels (Contaminants and Remediation Directorate, 2004). Lead is used as a construction material for equipment used in sulfuric acid manufacture, petrol refining, halogenations, sulfonation, extraction and condensation. It is used in storage batteries, alloys, solder, ceramics and plastics. It is also used in the manufacture of pigments, tetraethyl lead and other lead compounds, in ammunition, and for atomic radiation and x-ray protection. Lead is used in aircraft manufacture, building construction materials (alloyed with copper, zinc, magnesium, manganese and silicon), insulated cables and wiring, household utensils, laboratory equipment, packaging materials, reflectors, paper industry, printing inks, glass industry, water purification and waterproofing in the textile industry. Lead itself does not break down, but lead compounds are changed by sunlight, air, and water. When released into the air from industry or burning of fossil fuels or waste, it stays in air for about 10 days (Tuberose.com, 2011). Most of the lead in soil comes from particles falling down from the air. City soils also contain lead from landfills and leaded paint. Lead sticks to soil particles. It does not move from soil to underground water or drinking water unless the water is acidic or "soft". Lead stays for a long time in both soil and water (University of Alaska Fairbanks, 2011).

Humans have been mining and using this heavy metal for thousands of years, poisoning themselves in the process. Although mining is one of the oldest known occupations with

environmental hazards, the modern understanding of the small amount of lead necessary to cause harm did not come about until the latter half of the 20th century. No safe threshold for lead exposure has been discovered i.e there is no known amount of lead that is too small to cause the body harm (Policy Brief, 2013).

Blood lead levels are reported in micrograms per decilitre (μg/dl), or micrograms per 100 grams (μg/100 g) of whole blood, which is approximately equal to μg/dl. Soil lead levels are reported in parts per million (ppm). (ATSDR, 2007)

Lead poisoning (also known as plumbism, *Colica pictonum*, saturnism, Devon colic, or painter's colic) is a medical condition caused by increased levels of the heavy metal lead in the body (Mgrackeiner, 2011). 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 behaviour disorders. Symptoms include abdominal pain, confusion, headache, anaemia, irritability, and in severe cases seizures, coma, and death (Barbosa *et al*., 2005).

Routes of exposure to lead include contaminated air, water, soil, food and consumer products. Occupational exposure is a common cause of lead poisoning in adults. One of the largest threats to children and animals is lead paint that exists in many homes, especially older ones thus children in older housing with chipping paint are at greater risk (Singh, 2005).

Inhalation of heavy metal particles, even at levels below those considered nontoxic can have serious health effects (Melanie, 2006).Virtually all aspects of animals and human immune system function is compromised by inhalation of heavy metal particulates

(Keogh *et al*., 1992). Toxic metals can increase allergic reactions, genetic mutation, compete with "good" trace metals for binding sites and act as antibiotics killing beneficial bacteria. A lot of the damage caused by toxic metals is from the proliferation of oxidative free radicals (Royce and Rosenberg, 1993).

Acute poisoning is more common in young animals. Prominent Clinical signs are associated with gastrointestinal and nervous systems. In cattle, signs that appear 24-48hrs of exposure include ataxia, blindness, head pressing, bruxism, hyperesthesia and in coordination (www.merckmanuals.com). Sub acute form is seen in sheep or older cattle which is characterized by anorexia, rumen stasis, colic, dullness and transient constipation frequently followed by diarrhea, blindness, head pressing, bruxism, hyperesthesia and in coordination. Chronic poisoning is occasionally seen in cattle that exhibit many features in common with acute or sub acute lead poisoning (www.merckmanuals.com).

In avian species anorexia, ataxia, loss of condition, wing and leg weakness and anaemia are the most notable signs (Kahn *et al*., 2010).

Symptoms in children include irritability, loss of appetite, weight loss, sluggishness and fatigue, abdominal pain, vomiting, constipation and learning difficulties. Symptoms in newborns are mainly learning difficulties and retarded growth. Symptoms in adults include high blood pressure, declines in mental functioning, pain, numbness or tingling of the extremities, muscular weakness, headache, abdominal pain, memory loss, mood disorders, reduced sperm count, abnormal sperm, miscarriage or premature birth in pregnant women.

Risk factors include age, certain hobbies, living in an older home, country of origin, occupation and pregnancy (MFMER, 2010).

1.1 Statement of Problem

Lead poisoning is mostly caused by ingestion and inhalation of lead and lead compounds. Lead damages multiple body system particularly the nervous system. The Centres for Disease Control (CDC) defined childhood lead poisoning as a whole-blood lead concentration equal to or greater than 5µg/dL.

The continued occurrence of occupational lead over exposure and lead poisoning in the United States remains a serious problem despite awareness of its adverse health effects. Lead exposure is debatably the oldest known occupational health hazard (Kevin and Victor, 1998).

In March 2010, an unusually high number of deaths, primarily among children under the age of 5years in Bukkuyum and Anka Local Government Areas (LGAs) of Zamfara State, Northern Nigeria, were reported by Médecins sans Frontières (MSF-Holland) to state health authorities. Further studies on blood samples taken by MSF revealed that the increased mortality was the result of acute lead poisoning, which was determined to be caused by massive environmental contamination from artisanal mining and processing of gold found in lead-rich ore. The grinding of the ore into fine particles resulted in extensive dispersal of lead dust in the villages concerned, including within family compounds. Ingestion and inhalation of the fine lead particles was determined to be the major reason for high blood lead levels in victims' body (Marie, 2011).

It was established that lead poisoning claimed the lives of over 400 children and 30,000 others hospitalised since March 2010 in Zamfara state and was thought to be the world's worst recorded outbreak of lead poisoning (Sule, 2011).

The acceptable limit for lead in water by World Health Organization (WHO) is 10 microgram per liter but it was found to be10 folds more within the affected areas of

Zamfara state. Water in ponds was highly contaminated frequently reaching 200 micrograms per litre. In rural Nigeria it is not uncommon to find animals and humans drinking water from the same source. Thus, there could be an analogy between human exposures to that of domestic animals. In addition to exposure through water, additional exposure could have occurred through inhalation. It has been shown that inhalation or ingesting contaminated soil, dust, air, or water near waste sites, Inhalation of tobacco smoke, eating contaminated food grown on soil containing lead or food covered with lead-containing dust could result in lead toxicity (Habeck, 2010). There is limited information on indirect sources of exposure in this area. However a recent study reported a prevalence rate of 100% was reported in kidney and liver samples from cattle slaughtered in Sokoto Central abattoir (Bala *et al*., 2012).

Lead poisoning is one of the commonest occupational diseases (Kang and Kim, 2010). There are limited studies on the newly emerged problems of mining in Zamfara state in particular and Nigeria in general. However, the dangers of lead poisoning through this relatively new economic activity in the state emphasize the risk to the health of the community.

Socioeconomic factors associated with this problem could be non-availability of pipe-borne water, overcrowding, poverty, negligence, lack of awareness and unemployment.

The risk of lead poisoning to both humans and animals cannot be overemphasized in the area of study particularly as exposure to this substance is from the environment. Animals especially sheep, cattle and dogs often come in contact with lead containing materials and gradually accumulates in the system causing disease, retarded growth and even death (Tuborose.com., 2011). However this is often not considered in diagnosis due to lack of awareness, ignorance and lack of diagnostic materials.

In Zamfara State, the number of animals that died as a result of poisoning cannot be ascertained. The mining activity is undertaken in areas with high livestock populations. The fact that there was no socioeconomic impact assessment, the exact quantum of economic losses is also unknown. Animals that graze freely are likely to come in contact with environmental pollutants and are likely to become exposed simultaneously if not earlier than humans (Federation of Animal Science Societies, 2010). The potential role of animals as early warning of exposure and mortality to humans in this area has not been determined. It is also unknown if certain species of animals are more likely to exhibit signs of poisoning in the area before other species of animals and man.

Diseases which cannot be explained are mostly associated with spiritual causes resulting in decrease production and nervous disorders. Lead poisoning was said to be one of those spiritual ailment.

1.2 Justification

There is dearth of information on lead toxicity or poisoning in livestock in the study area especially in the light break of outbreak in humans, therefore this study may provide information that could lead to gaining better epidemiological picture of the problem in the study area. It will also enable authorities concerned to consider screening animals because of the attendant effects of lead that could invariably affect humans through the food chain.

Food animals are exposed to infectious agents and to a multitude of environmental contaminants that can accumulate in their bodies. Food animals can serve as sentinels of environmental health hazards because identification of infectious or foreign substance in food animals is a signal of potential biologic or chemical contamination of the animal's environment and also of humans that ingest the animal products or that live in the same

area. Suitable animal sentinel specie for risk assessment is one that is exposed to chemical contaminants in habitats that are shared with humans and or are comparable with human habitats and concentrations (National Research Council, 1991). Surveillance using sentinel species included observations of wild animals in field situations as well as experimental animals and observations revealed sentinel species data derived from monitoring programs or serendipitous observations and explored the potential use of such information in human health hazard and risk assessments and for evaluating causes or mechanisms of effect. Although it is unlikely that sentinel species data will be used as the sole determinative factor in evaluating human health concerns, such data can be useful as for additional weight of evidence in a risk assessment, for providing early warning of situations requiring further study, or for monitoring the course of remedial activities (Vander-Schalie *et al*., 1999). Following the outbreak of lead poisoning in Zamfara State much emphasis has been given to human exposure without consideration for animals. These animals if monitored and detected could serve as early warning system to man.

The Zamfara state lead poisoning outbreak resulted in high mortality among children (MSF, 2011). The primary occupation of the Zamfara State populace is crop and livestock production. Livestock farming (particularly sheep and goats) and poultry production are practiced. Animals behave in a similar pattern with children, and these animals are often reared within human shelters and they feed on remnants of food and often share same source of water and air. These animals also graze freely within the community and outside the homes as well as mining sites.

Goats are reported to be more resistant to lead poisoning compared to cattle and have been observed not to become ill under circumstances where companion cattle show signs of disease. Whether this is caused by innate resistance or unwillingness to consume sources of lead is not clear (Guss, 1997). Animals that graze near lead-zinc smelters had

elevated lead level along with depressed blood copper and cobalt levels (Swarup *et al*., 2006). Goats are selective in what they eat at least experimentally, is been documented that goats refused to eat lead based paint or pure lead acetate despite the sweet taste of the latter (Davis *et al*., 1976). Goats been selective browsers and are more resistant to diseases compared to sheep could accumulate lead bearing in mind that susceptibility to lead poisoning varies between individuals goats and may increase with pregnancy (Dollahite *et al*., 1975).

Ducks are dwellers of both terrestrial and aquatic habitats therefore water, soil and air contamination affects them as the same source of water are often used by man and livestock.

Sheep are companion animals found in this area and is been documented that the concentration of heavy metals in the body of grazing sheep reflects the environmental load more accurately and this affects sheep more than any other farm animals (Zantopoulos *et al*., 1999). However, the validity of this statement under free range and feed scarcity settings needs to be validated.

1.3 Aim of the Study

The aim was to increase understanding of the involvement of domestic animals in the outbreak of lead poisoning and environmental contamination due to lead in Anka local government area of Zamfara state.

1.4 Objectives of the Study

The objectives of this study are to determine:

1. The levels of lead in the blood of goats, sheep and ducks in Anka local government area of Zamfara state.

2. The relationship between species, location and management practices on the levels of lead in the blood of the animals.
3. If and which animals could be used as means of early warning of poisoning in humans in the study area.
4. The level of awareness of household members on lead poisoning in humans and animals in the study area.
5. The concentration of lead in the soils of households in the area

CHAPTER TWO

LITERATURE REVIEW

2.0 Lead and its Properties

2.1 Lead

Lead (Pb) is an element with atomic number 82. It has atomic mass 207.2/amu. It is soft with a low melting point of 327.5°C and a boiling point of 1740°C with a high density of 11.34g/cm3 at 293k. It is cubic in shape and blue in colour. Lead was discovered by the ancients and is from the greek word protos which means first. Lead is obtained from galena (Bentor, Yinon, 2012). Lead has 13 isotopes which are all stable.

Lead can be found in all parts of the environment in the air, the soil, the water, and even inside homes. Lead is considered to be a major environmental pollutant and constantly pose health hazard to man and animals. It has been incriminated to be the cause of accidental poisoning in domestic animals more than any other substance (Casas and Sordo, 2006).

There are permissible levels of minerals and trace metals in the body tissues which if exceeded can pose health hazards. Lead in concentration up to 0.25µgmL^{-1} is considered safe and above 0.35µgmL^{-1} is said to be toxic for ruminants and concentration of 1µgmL^{-1} is fatal for animals (Radostits *et al*., 2000; Swarup *et al*., 2006). Subsequently lead in animals tissues can be transferred to humans via the food chain (Nwude *et al*., 2010). Elements are often transferred from animals to man through the food chain. However in some instances it is the non-essential elements that are more importantly transferred through the food chain than the essential elements (Rogival *et al*., 2007).

Animal habitats are continuously being polluted with lead metal as a result of indiscriminate dumping of waste materials on the land and water bodies, illegal mining of ores, use of Tetraethyl lead as an anti-knocking additive to improve the quality of petrol and painting of animal houses (Kamala and Kumar, 1998; Dioka *et al*., 2004). Waste materials may contain heavy metals such as Lead and others which are dangerous to both human and animal health. Ruminants graze freely in the environment and drink water from ponds, streams, rivers and other sources that may be contaminated. Animals graze along the roads which might be contaminated with exhaust from vehicles that contain lead which could be a source of contamination in the environment (Nwude *et al*., 2010). A significant amount of elevated blood lead and cadmium levels was recorded in sheep grazing alongside motor way when compared with control location (Ward and Savage, 1994). These metals bio-accumulate in the organs and tissues of animals causing toxicity.

Human exposure to lead is estimated to account for 143 000 deaths every year and 0.6% of the global burden of disease (Mary, J. and Steephen Margolis, 2012).

2.1.1 Lead poisoning/toxicity

Lead poisoning or lead toxicity is defined as exposure to high levels of lead associated with health effects (Grant, 2009). The amount of lead in the blood and tissues as well as time of exposure determines toxicity (Pearson and Schonfeld, 2003). Blood lead levels indicate the amount of circulating lead within the blood stream and not the amount of lead stored in the body (Blood lead level testing, 2011). Blood lead levels are reported in two units either micrograms per decilitre (µg/dL) or micrograms per 100 grams (µg/100g) of whole blood which are numerically equivalent. Lead poisoning could be acute or chronic with the chronic being more fatal (Trevor *et al*., 2007). Lead poisoning does not only refer to symptomatic effects of lead but also the presence of high lead in an individual's blood stream which is yet to cause symptoms (Guidotti and Ragain, 2007).

Lead poisoning affects all the organs in the body ranging from the nervous, cardiovascular, renal and reproductive systems. Bones, teeth, and immune system are also affected. Hearing loss, tooth decay and cataracts have also been attributed to lead poisoning (White *et al*, 2007; Lanphear *et al*., 2005).

The toxic effects of lead have been documented for over 2000 years in both man and animals (Nriagu, 1983). The first published article in USA on lead poisoning in ducks caused by ingestion of spent shot was over a 100 years ago (Grinnell, 1894). In originating the field of occupational health, Dr. Alice Hamilton did a comprehensive work on the social cost of industrial lead poisoning in the early 1900s (Scherman, 2003). This indicates that work has been done for decades showing the dangers associated with lead in both man and animals.

In India, a study was done which showed the interaction of lead with some essential trace elements in the blood of anaemic children. There was a significant association between elevated blood lead levels and risk of anaemia (Ahmed *et al*., 2007).

In China there was a riot by the people living near the smelting plants because of the high levels of unhealthy lead (60-70%) found in their children. There are over 2000 children living in the Zinc smelter (Watts, 2009). This shows the increased awareness among the people over the dangers associated with lead.

There have been many studies on lead toxicosis in wildlife concentrates mainly in the avian species, most current literature falls within discrete categories such as raptors, loons or waterfowls and discuses a specific route of exposure (Janssen *et al*., 1986; Mateo et al., 2001). In a wide variety of waterfowl species, toxicosis as a result of accidental ingestion of spent lead shot has been reported (Petition for Rule making under the toxic substances control act, 2010).

Similarly it was reported that hunters and their families who admitted to eating birds hunted with lead shots had higher mean blood lead concentrations (128µg/dL) compared to hunters (15µg/dL) not eating hunted birds (Johansen *et al*., 2003). Secondary ingestion of chronically infected liver of a lead poisoned bird could cause poisoning in man (Guitart *et al*., 2002).

A Survey of Lead (Pb) residue in kidney and liver of slaughtered Cattle in Sokoto Central Abattoir was carried out and the lead level in liver was found to be higher than that of the kidney with a prevalence rate of 100% (Bala *et al*., 2011). Also the profile of lead in blood and hair specimens from cattle around isfahan oil industry in Iran was studied, in which the cows closer to the industry showed higher blood and hair lead levels compared to those staying further away (Pourjafar *et al*., 2008). Likewise in Egypt, heavy metals content in meat was analysed in tissues of grazing animals and a high amount of lead and cadmium were recorded (Abou-Arab, 2001). Cattle, sheep and horses are good indicators of pollution on vegetation (Debackere, 1983).

As more and more is learnt about the sub lethal effects of lead poisoning, the threshold levels of public health alarm/significance is continuously changed. By 1968, 80µg/dL of lead in blood was considered a level of concern for the children. Sometime in the 1980s it was reviewed to 50µg/dL and in 1995 it was reduce to 30µg/dL. This was again changed to 10µg/dL (Pokras and Kneeland, 2009). In 2012 this was amended to the current 5µg/dL (WHO, 2012). However there are studies which show that even levels below 2µg/dL can cause significant, long term effects in children (Lanphear *et al*., 2000; Canfield *et al*., 2003).

2.1.2 Merits and demerits of lead

Lead is cheap and has a long tradition of several uses. A lot of the exposure comes from human activities including burning fossil fuels, mining, and manufacturing. Lead and lead compounds have been used in a wide variety of products found in and around the homes, including paint, ceramics, pipes and plumbing materials, solders, gasoline, batteries, ammunition and cosmetics. Despite these uses its harmful effects outweigh the benefit to man and animals.

Lead is one of a limited class of element that can be described as purely toxic. In many decades of research, no nutritional value or positive biological effect has been established to result from lead exposure nor has any case of lead deficiency been noted in medical literature (www.chem.unep.ch/pops/pdf/lead/leadexp.pdf).

Developed countries significantly decrease the traditional use of lead including paints, gasoline and solders because of the health threats to man, animals and the environment. In spite of these, many lead products are readily available. In 1991, lead shot was banned in hunting waterfowls in the United States.

2.2 Sources of Lead Poisoning

Lead poisoning could be obtained from various sources such as:

- Lead dust: Environmental lead such as those found within Industries that are used to process lead acid batteries or lead wires or pipes and metal recycling (Manay *et al.*, 2008)
- Paints and pigments containing lead
- Lead shot
- Ceramics coated with lead

- Kohl, kajal,Al kahal or Surma an ancient cosmetic from the middle East, South Asia and Africa (Guidotti and Ragain, 2007).
- Toys
- Water: lead from atmosphere or soil could end up in ground surface water and posibly in drinking water (Chislom, J. J., 2007; Menkes, J. H., 2006). In the United States 14-20% of lead poisoning is via drinking water (Maus, *et. al*., 2005).
- Jewelleries
- Soil: These could be due to residues from lead gasoline, broken down lead paints, used engine oil, pesticides, contaminated landfills and industries (smelters or foundries) (Woolf *et al.,* 2007). Residual lead has been shown to contribute to lead exposure in the urban areas (Rogival *et al*., 2007).
- Food and consumer products like solders used for cans.
- Occupational exposure in adults during manufacturing of lead containing products like radiation shields, ammunitions, certain surgical equipments, fetal monitors, plumbing, circuit boards, jet engines and ceramic glasses (Patrick, 2006)
- Welders, rubber manufacturers, printing and processing of ore (Dart *et al.,* 2004).
- Combustion of solid waste (Dart *et al.,* 2004).
- Herbal remedies like Indian aguverdic preparation and remedies of Chinese origin (Patrick, 2006).

2.2.1 Route of exposure

The routes of exposure are mainly via ingestion and inhalation.

2.2.2 Pathogenesis of lead poisoning

Lead when ingested or inhaled is absorbed by the body and goes into the blood and soft tissues where eventually it is redistributed to bones. The degree of absorption and

retention is influenced by dietary factors such as calcium or iron levels. In ruminants, particulate lead lodged in the reticulum slowly dissolves and releases significant quantities of lead. Lead has a profound effect on sulfhydryl-containing enzymes, the thiol content of erythrocytes, antioxidant defences, and tissues rich in mitochondria, which is reflected in the clinical syndrome. In addition to the cerebella haemorrhage and oedema associated with capillary damage, lead is also irritating, immunosuppressive, gametotoxic, teratogenic, nephrotoxic and toxic to the hematopoietic system (www.merckmanuals.com).

Lead also substitutes for and compete with calcium thereby disrupting calcium homeostasis and binds with sulfhydyl group to stimulate release of calcium from the mitochondrial membranes. Lead also substitutes for zinc in zinc mediated processes which in turn increase oxidative stress, inhibit anti oxidative enzymes and alters lipid metabolism (Ahmeda and Siddiqui, 2007).

In the blood stream, lead interferes with haemoglobin function, limiting the amount of oxygen that is carried to various organs. Lead interferes with heme biosynthesis and interrupts the formation of new red blood cells in the bone marrow resulting in anaemia (Ahmeda and Siddiqui, 2007).

Lead can displace biologically important chemicals like calcium, zinc and magnesium which interfere with a variety of the body's chemical reactions. Lead toxicity affects all the systems in the body but the most effects are seen in the nervous, digestive and circulatory systems. Nerves requires calcium to transmit impulse and lead interferes with functions dependent upon nerve conduction like learning, blood pressure, reaction time and muscle contraction (Pokras and Kneeland, 2009).

2.2.3 Symptoms/clinical signs

Acute poisoning is more common in young animals. Prominent clinical signs are associated with gastrointestinal and nervous systems. In cattle, signs that appear 24-48hrs after exposure include ataxia, blindness, head pressing, bruxism, hyperesthesia and in coordination. Sub-acute form is seen in sheep or older cattle characterized by anorexia, rumen stasis, colic, dullness and transient constipation frequently followed by diarrhoea, blindness, head pressing, bruxism, hyperesthesia and in coordination. Chronic poisoning is occasionally seen in cattle that has many features in common with acute or sub acute lead poisoning.

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 the acidity of the fore stomachs (Blakley and Brockman, 1976). Goats are reported to be more resistant to lead poisoning compared to cattle and have been observed not to become ill under circumstances where companion cattle show signs of disease; whether this is caused by innate resistance or unwillingness to consume sources of lead is not clear (Guss, 1997).

In avian specie, anorexia, ataxia, loss of condition, wing and leg weakness and anaemia are the most notable signs (Kahn *et al*., 2010).

Symptoms in children include irritability, loss of appetite, weight loss, sluggishness and fatigue, abdominal pain, vomiting, constipation and learning difficulties. Symptoms in newborns are mainly learning difficulties and retarded growth. Symptoms in adults include high blood pressure, declines in mental functioning, pain, numbness or tingling of the extremities, muscular weakness, headache, abdominal pain, memory loss, mood disorders, reduced sperm count, abnormal sperm, miscarriage or premature birth in pregnant women.

2.2.4 Diagnosis of lead poisoning

Lead poisoning can be diagnosed by Radiography. Radiograph can detect metal density and location in the body. Radio dense lines are seen in the metaphysis of long bones, Lead containing foreign materials like paint chips may also be seen in the gastrointestinal tract (Kosnet M. J., 2007). However the limitation of Radiography is its inability to determine the type of metal, hence further investigation is required. (Myck *et al., 2005)*.

Toxicological analysis can be used to analyse liver and kidney samples. Lead isotopes could give the origin of lead.

A very good and important diagnosis is history and clinical signs. Blood could be tested for lead(pb) using methods such as Lead care II analyser or decrease level of some enzymes which lead interferes with like zinc protoporphyrin or ALAD. (Myck *et al*., 2005). Basophylic stripping of Red Blood Cell, microcytosis and Hypochromasia are also suggestive of lead poisoning (Patrick, 2006).

2.2.5 Blood analysis with lead care II

Lead care II is a portable device used for testing blood for lead. Lead Care System II was developed as a more robust kit, with less risk of technical error. The Lead Care II Blood Lead Analyzer and test kit provide a measurement of the amount of lead in a fresh whole blood sample. The Lead Care II Blood Lead Analyzer is intended for in vitro (external) use only. It is for testing lead only. The test kit components are designed for use only with the Lead Care II Blood Lead Analyzer.

The Lead Care II Analyzer tests the blood lead level and reports it on the screen in three minutes. Results are shown in micrograms (μg) of lead (Pb) per decilitre (dL) of blood. Lead care II analyzer detects the Blood Lead Level (BLL).

The Lead Care II Blood Lead Analyzer uses an electrochemical process that detects and measures the level of lead in the blood sample. Mixing the blood with the Lead Care II treatment reagent automatically releases the lead from the blood and by the time the test is complete, the blood lead level appears on the screen. The test result remains on the screen until another test is carried out or the analyzer becomes inactive.

Lead Care System II includes a measuring device and requires control analyses with each new kit rather than with every test, as was needed for the original LCS kit. The analyser comes with 48 Blood Lead Sensors, 48 Lead Care II Treatment Reagent Tubes, 50 Lead Care II heparinised Capillary Tubes and Plungers, 50 Lead Care II Droppers, 1 Calibration Button, Lead Care II Package Insert, Lead Care Labels and Worksheets

2.3 Treatment of Lead Poisoning

The treatment for lead toxicity is based on the following principles:

First of all identify the source of poisoning and remove the patient from the source. Depending on the extent of poisoning, hospitalisation and the use of chelating agent becomes necessary. Chelating agents are organic molecules which bind to the metal at two or more points. Chelating agents are used to produce stable compounds with relatively less toxicity and also to enhance the excretion of metals. Examples of chelating agents include succinyl transferase.

Bowel irrigation, Cathartics, Endoscopy, or Surgical intervention to eliminate the source of exposure if found within the gut, gastrointestinal tract and prevent further exposure is also esssential. Surgical intervention may be necessary in cases of Lead-containing bullets and shrapnel if they are in or close to fluid-filled or synovial spaces as there is threat for further exposure (Kosnett, 2006).

If lead encephalopathy is present, anticonvulsants may be given to control seizures, and treatments to control swelling of the brain such as corticosteroids and mannitol (Kosnett, 2007).

Treatment of organic lead poisoning involves removing the lead compound from the skin, preventing further exposure, treating seizures, and possibly chelation therapy for people with high blood lead concentrations (Kosnett, 2007).

2.4 Prevention/Control of Lead Toxicity

Lead poisoning is preventable if exposure to lead is prevented (Rossi, 2008). Prevention could be by individuals or measures taken by families to avoid lead exposure. These measures could be in different ways but a few are mentioned here;

Increasing the frequency of hand washing

Intake of calcium and iron

Discouraging kids from putting their hands to their mouths

Eliminating lead-containing objects such as blinds and jewellery in the house (Payne, 2008)

Houses with lead pipes or plumbing solder should be replaced (Payne, 2008). Less permanent but cheaper methods are available and these include running water in the morning to flush out the most contaminated water or adjusting the water's chemistry to prevent corrosion of pipes (Payne, 2008).

Lead testing kits are commercially available for detecting the presence of lead in the household (Salvato *et.al*, 2008)

Cold water only from the tap should be used for drinking, cooking, and making baby formula. Hot water is more likely to contain higher amounts of lead compared to cold water. Bearing in mind most of the lead in household usually comes from plumbing in the house and not from the local water supply (National Environmental Public Health Tracking Network, 2010).

Preventive medicine goes a long way in the sense of identifying and intervening with high-risk individuals and animals. Screening programs/methods to check individuals and animals from time to time especially those leaving near lead related industries. (Myck, 2005). Educating the affected population of the dangers associated with lead poisoning and the need to identify the source of poisoning. Public health or Public enlightenment helps in reducing the risk at the population level (Guidotti and Ragain, 2007).

Government should regulate the amount of lead disposed/released into the soil, water, air, household dust and products (Lanphear *et. al.,* 2005). In some places, remediation programs exist to decrease lead load when it is found to be high, for example in drinking water and soil (Payne, 2008). Recommendations by health care professionals to lower childhood exposures. Regulations exist to limit the amount of lead in paint; for example, a 1978 law in the US restricted the lead in paint for residences, furniture, and toys to 0.06% or less (Dart *et al.,* 2007). In October 2008, the US Environmental Protection Agency reduced the allowable lead level by a factor of ten to 0.15 micrograms per cubic meter of air, giving states five years to comply with the standards (Chisamera, 2008). The European Union's Restriction of Hazardous Substances Directive limits amounts of lead and other toxic substances in electronics and electrical equipment (Jonathan, P. S and Duckstand M. J., 2008). As a more radical solution, entire towns located near former lead mines have been "closed" by the government, and the population resettled elsewhere, as was the case with Picher, Oklahoma in 2009 **().**

2.5 Soil

Soil is the surface of the earth which is not water, air, or rock. Soil is often defined based on interest and need. The interest for soil is primarily for agricultural or engineering purposes and this often reflects in the definitions, classification systems, and research on soil. Soil is a natural body consisting of layers that are primarily composed of minerals, mixed with at least some organic matter, which differ from their parent materials in their texture, structure, consistency, colour, chemical, biological and other characteristics. It is the loose covering of fine rock particles that covers the surface of the earth (Birkerland, 1999).

Soil has been incriminated to be a major source of lead poisoning (Lynda et al., 2011). The accepted soil range lead level is between 50 and 400 parts per million. Mining, smelting, and refining activities have resulted in substantial increase in lead levels in the environment, especially near mining and smelting sites. Residual lead in soil contributes to lead exposure in urban areas (Guidotti and Ragain, 2007).

Lead content in soil could be due to broken-down lead paint, residues from lead-containing gasoline or pesticides used previously, contaminated landfills, or nearby industries such as foundries or smelters (Woolf *et al.,* 2007). Leaded soil is less of a problem in countries that no longer have leaded gasoline though it remains prevalent, thus raising concerns about the safety of urban agriculture (Murphy, 2009).

Food grown in contaminated soil can present a lead hazard, eating vegetables or animals grazing on such soil can also pose danger to both man and animals (Yu, 2005).

2.6 Soil Analysis with a Handheld XRF Analyzer

Handheld X-ray fluorescence analyzer is a good instrument for elemental soil analysis. The handheld X-ray fluorescence analyzer is an instrument for environmental screening

which is fast and reliable. It allows the testing of the elemental composition of soil or sludge for all 8 Resource Conservation Recovery Act metals (RCRA) (Ag, As, Ba, Cd, Cr, Hg, Pb, Se), 12 of the 13 Priority pollutants (Ag, As, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Se, Tl, Zn, Be), and even light elements (Mg, Al, Si, P, S).

Soil Analysis via XRF (x-ray fluorescence) is a widely used and accepted method for site investigation, assessment, remediation and monitoring of heavy metals.

2.7 Animals as Sentinels

Animal sentinels or sentinel species are animals used to detect risk to humans by providing advanced warning of danger. Some animals could serve as sentinels because they are more susceptible or have greater exposure to a particular hazard than humans in the same environment (National Research Council, 1991)

Animal sentinels for disease surveillance could be individual animal or animal population that exhibit similar characteristics with the population of interest. It is important to note that the animal used as sentinel must be susceptible to the disease of interest.

Sentinels should be just as likely to be affected by the disease as the target species. Increased susceptibility gives an advantage for early detection which in turn allows for rapid implementation of disease control and prevention strategies to avoid or minimise spread of disease in the target species.

The animal used as sentinel should be able to generate measurable clinical or immunologic disease response. Clinical signs of disease should be recognisable in the sentinel but do not necessarily need to be identical to the clinical signs of the disease in the target species. The immunologic response should be rapid and easily measured (Peter et. al, 2006).

Animals could be incidental or experimental sentinels for disease. Incidental animal sentinels are those animals that share a common environment with their owners e.g companion animals like pets. Incidental animal sentinels are not purposely placed in a situation where disease may occur specifically for the purpose of detection. An example is animals that use same water as their owners could serve as incidental sentinels for water borne illnesses. So also animals sharing a common household with their owners could serve as incidental sentinels for household environmental contamination.

Companion animals are effective sentinels as they share a common environment with their owners. In intimate contact with their owners, companion animals often eat similar food, share the same room, bed and even serve as travel companions making their disease risk similar to that of their owners. Thus the health of the companion animals often mirrors the health of or suggests the health risk of the owner or humans in the same house hold (Peggy, 2009).

Lead exposure in animals and humans is well known and the detrimental clinical effects have been documented for decades. Identical biological mechanism of toxicity in both man and animals including companion animals had allowed for the successful use of dogs as animals for toxicological studies of lead exposure (Stowe et. al., 1973).

The use of companion animals as sentinels for environmental lead contamination has also been successful in determining human health risk for plumbism; for instance both cats and dogs suffering from plumbism have lead to the discovery and successful treatment of non clinical lead toxicity in children living in the same household (Maflay *et al*., 2008).

Environmental lead exposure beyond the house hold environment can also be determined through serological surveillance of blood lead concentrations in both cats and dogs. A

study of pets and their owners living near a secondary lead smelter in Illinois found that when a dog or cat in a household had a high blood lead concentration, there was a significant increase in the likelihood of finding a person in the same household with a high blood concentration (Berny *et al*., 1995).

In Uruguay, simzilar findings were reported following investigation of the "La Teja" neighbourhood were people settled into an area of abandoned lead handling factories while blood lead concentrations where significantly higher in dogs than in children. Correlation between high blood lead concentrations in dogs and children was evident (Maflay *et al*., 2008).

In Nigeria several works has been done on heavy metals.

CHAPTER THREE

MATERIALS AND METHODS

3.0 Description of Study Area

Zamfara State is situated in the north western part of Nigeria and occupies 39,762 km2. Its capital is Gusau. It shares borders with Kebbi, Kaduna, Sokoto, Niger and Katsina states. It also shares an international boundary with Niger Republic to the north. The State has 14 Local Government Areas (LGAs), 62 districts and 147 political wards. Its major towns are Gusau, Kauran-Namoda, Anka, Talatan-mafara and Zugu. The total population of Zamfara State is estimated to be 3,582,912. The predominant occupation is farming and rearing of livestock, with over 80 percent of its people engaged in various forms of agriculture. Major agricultural produce are millet, guinea-corn, maize, rice, groundnuts, cotton, tobacco and beans. Some industrial infrastructure exists within the State for the processing of these raw materials into finished products.

3.1 Pre sampling Activities

3.1.1 Advocacy visit

A letter of introduction was obtained from Ministry of Livestock, Zamfara state which was copied to Ministry of health, Ministry of Environment and Anka Emirate Council. The Anka Emirate Council was visited to inform them on the proposed work intended to be carried out as well as seek their consent. The villages intended to be visited were identified as the villages reported by MSF to be involved in Lead poisoning outbreak which are Abare, Bagegga, Dareta and Sunke.

The questionnaires were pretested in Abare Community.

3.2 Sampling Procedure

A kinsman was sent alongside the team to inform the Village Heads as well as look at the communities which informed the choice of systematic random sampling.

Small ruminants (Sheep and Goats) and Ducks were chosen because they are the companion animals found in this locality. Hardly do you come across a house without one of these animals.

The sample size was calculated using a formula by Thrushfield (2005).

$$n = \frac{z^2 Pq}{d^2}$$

Where: q = 1- p

n = sample size

p = prevalence rate (50%)

z = desired confidence = 1. 96

d = allowable error = 0.05

40% of the total sample (384.16) was derived.

40% * 384.16 = 538

533 animals were sampled in order to minimise error and optimally use the available test kit.

3.3 Sampling Design

The four villages (Abare, Bagegga, Dareta and Sunke) reported to be poisoned were sampled. The Village Head's house was the first household to be sampled; subsequently

sampling was done in every 4th house from the starting point. A maximum of 5 and a minimum of 3 animals were sampled from each house hold depending on the population of the animals and consent of the owners.

3.4 Data Collection

3.4.1 Collection of blood sample

A minimum of 2 sheep and a maximum of 3 goats were sampled from each house visited. The animals were properly restrained and 5mls of blood was drawn from the jugular vein of sheep and goats and 2mls from the wing vein of ducks which was immediately transferred into an EDTA bottle. The sample was immediately labelled for identification. The samples were transported on ice pack to the laboratory for analysis.

3.5 Questionnaire Survey

A closed question questionnaire was used to evaluate human and animal involvement in lead poisoning as well as determine the awareness levels.

Questionnaires were administered to households by the Researcher based on the consent of the occupants. The head of the family or a representative of the family answered the questions from the questionnaire. The village head's house was visited first where the first questionnaire was administered. Afterwards the questionnaires were administered in accordance with blood sample collection.

3.6 Soil Sampling

The soil sampling was based on a systematic random sampling in accordance with questionnaire survey. The soil at the entrance of the house is tested with the hand held field portable florescence field X-ray as directed by the manufacturer.

3.7 Analysis of Samples

The Lead care II test kit was used to test the presence and level of lead in blood. The Lead care II blood lead analyser was unpackaged and arranged carefully as described by the manufacturer (ESA Magellan biosciences, Cliawaived.com, San Diego). A calibration button (sensor) was removed and the Lead care II analyser was switched on and the calibration button was used to calibrate the analyser.

Before the analysis of blood was carried out it is expected a quality control test be carried out which was done with a quality control reagent level 1 and level 2 controls that came with the test kit.

3.7.1 Quality control analysis

A treatment reagent tube was picked and labelled “level 1”. The cap of the control reagent level one was removed and a capillary tube was inserted and 50µl of blood was drawn and inserted into the treatment reagent tube labelled “level 1”. A plunger was used to help empty the contents of the capillary tube properly into the treatment reagent tube after which the plunger was discarded. The mixture of the reagent and control was thoroughly mixed until it gave a red colour.

A sensor was inserted into the Lead care II analyser and the analyser sounded a beep. A drop of the red mixture was dropped on the sensor with the aid of a transfer dropper which was left for 3minutes. The result appeared on the screen which fell within the

range of the given control result as in the kit indicating the analyser and test kit are in good condition.

The same method was applied for level 2 control and it also fell within the given range which indicated the analysis for blood could be carried.

3.7.2 Blood analysis

The Lead care II Blood analyser was used to analyse blood samples collected. The blood samples where brought out of the refrigerator and properly arranged on a rack which was allowed to stand at room temperature until it equilibrates with the room temperature.

Analyses of test samples were conducted after the analysis and calibration of the Analyzer with the controls. The analysis of the samples was done when the analyser displayed on the screen "prepare sample". A treatment reagent tube was picked and labelled to correspond with the labelling on the blood sample bottle. A capillary tube was inserted into the sample bottle, 50µl of blood was drained and gauze was used to wipe excess blood on the capillary tube. The cap of the labelled treatment reagent tube that corresponds with the blood sample drawn was removed and the capillary tube was inserted into the treatment reagent tube then a plunger was used to empty the blood sample into the labelled treatment reagent tube. The cap of the treatment reagent tube was replaced and thoroughly mixed until a brown colouration was formed. Both the capillary tube and plunger were discarded as they are not reusable.

A sensor probe was then inserted into the Lead care II analyser in preparation for sample loading, as soon as the Analyzer is ready a message appeared on the screen "Add a drop of sample to X sensor". A transfer dropper is then used to take a drop of the brown mixed treatment reagent and blood sample to the sensor inserted into the analyser. The analyser then beeped and after 3 minutes it beeped again indicating the analysis was completed

and the result was displayed on the screen in µg/dL. The results were recorded on the Lead care II worksheet provided alongside the kit. The analyser is only able to detect blood lead between 3.3µg/dL to 65µg/dL. Blood lead levels below 3.3µg/dL appear as "LOW" and above 65µg/dL appears as "HIGH". The sensor was removed and discarded for each sample. This method was replicated for all the other 532 blood samples.

3.7.3 Analysis of soil samples

Dried soil samples were tested from the entrance of the houses questionnaires were administered and measured using the handheld X-ray Florescence (XRF) analyzer.

The XRF hand-held analyzer was placed on the soil with the glass side facing the soil. The XRF analyzer when switched on is allowed to stabilize which takes about 180 seconds before pretesting. The soil sample was pretested for another 2 minutes. After the pretesting the test soil is placed in contact with the XRF probe which simultaneously detects other metals. The equipment is designed to analyse 56 different types of heavy metals in less than a minute. The value obtained for lead level was then recorded in parts per million (ppm) as displayed on the XRF machine screen as it was the only value needed.

The same procedure was repeated for all the 89 samples tested.

3.7.4 Analysis of questionnaires

Questionnaire data obtained were entered into Microsoft Excel, filtered and sorted out for consistency. Statistical analysis was done by a statistical package for social sciences (SPSS) version 16.0 for descriptive statistics of responses. Pearson correlation coefficient was used to assess relationship between soil levels and blood lead levels in each community.

CHAPTER FOUR

RESULTS

4.0 Results of Blood Lead Assay

The levels of lead in the blood of goat, sheep and ducks reared within households in Abare, Bagegga, Dareta and Sunke villages of Anka local government area was evaluated using the Lead care II analyser. Likewise experience of household members regarding the involvement and responses of various animal species during the period of human outbreak was also studied using a structured questionnaire. Soil samples were also analysed using an XRF hand analyser.

4.1 Blood Lead Levels in Goats, Sheep and Ducks

A total of 533 animals were tested for lead out of which 296 (55.7%) were goats, 219 (41.2%) sheep and 18(3%) from ducks. Out of these, 355(67%) had blood lead above 5µg/dL and 176 (33.1%) was below 5µg/dL (Table 4.2). The following are precise record obtained from the villages sampled;

4.1.1 Goats

Following the 296 goats sampled, 80 of them had blood lead level less than 5µg/dL, 188 fell within the range of 5 - 24µg/dL, 17 within 25 - 44µg/dL and 11were within the range of 45-64µg/dL (Table 4.1).

4.1.2 Sheep

Out of the 219 sheep sampled, 96 had blood lead level below 5µg/dL, 94 had blood lead level within the range of 5 - 24µg/dL, 14 within the range of 25 - 44µg/dL, 13 within the range of 45 -64µg/dL and 2 were above 65µg/dL (Table 4.1).

4.1.3 Ducks

Of the 16 ducks sampled, 11 had blood lead level above 65µg/dL, 2 fell within the range of 45 - 64µg/dL and 2 within 25 - 44µg/dL. A duck had blood level within the range of 5 - 24 µg/dL (Table 4.1).

4.2 Relationship between Species, Location, Management and Levels of Lead in Animals

The management system was the same in all the four (4) villages sampled which was semi intensive method of rearing livestock (Table: 4.4 and 4.5). Blood samples from ducks across the locations recorded the highest (above 65µg/dL, 45 -64µg/dL and 24 - 44µg/dL) amount of blood lead levels. Samples from Bagegga were observed to have higher amount of lead in their blood in both sheep and goats compared to other villages. In all the villages (Bagegga, Abare, Sunke and Dareta) goats had higher lead level compared to sheep. (Fig: 4.1)

The people of these communities are located more than 500m to 1km away from the mining sites and over 75% of the populace have suffered lead poisoning leaving some with permanent disability (Table 4.2 and 4.3). Both man and animals suffered lead poisoning in these communities (Fig: 4.2). Animals are reared semi-intensively (Table 4.4) signifying during grazing they may be exposed to lead. (Fig: 4.3).

4.3 Potential Animal Species Suitable for Early Warning Sign in Lead Poisoning

Questionnaire responses obtained from the 90 households surveyed indicated a total of 2,617 animals were available in the households consisting of 939 goats, 493 chickens, 491 sheep, 217 cattle, 193 ducks, 147 guinea fowl, 101 pigeons, 20 cats, 12 dogs and 4 donkeys. These animal species were commonly reared within the household in all the communities sampled. Sunke had the highest animal population followed by Abare, then Bagegga and least in Dareta (Table 4.9). Most (91.1%) of the respondents rear animals semi intensively while a few (2.2%) had no animals. Goat was the most widely distributed with about 27 households harbouring them followed by sheep, chickens, ducks and cattle. Goats were to 19 houses and chickens to 21 houses. Cattles and guinea fowls were found in a few houses. Dogs and Pigeon were found in a number of houses (Table: 4.9).

The highest morbidity was recorded in Sheep, Ducks, Chicken and Goats according to the seriousness of this disease observed by the respondents. Ducks recorded the earliest mortality with signs of seizures followed by sheep. Mortalities were also recorded in Sheep, Chicken, Goats, Guinea fowl and a few cattle (Table: 4:10).

Ducks had the highest levels of blood lead followed by goats and sheep respectively. (Fig: 4.1).In the process of administering the questionnaire it was revealed that ducks and sheep started dying before children. About 4- 5 months later MSF diagnosed the cause of death as Lead poisoning.

4.4 Results of Assessment of Awareness about Lead Poisoning Amongst Household Members in the Study Area

A total of 90 respondents were surveyed using the questionnaire in this study. Out of which 64 (71.1%) were males and 26 (28.9%) females. The study participants were

mostly (72.2%) within the age range of 20- 59 with a few (15.6%) less than 20years and some (11.1%) above 60 years. From the study about (24.4%) of the respondents had no any form of formal education, 17.8% had a primary education, 11.1% had secondary education, 10% had tertiary education and 3.3% adult education. About 33.3% of them are engaged in Quranic education.

The main source of water of these communities are borehole and well water (44.4%), 39% rely solely on well water and 14.4% depend on borehole while 2.3% have other combinations. Both man and animals rely on the same source of water. Animals are reared mostly (91.1%) semi-intensively while a few are intensively managed (4.4%), 4.4% do not keep animals.

The major (43.3%) occupation of the study participants is farming, a few (5.6%) combine farming and livestock management, 7.8% are involved in mining, 7.8% rely solely on livestock production and 28.9% are into others such as tailoring and business.

Lead poisoning was diagnosed in these communities by Medicines san Frontiers (MSF) in 2010 when over 400 children died. About 53.3% had lead poisoning diagnosed amongst family members, 16.7% amongst neighbours, 21.1% from awareness campaigns and 9% claimed they were unaware. Man (74%) and animals (67.8%) had suffered lead toxicity in these communities. Inhalation is believed to be the major (41.1%) source of exposure with a few (11.1%) believing the route of exposure is via ingestion and some (24.4%) said both ingestion and inhalation. 11.1% said is just from God and 12.2% don't know.

In 2012, 19% recorded abnormal behaviour and 38% death among their animals. 11.1% also recorded death in their families. Most (91.1%) of the study participants stay more than 1km away from the mining site though at one point of time either family members or

neighbours were involved in mining activity. It was clear that 59% of the respondents used to process gold ore at home and 4.4% still do. 37% claimed they never did such activities in their homes.

A summary of the villages and their findings is stated below;

4.4.1 Abare

About 29.2% of the respondents were females and 70.8% were males within the age range of 20- 59(62.5%). 12.5% of the respondents were above 60 and 25% were below 20 (Table: 4.4). About 41.7% of the respondent had no form of education, 4.2% had completed secondary school, and 29.2% are attending Quranic School. 16.7% had completed their primary education and 8.3% are engaged in adult education (Table: 4.6).

The main source of water is borehole and well. 75% of the respondents depended on both borehole and well. 25% depended only on well water (Table: 4.7). Animals are reared majorly semi intensively (83.3%) and a few (12.5%) intensively (Table: 4.5). Most (45.8%) of the respondents were farmers, 8.3% are engaged in livestock production and 8.3% a miners. 29.2% engaged in other businesses (Table: 4.7).

Lead poisoning was heard of when it was diagnosed in homes by MSF. Up to 54.2% knew about the disease when it was diagnosed in either their homes or at neighbours. 29.2% knew through awareness campaigns and 16.7% claimed they are unaware (Fig: 4.4).

Both man and animals suffered lead poisoning, 62.5% experienced lead poisoning in their homes and 75% believe it is via ingestion and inhalation. 20.8% believe lead toxicity is from God and 4.5% say they don't know (Fig: 4.3).

In 2012, a few (12.5%) noticed unusual behaviour in their animals, 62.5% noticed unusual mortality in their animals while 29.2% also recorded mortality amongst humans. However 54.2% said they are not sure both the behaviour and death seen were associated with lead poisoning.

About 40.6% of the respondents are engaged in mining activities and 37.5% used to process materials at home while 12.5% currently process materials at home. It was clearly seen that the respondents stayed far away (over 1kilometer) from the mining sites (Table: 4.3).

4.4.2 Bagegga

The respondents were mostly (84.6%) males with a few (15.4%) females. 76.9% of the respondents fell within the age group of 20 - 59. 15.4% are less than 20years old and 7.6% were above 60 (Table: 4.5). About 81% of the respondents had a formal education, 15.4% had only Quranic education and 3.8% had no any form of education (Table: 4.6).

The major occupations of the respondents were farming and livestock production (65.4%). 7.7% are miners, 3.8% were involved in mining, farming and livestock production. 23.1% are involved in other trades (Table: 4.7).

61.5% of the respondents rely on borehole and well as their source of water. 38.5% rely on well water only (Table: 4.8), both man and animals rely on same source of water. About 88.5% of the animals are reared semi-intensively and 3.3% intensively (Table: 4.4).

Lead poisoning was experienced in almost every home as 53.8% of the respondents knew about lead poisoning via family and neighbours been diagnosed by MSF, 34.6% knew through awareness campaigns and 11.5% claimed they are not aware (Fig: 4.4).76.9%

belief the route of exposure is through ingestion and inhalation. 19.2% said they don't know about lead poisoning (Fig: 4.3).

About 81% have experienced lead poisoning in man and 54% had similar experience in animals, 7.7% called upon animal health workers to handle the case without success, 7.7% ignored the case and about 34.6% allowed the animals to die.

In 2012, 23.1% noticed unusual behaviour in their animals and 26.9% recorded unusual mortality. 15.4% believe the abnormal behaviour and death recorded was as a result of lead poisoning and 26.9% are not sure if the problem is associated with lead poisoning or not.

Interestingly 46.2% of the respondents admitted to processing gold ore at home while 53.2% claimed they have never done such. 80.8% of the respondents live more than 1km to the mining site and 19.2% stay close (between 500m to 1kilometer) (Table: 4.3).

4.4.3 Dareta

The age group of the respondents was mainly (68.5%) 20-59 with a few (21.1%) above 60 and some (10.5%) less than 20years old. Most (79%) were males with few (21%) females (Table: 4.5). 62.5% had Quranic knowledge, 20.8% had finished primary education and 8.3% had secondary education, 8.3% had no any education whatsoever (Table: 4.5) and 84.2% of the respondents were farmers, livestock owners or miners or a combination of the 2 or 3 and 15.8% were engaged in other forms of trade/business (Table: 4.7).

Majority (63.2%) of the people depend on well water as their source of water and 31.6% depend on both well and borehole, 5.3% depend on other combinations. Man and animals rely on same source of water though some animals also drink from the ponds (Table: 4.8).

Lead poisoning has been recorded in almost (89.5%) every home therefore it is no longer new in this community and 10.5% of the respondents said they were unaware of lead poisoning

Similarly 68.4% had experienced lead poisoning in their animals and 31.6% had no such experience in animals. 5.3% of the respondents called upon animal health workers to handle the problem with no success and 5.3% ignored the animals. 78.9% watched their animals die with no help as nothing could be done.

15.8% knew about lead poisoning through awareness campaigns, 79% was via family and neighbours diagnosed and 5.3% were not aware (Fig: 4.4). 73.7% believe the route of exposure of lead poisoning is via ingestion and inhalation while 26.3% said they don't know (Fig: 4.3).

In 2012, 31.6% of the respondents noticed abnormal behaviours in their animals with 21.1% recording unusual deaths and believing it is associated with lead poisoning. 47.4% are not sure if both the abnormal behaviours and deaths were associated with lead poisoning.5.3% belief it was God's doing and 26.4% said they don't know.

It is interesting to know 78.9% of the respondents used to process gold ore at home and 5.3% still do.84.2% of the respondents stay more than 1km away from the mining site, 10.5% stay between 500m to a kilometre away from the mining site (Table: 4.3).

4.4.4 Sunke

Interestingly 52.4% of the respondents were females with 47.6% males, 80.95% fell within the age group of 20-59 years old, 9.5% were above 60years old and 9.5% were less than 20years old. In this part of the community education is not something of value as only 14.3% had completed their secondary school and 43% were in various Quranic schools. 43% have no form of education (Table: 4.6).

Farming, livestock production and mining is the major occupation found within this community. 47.6% of the population are engaged in other forms of trade (Table: 4.7). the major (52.4%) source of water is borehole and well, 33.3% rely on only well water while 14.3% depended solely on borehole (Table: 4.8).

Lead poisoning is no longer news in these community as 17.2% believe it is like any other trial from God and 82.8% believe it is through ingestion or inhalation(Fig: 4.3).10.3% of the populace knew through awareness programs and 86.2% knew through family or neighbours been diagnosed however 3.4% claimed they are unaware (Fig 4.4).

Similarly 14% had experienced such in their animals though 75.7% did nothing as the animals died and 6.9% called upon animal health workers for medication. 58.6% of the respondents diagnosed lead poisoning based on the clinical signs exhibited by the animals which was similar to that of man. As at 2012, 19.04% had their experience in less than a year while 81% is more than a year. In 2012, 10.3% noticed unusual behaviours in their animals and 41.4% experienced unusual mortality, 51.7% were so sure it was associated with lead poisoning and 27.6% are not sure.

Mining is an occupation which 17.2% still depend totally on as a source of income and 41.2% of the households are also engaged in one form of the mining activity or the other. 65.5% of the respondents admitted to processing materials at home and 6.9% still do. All the respondents stay more than 1km away from the mining site (Table: 4.3).

4.5 Soil Lead levels in Households of Study Area

A total of 90 soil samples were analysed out of which 47% were found to be contaminated with lead, 30% not contaminated and 23.3% were undetermined (Table: 4.11).

Table 4.1: Blood Lead Levels in Various Species within the Ranges

	Number of animals (%)			
Lead Level	Sheep	Goats	Ducks	Total
Less than 5	96 (18.1%)	80 (15.1%)	0 (0%)	176 (33.1%)
5 - 24µg/dL	94 (17.7%)	188(35.4%)	1(0.1%)	284(53.3%)
25 - 44µg/dL	14(2.6%)	17(3.2%)	2(0.4%)	34(6.2%)
45 - 64µg/dL	13(2.4%)	11(2.1%)	2(0.4%)	26(4.9%)
Above 65µg/dL	2(0.4%)	0(0%)	11(2.1%)	13(2.4%)
TOTAL	219 (41.2%)	296 (55.7%)	16 (3%)	533 (100%)

Table 4.2: Total Number of Animals Sampled Showing Percentage Poisoned and Not Poisoned

	SPECIE			
STATUS	GOATS	SHEEP	DUCKS	**TOTAL**
POISONED	216(72.9%)	123(56.16%)	16(100%)	**355**
NOT POISONED	80(27.02%)	96(43.85%)	0(0%)	**178**
TOTAL	**296(55.7%)**	**219(41.24%)**	**16(3.01%)**	**533**

Table 4.3: Relationship between Distances of Respondent Location from Mining Site to Residence

Distance of respondents house from mining site	Experience with lead poisoning		
	Yes	No	Total
Less than 500m	1(100%)	0(0%)	**1(1%)**
500m - 1km	6(86%)	1(14.3%)	**7(8%)**
More than 1km	67(67%)	15(18.3%)	**82 (91%)**
Total	**74**	**16**	**90**

Table 4:4: Demographic and Management Practices amongst Households

Variables	Distribution	
Sex	Males	64
	Females	26
Age	< 20	14
	20 - 59	65
	> 60	10
Management Practices	Semi intensive	82
	Intensive	4

Table 4.5: Sex, Age Group and Management Practice of Correspondents According to the Villages

Location	Sex		Age group			Management systems	
	Males	Females	<20	20 - 59	>60	Semi intensive	Intensive
Abare	17	7	6	15	3	21	3
Bagegga	22	4	4	20	1	23	1
Dareta	15	4	2	12	4	18	0
Sunke	10	11	2	18	2	20	0
Total	**64**	**26**	**14**	**65**	**10**	**82**	**4**

Table 4.6: Educational Qualifications of Respondents

	Level of Education					
Location	Quranic School	Primary School	Tertiary Institute	Secondary School	Adult Education	None
Abare	10	5	0	1	2	10
Bagegga	23	13	1	10	0	1
Dareta	15	5	0	2	0	2
Sunke	12	2	0	3	0	9

Table 4.7: Distribution of Respondents by Occupation

Location	Occupation								**Total**
	Mining	Farming	Live Stock	Politician	Civil Servant	Local Orthopaedic	Unemployed	Others	
Abare	4	13	2	0	0	0	0	5	**24**
Bagegga	5	14	3	1	2	0	1	0	**26**
Dareta	2	16	6	0	0	1	1	0	**19**
Sunke	3	6	3	0	0	0	1	8	**21**
Total	14	49	14	1	2	1	3	13	**90**

Table 4.8: Respondents Source of Water

Source Of Water				
Well	Borehole	Borehole/Well	Other combinations	Total
35	13	40	2	**90**

Table 4.9: Population of Animals within the Sampled Households in Abare, Bagegga, Dareta, and Sunke Villages in Anka L.G.A

Specie / Villages	Dareta	Baggage	Sunke	Abare	**Total**
Cattle	57	39	87	34	**217**
Sheep	61	107	164	159	**491**
Goats	196	138	277	328	**939**
Dogs	5	4	3	0	**12**
Cats	5	14	0	1	**20**
Ducks	17	13	127	36	**193**
Chicken	65	137	141	150	**493**
G Fowl	34	14	65	34	**147**
Other Poultry (Pigeons)	3	42	20	36	**101**
Horses/Donkeys	3	0	0	1	**4**
Total	**446**	**508**	**884**	**779**	**2617**

Table 4.10: Pattern of Mortality amongst Animal Households in Abare, Bagegga, Dareta and Sunke

Animals	Population	Morbidity	Mortality
Cattle	Some	Few	Few
Sheep	Most	Most	Most
Goats	Most	Some	Some
Horse/Donkeys	Few	None	Few
Dogs	Few	None	None
Cats	Few	None	None
Chicken	Most	Most	Most
G/fowl	Some	Some	Few
Ducks	Most	All	All
Other poultry	Few	Few	None

Table 4.11: Soil Lead Levels of the Four (4) Communities Sampled.

Location	Contaminated	Not Contaminated	Un - Determined	**Total**
Abare	8 (33.3%)	13 (54.2%)	3 (12.5%)	**24**
Bagegga	21 (80.8%)	3 (11.5%)	2 (7.8%)	**26**
Dareta	4 (21.9%)	6 (31.6%)	9 (47.4%)	**19**
Sunke	9 (42.9%)	5 (23.8%)	7 (33.3%)	**21**
Total	**27**	**42**	**21**	**90**

Contaminated = Lead Levels Above 400ppm

Not Contaminated = Lead Levels Below 400ppm

Undetermined = No lead in soil

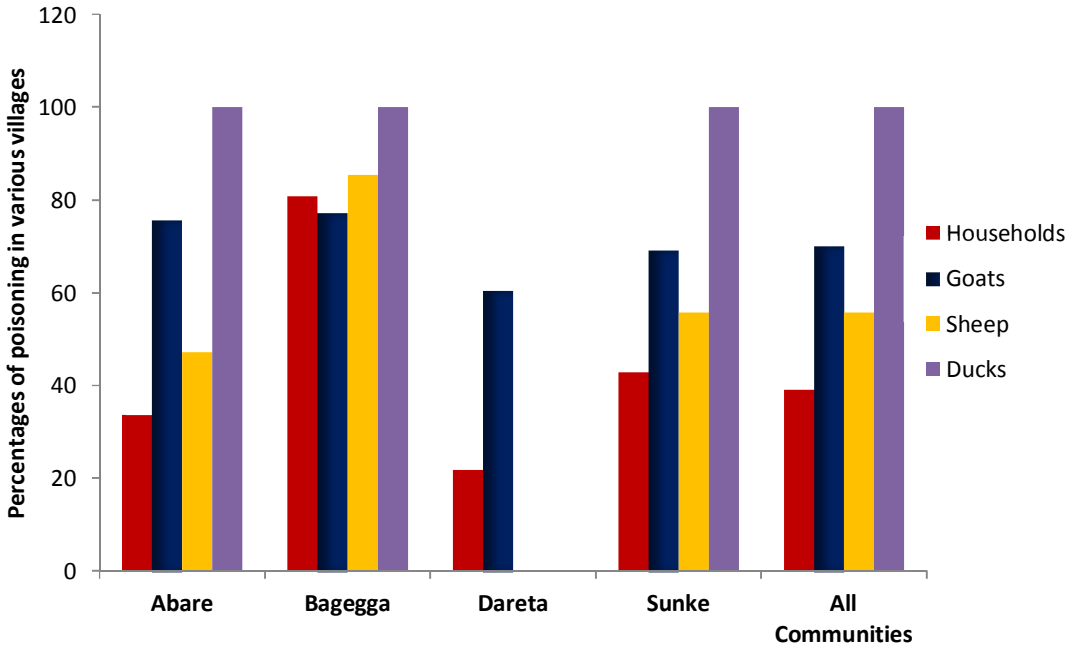


Figure 4.1: Households Showing the Percentage of Blood Lead Level in the Various Villages

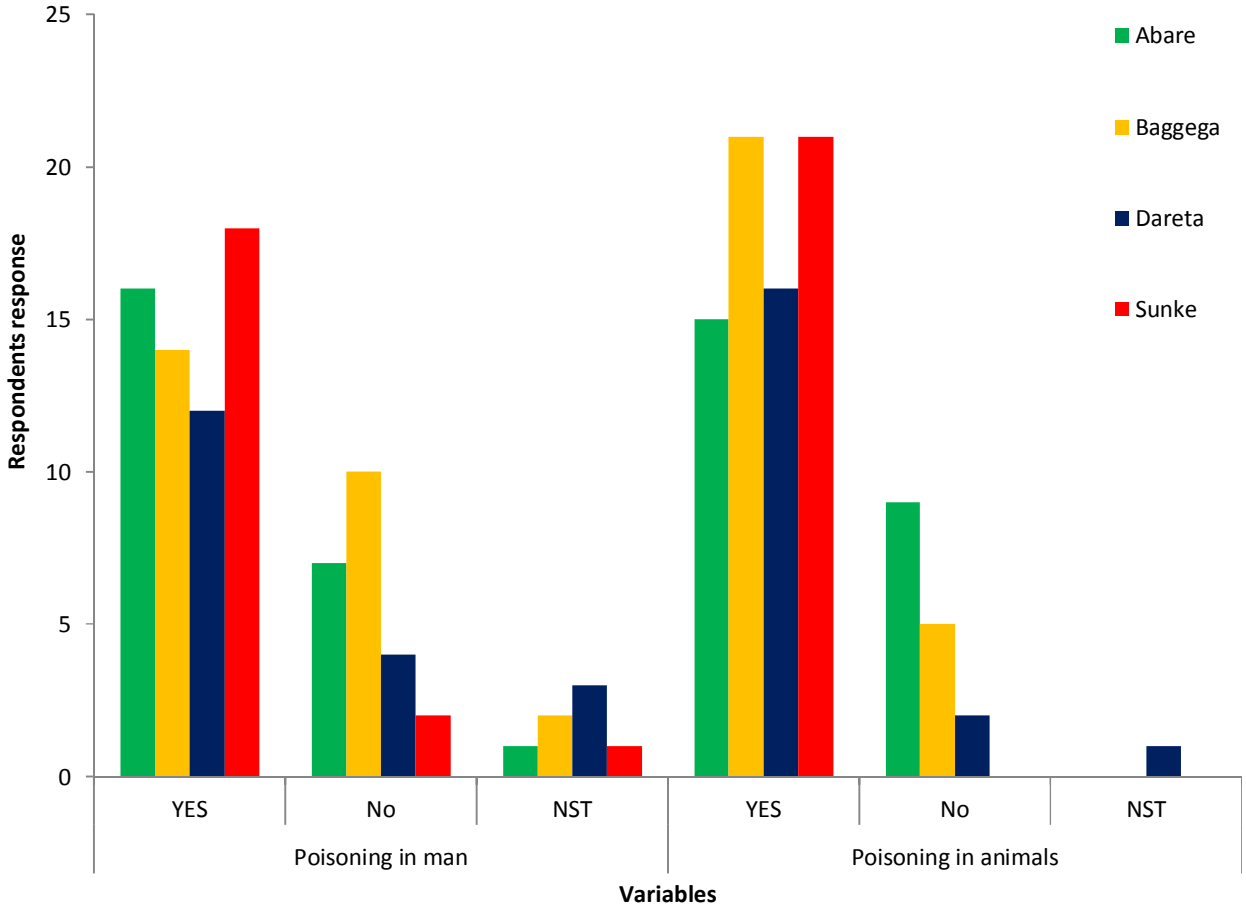


Figure 4.2: Relationship between Lead Poisoning in Man and Animals

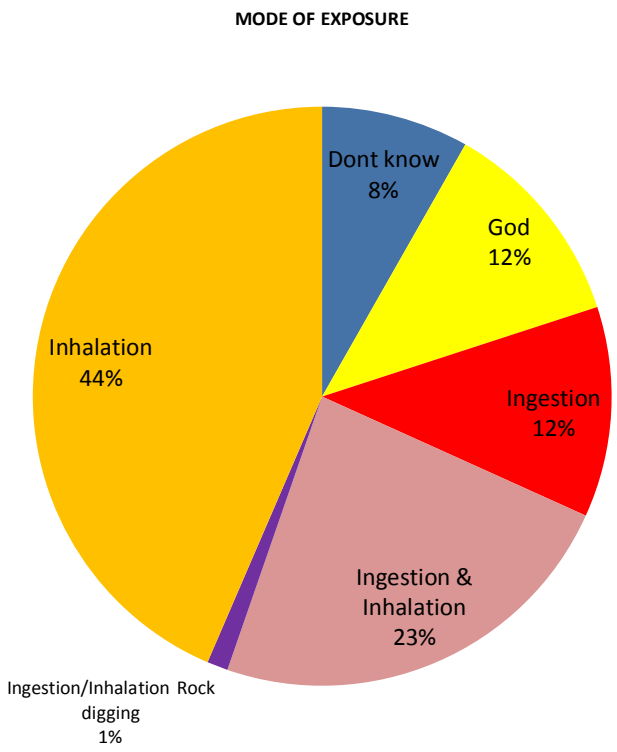


Fig 4.3: Pie chart showing Route of Exposure to Lead Poisoning Based on the Respondents Knowledge

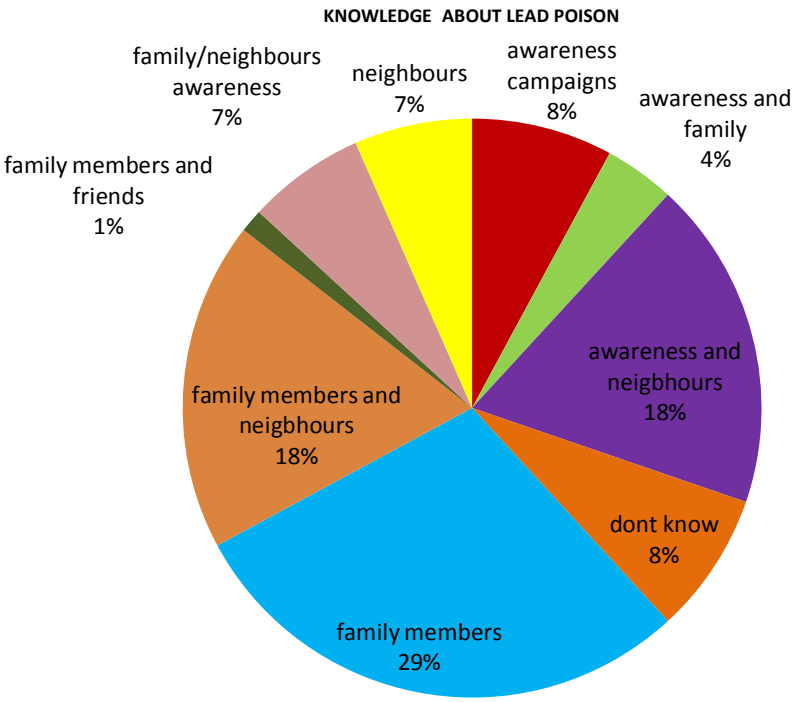


Fig 4.4: Knowledge of Respondents about Lead Poisoning

CHAPTER FIVE

DISCUSSIONS

5.0 Survey of Blood Lead Level in Anka L.G.A

Several studies have been carried out on lead poisoning and quite a number of works has been done since the high mortality recorded in Zamfara state in children 2010 due to lead toxicity (MSF, 2012) however there has been little or no effort with regard to the companion animals within the locality.

The highest population of animals was found in Sunke, Abare, Bagegga followed by Dareta. Goats were found to be more across the villages followed by sheep, chicken, ducks and cattle. This could explain why the highest sample was from goats followed by sheep and chickens. In this study about 68% of animals tested had high blood lead level defined as greater than 5µg/dL. This is an indication that these animals are poisoned. Generally goats had higher blood lead levels compared to sheep, which could be explained on the basis that goats are selective browsers (). Interviews conducted during the study revealed that sheep sampled at the time of investigation were newly introduced as most of the old stocks were dead from suspected lead poisoning or slaughtered for consumption. From the study it could be deduced that sheep succumb to lead poisoning faster than goats. Moreover, cattle and horses are also regarded as good indicators of environmental pollution on vegetation (Debacker, 1983).

Bagegga recorded the highest blood lead level among the locations, though in Sunke ducks had a higher blood lead level. In Bagegga no duck was found. The high levels recorded in ducks could be because ducks are both terrestrial and aquatic habitats. Ducks usually move in groups and mingle more with others unlike sheep and goats that are tied by the limb or confined within a section of the house.

Ducks recorded the highest blood lead level followed by goats then sheep. Goats and sheep are in some respects similar to companion animals. They eat left over human food, often share same beddings and sometimes serve as travel companions thereby making their disease risk factors similar to that of their owners (Peggy, 2009: Federation of Animal Science Societies, 2010). Companion animals are effective sentinels as they share common environment with their owners. In this locality it is not uncommon to find sheep and goats eating remnants of what the owners ate, drink water from the same source as the owner as well as share rooms and some beddings. Old men and women as well as children are fond of their sheep and goats and often consider them as part of the family rather than as food animals.

In all the villages sampled, goats and sheep are reared semi intensively whereby they are kept at the compounds and go out to graze thereby coming in contact with air borne infections and environmental contaminants.

Undiagnosed plumbism has been treated in children based on diagnosis in cats and dogs (Maflay *et al*., 2008). Similarly Berny *et al.* (2005) reported seeing cats and dogs with high blood lead level concentration increase the chances of the habitats living within the same house hold to have high blood lead concentration. In this part of the Northern Nigeria there are few pet dogs or cats. Therefore it is expedient to exploit available animals which are chickens, ducks, sheep and goats as sentinels. Ducks were reported to have been found dead in all the villages before children started dying. Some months later MSF diagnosed the cause of death in children as lead poisoning (Environmental Emergency Response Mission Zamfara State, 2010).

Sheep, goats and duck are incidental animal sentinels as they share a common environment with their owners bearing in mind they are just as likely to be affected by the

disease as the target species. Increased susceptibility gives an added advantage for early detection which allows for rapid implementation of disease control and prevention strategies to minimise or avoid spread of disease in the target species (National Research Council, 1991). Ducks in these communities exhibited abnormal behaviours like salivation, convulsion and hyperesthesia which were thought to be associated with spiritual issues, followed by similar observations as sheep and goats.

Small ruminants and ducks may be justified as companion animals within these localities, since almost every home keeps one or both of these animal species. It has been established that identical biological mechanisms of toxicity exist in both man and animals including companion animals which has allowed for successful use of dogs for toxicological studies of lead exposure (Stowe *et al*., 1973).

Food animal's especially small ruminants are found to have high blood lead which is redistributed to various organs in their body. These animals are slaughtered and consumed by man and the lead is passed across the food chain. Secondary ingestion of chronically affected liver of a lead poisoned bird can cause poisoning in man (Guitart *et al.,* 2002).

Toxicosis due to accidental ingestion of lead shots has been reported in literatures (Pain, 1992). A prevalence of 100% was found in kidney and livers of slaughtered cattle in Sokoto State (Bala *et al*., 2011). Similarly heavy metal contents in tissues of grazing animals in Egypt was analysed and high amounts of lead and cadmium were recorded (Abou- Arab, 2001).

Most of the respondents were males within the age group of 20-59 years. More than half of the population had no formal education. This may be responsible for the difficulty experienced in relating with the respondents. People within this terrain have never left

their villages and hardly do non indigenes come until when gold was found in the communities. The gold mining activities are responsible for lead poisoning outbreak.

Lead poisoning came to lime light when it was diagnosed in almost every home, leaving behind permanent disabilities such as blindness, reproductive disabilities as well as growth deformities and death among children, men, women and animals. Some animals such as chickens, ducks, pigeons and guinea fowl were decimated within one and half year. The fear of restocking the livestock population by some individuals is still high due to the tragic losses experienced.

The people of Abare, Bagegga, Dareta and Sunke villages believe that Lead poisoning occurs through ingestion and inhalation, though some still believe it is spiritual while a few still do not know what is really happening because their animals started dying and shortly after their children. The confusion is not farfetched from the fact that their ancestors have been mining before them.

In 2012, unusual deaths were still recorded in Abare, Sunke, Bagegga and Dareta. Abnormal human behaviours have also been recorded in Dareta, Bagegga, Abare and Sunke respectively.

Mining activities took place at the mine sites by able men and women, but processing of ores mining materials was done at home or close to homes. Women ground the materials at home with the pestle and mortar they used for usual domestic activities and sieved with their sievers. Women, children, animals and neighbours are all exposed to lead dust in the process through inhalation. Animals could be seen licking the pestle and mortar or even eating the content of the mortar. Children and animals are often seen playing with soil or ingest the soil containing lead particles. Vegetables and crops is grown in contaminated soil poses a danger to both man and animals that graze or feed on it (Murphy, 2009).

Animals and children also come in contact with the miners clothes, mining sites when they hang and dump them after work.

Streams which were used to wash processed ores are now being deserted however children and animals cannot be stopped from visiting such places.

More than half of the soil samples were contaminated. Bagegga recorded the highest contamination of soil followed by Sunke.

Remediation had taken place in Dareta and some part of Abare and selected houses in Sunke. Bagegga was yet to be remediated and parts of Abare and Sunke due to insufficient funds by the government.

Blood lead levels in Bagegga was higher followed by Sunke, Abare and Dareta, thus there is an analogy between blood lead and soil lead bearing in mind that soil has been incriminated to be the major source of lead poisoning (Lynda *et al.*, 2011).

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATION

6.0 Summary

A total of five hundred and thirty one (531) blood samples consisting of (219(41.2%) from sheep, 296(55.7%) from goat and 16(3%) from ducks were tested for lead using Lead care II analyser. Questionnaires were administered to household members completed through interviews conducted.

90 soil samples were analysed using the handheld portable XRF machine, out of which 47% were contaminated.

Of all the animals tested 359(67.79%) were contaminated as blood lead was above 5µg/dL and 171(32.2%) had levels below 5µg/dL. Ducks had the highest blood lead level followed by goats and sheep. Sheep and goats from Bagegga had the highest blood lead levels so also was the soil from Bagegga followed by Sunke, Abare and Dareta respectively.

Inhabitants of this locality usually do not leave their villages and have little or no form of formal education. Awareness of lead poisoning followed diagnoses of the conditions in homes or neighbourhood.

Sheep, goats and ducks are sort of companion animals in these localities and hardly is there a home without them. Animals were said to have exhibited abnormal behaviours followed by death before children were reported to exhibit similar signs. These animals may therefore be suitable indicators of environmental pollution and may be used as early warning signs of lead poisoning to protect the public.

Lead poisoning has been experienced in both man and animals in Anka local government Area of Zamfara State. These left behind social and economic impacts which cannot be quantified materially and socially.

6.1 Conclusion

High blood lead levels were found in sheep, goats and ducks. Ducks had the highest blood lead levels followed by goats and then sheep. Most of the ducks sampled were from Sunke. In these note it is therefore concluded that these animals could be used as sentinels as they somehow reflect the health status of their owners and these animals came down with lead toxicity earlier than humans.

A correlation between the blood lead levels and Soil levels was observed. The communities had highly contaminated soil which in turn reflects the blood lead levels in the animals sampled. Both man and animals have experienced lead toxicity in these localities. Based on the observations and findings made it is only wise to use these companion animals as early warning signs to improve public health.

Residents of this community were aware of lead poisoning and almost every home had reported this condition. However ignorance or rather limited access to the urban area as well as formal education makes them handicapped.

6.2 Recommendations

On the basis of the results obtained from this work, it is recommended that;

- Screening of animals around mining sites should be done on a regular basis to detect early problems.
- Screening for lead poisoning should be included into regular routine diagnosis around places where mining and related activities takes place
- Veterinarians and Medical doctors should be deployed to those communities to handle the cases
- Immediate remediation of the affected communities should be done
- Surveillance of this type of work needs to be done from time to time.
- Alternative source of livelihood should be provided so that these communities can change their source of revenue.
- Infrastructures such as road, schools and boreholes should be made available so that the standard of living of the villagers will be improved
- Animals diagnosed with lead poisoning should be treated instead of allowed to die or slaughtered for consumption
- The Government of Zamfara State needs to step up the rural development by improving the lives of this people and Laws should be made to punish those who violate.
- Veterinary extension services should be undertaken which will aid identify such problems.
- There is need for both veterinarians and human medics to work together and collaborate towards achieving one health.

- The people within this community need to be educated on the dangers associated with consumption of sick animals.
- Awareness on the need to report cases of dying animals to veterinarians need to be emphasized

6.3 Limitations

- Transportation was a big challenge due to difficult terrains and bad road connecting the L.G.A to the villages as well as a river separating 2 of the villages which was unanticipated
- Rain fall
- Ducks were decimated as of time of visitation which limited number of samples
- People of this locality had no formal education and were unexposed which made it difficult to deal with them thereby prolonging the stipulated time.
- Prolonged and Protracted negotiation with Ministry of Health and Environment on the use of their laboratory and equipment.
- The Lead care II analyser can detect only blood lead level between 3.3µg/dL to 65µg/dL.

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APPENDICES

Appendix I: Questionnaire

Department of Veterinary Public Health and Preventive Medicine

Faculty of Veterinary Medicine,

Ahmadu Bello University, Zaria.

This questionnaire is part of a research study on the problem of lead poisoning in humans and animals in Anka Local Government Area of Zamfara State. Please read each question carefully and then select what you feel is the best answer. Where the response of your choice is not indicated please indicate your response within the spaces provided. Responding to the full questionnaire should only take you a few minutes. Information provided shall remain confidential and will be used solely for academic purposes.

Thank you

Nabilah Dalhatu

DEMOGRAPHIC INFORMATION

1) Location

   a). Ward/Village ._____.

   b). Local Government Area._____.

   c). Address.

2) Gender
   a) Male
   b) Female

3) Age
   a) < 20
   b) 21-40
   c) 40-60
   d) Above 60

4) Educational background
   a) Primary School
   b) Secondary School
   c) Tertiary
   d) Islamic School
   e) None
   f) Others (Specify)

5) Population of household/compound

a) Number of adults	
b) Number of adolescents	
c) Number of children	
d) Total	

6) Primary occupation
   a) Mining
   b) Farming
   c) Rearing of livestock
   d) Hunting
   e) Unemployed
   f) Others specify

7) Source of water
a) Borehole
b) Tap water
c) Streams
d) Wells
e) Rivers
f) Others

ANIMAL PRODUCTION

8) Population and types of animals within the household/compound

Animals	**Number**
Cattle	
Sheep	
Goats	
Dogs and cats	
Chickens	
Ducks	
Other poultry	

Other livestock	
Total number of animals	

9) What is the method of rearing animals?
   a) Intensive
   b) Semi intensive
   c) Extensive

10) What is the nature of your experience with lead poisoning?
   a) I suffered it myself
   b) Members of my family suffered it
   c) Some people in my neighborhood suffered it
   d) Some people in my family died
   e) Some people in my neighborhood died
   f) Nobody I know

11) How long was this experience suffered by you/member of your family/neighborhood and when did it occur?
a) Less than 3months
b) 3-6 months
c) 7-9 months
d) 10months- 1year
e) 1year and above

12) Within this period have you experienced any unusual illness/death among animals?
   a) Yes
   b) No

13) What is the nature of the illness observed?

Animals	**Illness**	**Observed**	**Not observed**
Cattle	Blindness, Salivation, Muscle tremor, Spastic twitching of eyelids, Ataxia, Convulsions, Jaw Champing, Bruxism		
Sheep	Anxiety, hysterical barking, jaw champing, salivation, blindness, ataxia, muscle spasms, opisthotonos, and convulsions may develop		
Goats			

Dogs and Cats	Anorexia, Colic, Emesis, and diarrhea or constipation. CNS depression		
Chickens	Anorexia, Ataxia, loss of condition, Wing and leg weakness, and Anemia		
Ducks			
Other Poultry			
Other Livestock	Chronic syndrome characterized by weight loss, depression, weakness, colic, diarrhea, laryngeal or pharyngeal paralysis (roaring), and dysphagia that frequently results in aspiration pneumonia.		

14) How was the manifestation of these problems?

Animals	**Adults**	**Young**	**Both**
Cattle			
Sheep			
Goats			
Dogs and cats			
Chickens			
Ducks			
Other Poultry			
Other Livestock			

15) What proportion of these animals died?

Animals	**Few of them**	**Some of them**	**Most of them**	**All of them**
Cattle				

Sheep				
Goats				
Dogs and cats				
Chickens				
Ducks				
Other Poultry				
Other livestock				

16) How did you know it was lead poisoning?
a) Hospital Diagnosis
b) Self diagnosis
c) Others (Specify)

17) Did you notice any abnormal behavior in your animals (specify)
a) When
b) How

18) How was the problem handled?
a) Veterinarian
b) Herbalist
c) Ignored
d) Died

19) Did you loss any animal?
a) How?
b) How Many?
c) Any additional Information?

20) How often do they come down with lead poisoning
    a) Often
    b) Very often
    c) Rarely
    d) Not at all

21) What is the morbidity/mortality in your family within this year?
a) 1-2
b) 3-4
c) 5-6
d) Above 6
e) None

22) Did you notice any unusual behavior in your animals within this year?

23) Any unusual mortality in your animals?

24) Was the mortality noticed before or after you heard about lead poisoning?

25) Do you believe lead poisoning exist? (reasons for answer)

26) How did you hear about lead poisoning?
a) Diagnosed in my family
b) Awareness Program
c) Diagnosed in my neighborhood
d) Through a Friend/Family/Colleague

27) What do you think is the source of lead exposure?
a) Ingestion
b) Inhalation
c) Others (specify)

MINING ACTIVITIES

1) How close are you to a mining site?
   a) Very close less than 500m
   b) Close 500m to 1 km
   c) Further away >1km

2) What is the nature of engagement of the member(s) of the household in mining activity?
   a) I am engaged or was engaged
   b) Some members of the household are engaged
   c) Some members of a neighboring household are engaged
   d) Nobody engaged

3) If engaged (a-c above) do the person(s) engaged process or handle mined material at home?
   a) Yes sometimes ago
   b) Yes currently
   c) Not at all

4) How often do you carry out these mining activities?
   a) All the time
   b) Most of the time
   c) Some of the time
   d) Not at all

Appendix II

Pack of Lead Care II Testing Reagents



Appendix III

Complete Work Area of the Analysis Comprising of the Lead Care Analyser, Treatment Reagents, Capillary Tubes, Gauze, Dispenser, Treatment Controls and Worksheet.



Appendix IV

The Calibrator Button Labelled 1204A



Appendix V

The Control Reagents (Blue and White Cap)



APPENDIX VI

Blood Sample Been Transferred from the EDTA Bottle into the Treatment Reagent Tube with a Capillary Tube



Appendix VII

Blood Sample about to be transferred into the Treatment Reagent Tube with a Capillary Tube



Appendix VIII

Treatment Reagent Tube with Blood Thoroughly Mixed Together



Appendix IX:

Brown Mixture of Blood and Reagent



Appendix X

A Dropper used to pick the Mixed Reagent and Blood to be Dropped onto the Sensor Slot



Appendix XI

Sensor Slot Inserted into the Analyser



Appendix XII

Analysis of Blood Sample Taking Place



Appendix XIII

Result of Analysis Displayed on the Screen



Appendix XIIII

Hand Held Portable X-ray used for Soil Analysis

