ASSESSMENT OF HEAVY METAL~~S~~ AND AGROCHEMICAL RESIDUES IN RUMINANT FEEDS AND MILK: A CASE OF PERI-URBAN AREAS IN MWANZA CITY

BY

THERESIA MARCEL NGOLY

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ABSTRACT

A study was conducted in peri-urban areas of Mwanza city to determine the levels of Lead (Pb), Chromium (Cr), Cadmium (Cd) and Mercury (Hg) in soils, forages, concentrate feeds, water and cow's milk. In addition, the levels of agrochemical residues (DDT, Lindane, Thiodan and Dieldrin) were assessed in forages. The soil and forage samples from the road sides had the highest concentration of Pb, Cr, Hg and Cd, followed by samples from the industrial areas and lastly the crop fields. The concentration of Lead in soils ranged from 10.72 mg/kg in crop fields to 18.6 mg/kg in areas near roads. In forages, Pb content was highest in *Commelina spp* (312.5 mg/kg). The amount of Pb in rice straws was 7.2 mg/kg, in concentrates it ranged from 1.95 in maize bran to 5.76 mg/kg in fish meal. Water samples had Pb content of 0.60 mg/kg in wet season and 0.13 mg/kg in dry season. The amount of Pb in milk was 0.028 mg /kg. Chromium concentration ranged from 5.12 to 10.32 mg/kg in soils from crop fields and road sides, respectively. In forages the highest Cr content was found in *Cucumig ssp* (11.26 mg/kg). In rice straws, Cr content was 19.53 mg/kg. In concentrates Cr content was highest in fish meal (2.8 mg/kg). Higher levels of Pb and Cr were observed in samples collected in the dry season than in the wet season. Among the agro-chemicals analyzed, only DDT was detected in rice straws (2.61 to 232.07 ppm) and *Cynodon dactylon* (25.37 to 50.20 ppm). It is concluded that Pb and Cr are the predominant heavy metals found in the areas near roads and industries in Mwanza peri-urban areas. The DDT in crop residues is higher than in forages found within the same vicinity.

DECLARATION

I, Theresia Ngoly, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work and that has never been nor concurrently being submitted for a higher degree awards in any other University.

22/9/2009

Theresia Ngoly
(M.Sc Candidate)

Date

The above declaration is confirmed

30/9/2009

Dr. S. W. Chenyambuga
(Supervisor)

Date

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DEDICATION

This work is dedicated to my father, the late Mr. Ambrosi Minde, my mother Rose Ambrosi who laid the basis of my education and the uncountable sacrifices for upbringing and educating me. May the Almighty God bless them.

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LIST OF ABBREVIATIONS AND ACRONYMS

mg/l - Microgram per Liter

µg - Microgram

µg/dl - Microgram/deciliter

ACD - Allergic Contact Dermatitis

Ag - Silver

AS - Arsenic

Cd - Cadmium

CNS - Central Nervous System

Co - Cobalt

Cr - Chromium

Cr (iii) - Trivalent chromium

Cu - Copper

DDT - Dichlorophenyl-Trichloroacetic Acid

ECD - Electron Capture Detector

EDTA - Ethylenediamine Tetra- Acetic –Acid

ETAC - Ethyl Acetate

g - gram

g/l - grams / liter

Hb - Haemoglobin

HCH - Hexachlorocyclohexene

HCl - Hydrochloric Acid

Hg - Mercury

ICP - Induced Coupled Plasma

ILO - International Labour Organization

Km^2 - Square kilometer

LDLO - Lowest Lethal Dose

LVEMP - Lake Victoria Environmental Management Project

Mn - Manganese

mg/kg - Milligrams/kilogram

mg/m^3 - Milligrams per cubic meter

$Na_2 SO_4$ - Sodium Sulphate

Ni - Nickel

OC - Organochloride

Pb - Lead

PEC - Permissible Exposure Limit

p.p.m - parts per million

SAS - Statistical Analysis System

SEAMIC - Southern and Eastern African Mineral Centre

SH - Sulfhydryl group

SPSS - Statistical Package for Social Science

TEL - Tetraethyl lead

TML - Tetramethly Lead

TPRI - Tanzania Pesticide Research Institute

WFP - World Food Program

WHO - World Health Organization

Zn - Zinc

CHAPTER ONE

1.0 INTRODUCTION

Heavy metals are metal or metalloid materials with a density greater than four or five g/l. Heavy metals are found in many places especially in areas where industries and factories are predominant. Common examples of such metals are Lead (Pb), Cadmium (Cd), Mercury (Hg), and Chromium (Cr). These metals are detrimental to both livestock and humans. Generally all heavy metals could be toxic to animals if consumed beyond certain limits. These heavy metals enter food chain of grazing animals through contamination of pastures and water. The contamination of pastures can occur on soil that are naturally rich in metals or following anthropogenic events such as prolonged use of sewage sludge and nuclear reactor accident (Madyiwa *et al.*, 2006). There are various sources of heavy metals ranging from polluted waters to rocks, industrial work places, construction sites, garages, mining areas and motor vehicles (Lentech, 2007).

In peri-urban areas of Mwanza city, there are factories and industries which emit pollutants that contain heavy metals such as lead, cadmium, chromium and mercury. Furthermore, roadways and automobiles are the other sources of heavy metals in Mwanza. Zinc, copper, and lead are three of the most common heavy metals released from road travel. Cattle kept in Mwanza peri-urban areas are reared either partially or fully on natural pastures growing around industrial areas and roadsides. These pastures are vulnerable to exposure to unknown levels of chemicals and heavy metals, both individual elements and their compounds, from industrial effluents (McCallum, 2007) and car emissions.

Grazing animals also might be exposed to agrochemicals used in crop fields to control pests and diseases. These chemicals have detrimental effects to the environment, and cause ill effects to both humans and livestock (Batchelder, 2001). Farmers in Mwanza peri-urban areas have for a long time been using Thiodan, Dieldrin and Lindane for pest and disease control on cotton, paddy and maize. Studies have shown that prolonged use of these agrochemicals can lead to their accumulation in soils and their uptake by pastures (Batchelder, 2001). This, in turn, can directly affect animals and indirectly human health. Agro-chemicals, for example, insecticides, fungicides and chemical fertilizers have been implicated in respiratory diseases, hearing defects and numerous skin conditions in humans (Julio, 2004). There is scarcity of information on the levels of agrochemicals in forages and animal products in Tanzania. In view of the potential for transmission of these chemicals via animal products into human food chain, it is imperative that some preliminary assessment be made to quantify the extent of agrochemical residues in animal products, soils, forages and water.

1.1 Problem Statement and Justification

Mwanza peri-urban areas are places where a number of factories are found and extensive agricultural activities are carried out, including livestock keeping. The factories discharge effluents which contain pollutants such as cadmium, chromium, lead and mercury which toxify the soils. Hence, the livestock grazed in areas around the factories are exposed to risks of ingesting toxic levels of heavy metals. Reports by Lake Victoria Environment management project, (LVEMP) show that, the Lake is heavily polluted by domestic wastes, industrial discharge and agricultural run-off (Matsamura, 2004). Furthermore, car emissions progressively increase the concentrations of heavy metals in the soils and pastures (Luilo and Othman, 2003). These chemicals may enter the food chain and affect human health. Animals grazing around highways and industrial sites develop increased heavy metal concentration in their blood due to uptake from both pastures and soils (Parkpian *et al.*, 2003). However, the extent of heavy metal and agrochemical pollution on communal grazing lands is not well documented in Tanzania, particularly in Mwanza peri-urban areas. It is also not known to what extent these heavy metals occur in common animal products obtained from the livestock grazing in the polluted areas. Therefore, this study was carried out to assess and quantify the degree of heavy metal and agrochemical pollution in soils and pastures, and the consequence of this pollution in livestock products.

1.2 Objectives

1.2.1 General objective

The overall objective of this study was to determine the levels of heavy metals and agrochemical residues in soils, forages and animal products (milk) in peri-urban areas of Mwanza City.

1.2.2 Specific objectives

(i) To determine the household socio-economic activities and cattle management practices of farmers in peri-urban areas of Mwanza City.

(ii) To quantify the levels of heavy metals (Cadmium, Chromium, Lead and Mercury) in soils, pastures, crop residues and water sources which were prone to exposure to industrial wastes in peri-urban areas of Mwanza city.

(iii) To compare the levels of heavy metals in soils, forages and water in different seasons (wet and dry).

(iv) To quantify the levels of agro-chemicals (DDT, Thiodan, Dieldrin and Lindane) in crop residues and forages in peri-urban areas of Mwanza city.

(v) To determine the amount of heavy metals in milk of cows that had been grazing on the polluted pastures of peri urban areas of Mwanza city.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Heavy Metals

Heavy metals refer to elements that are metals or metalloids (elements that have both metal and non metal characteristics). These exist as natural components of the earth's crust and cannot be degraded or destroyed (Goyer, 1996). They have densities above five (5) g/cm^3. Examples of heavy metals are Chromium (Cr), Arsenic (As), Cadmium (Cd), Lead (Pb), Mercury (Hg), Zinc (Zn), Copper (Cu), Cobalt (Co), Nickel (Ni), Silver (Ag) and Manganese (Mn). Since they cannot be degraded/destroyed, they are persistent in all parts of the environment. Human activities influence their natural geological and biological redistribution through pollution of air, water and soil (Hawkes, 1997).

2.1.1 Sources of heavy metals

Heavy metals originate from mines, smelters, foundries, coal burning, power plants, diffuse sources such as combustion by-products and vehicle emissions (United Nations, 1998). Some plants like beans may contain zinc, copper and cadmium as a result of pollution. Some plants can accumulate more cadmium and copper than others (Dermizen and Ahmet, 2006).

Heavy metals enter the body of animals via food, water and air. When they are taken up by the body, they are stored at a faster rate than they are broken down (Lentech, 2007). The pathway for toxic metals is normally through the soil as soil contaminant, through the ground water as water pollutant and through the atmosphere as industrial gases (Karl and Theo, 2004).

2.1.2 Effects of heavy metals

Humans alter the chemical form of heavy metals released to the environment and influence metal toxicity by allowing it to bioaccumulate in plants and animals. Studies have shown that if heavy metals become concentrated in the food chain, they attack specific organs of the body (Goyer, 1996). Urban atmosphere, motor vehicle Lead (Pb) and industrial Vanadium, Nickel, Chromium. Cadmium exert greatest effects which affect water, soil and vegetation (Davydova, 2008).

Heavy metals cause adverse health effects such as allergic reaction, for example, Beryllium and Chromium. Some heavy metals cause neurotoxicity (e.g. Lead), nephrotoxicity (e.g. mercuric chloride and cadmium chloride) and cancer (e.g. Arsenic). Hexavalent chromium (Hawkes, 1997) causes breakdown of immune system and diseases of the central nervous system. Heavy metals knock out the senses of smell in humans and animals (Scholz, 2007).

2.1.3 Characteristics of heavy metals

2.1.3.1 Cadmium (Cd)

This is a heavy metal and has an atomic weight of 112.411 g, and an atomic number of 48. It is an extremely toxic metal with no biological function. It is persistent and once absorbed by an organism, remains in the body throughout and eventually it is excreted (Lentech, 2007). In chronic exposure, it accumulates in the body, especially in the kidneys and liver. Hence, Cadmium is one of the commonest environmental poisoning elements (Rel, 1990).

- **Sources of Cadmium**

Cadmium metal comes from industrial workplaces, ore processing areas, smelted silver work places or alloys like pigments and batteries (McCallum, 2007). In Cigarette fumes, the amount of cadmium ranges from 0.007 to 0.35 µg per cigarette (McCallum, 2007). Other sources include ingestion of foodstuffs that absorb cadmium from the soil (Opporto *et al.*, 2007), irrigation water from rivers contaminated by mining, sewage waste, fertilizer, polluted ground water (Rel. 1990). Welding and smelting of Lead, Zinc and Copper that occur in mixed ores with Cadmium are other sources of Cd.

- **Effects of Cadmium**

Human daily intake of Cd can amount from 20 to 40 µg through ingestion and inhalation. Only 5 to 10% is absorbed. Cadmium inhibits various enzyme systems. It inactivates enzymes having Sulphydryl groups and produce uncoupling of oxidative phosphrylation in mitochondria. It can compete with other metals like Zinc and Selenium for inclusion into metallo enzymes and may compete with Calcium for binding sites on regulatory protein like Calmodiulin (Rel, 1990).

Acute Cadmium intake causes testicular damage while few hours of exposure causes necrosis and testicular degeneration with complete loss of spermatozoa. Inhalation of cadmium causes severe lung irritation and damage (fume fever). Chronic inhalation causes emphysema and obstructive airways, this occurs before kidney damage is seen. However, twenty (20) years of exposure may be needed before these effects are seen. Long term ingestion causes kidney damage known as proteinuria and microglobulinuria, and disorders of calcium metabolism causing osteomalacia. Cadmium also causes lung and prostate cancer (Rel, 1990). Lethal dose of cadmium (Cd) ingestion is estimated to be between 350 and 890 mg.

2.1.3.2 Chromium (Cr)

Chromium is a heavy metal with an atomic weight of 51.9961 g and atomic number 24. It is steel grey, lustrous, hard metal and has high melting point. It is tasteless, odourless and malleable (Wikipendia, 2007). It exists in different forms: divalent, trivalent and hexavalent chromium. Only hexavalent chromium is recognized as human carcinogenic (Department of Health Service, 2007). Chromium comes from spraying anti-corrosion coatings, welding and cutting stainless steel. The spraying of anti-corrosion coatings that has Zinc chromate, for example, creates a mist that can be inhaled. On the other hand, Chromium may come through the process of electroplating in which gases that can be inhaled are created. The Department of Health Service (2007) also shows that during welding, the vaporized metal condenses into particles that can be inhaled. The hexavalent chromium is found in pigments used for paints, inks and plastics. It enters the body through inhalation or swallowing. Nonetheless, hexavalent chromium is used in pigments, paints, inks, plastics and as anticorrosion agent, in protective coatings, chrome plating, wood preservative and leather tanning.

- **Uses of trivalent Chromium (Cr (III) or Cr 3+)**

This chromium is required in trace amounts for sugar and fat metabolism in humans (Glucose tolerance factor). Its deficiency may cause chromium deficiency disease. It potentiates the action of insulin. The trivalent chromium occurs in higher organisms throughout the body, but it is concentrated highly in liver, kidney, spleen and bones (Garcia *et al.*, 1999). It also helps in transport of amino acids to where they are needed. It controls appetite, cleans arteries by reducing cholesterols and triglyceride levels.

- **Effects of Chromium**

Low levels of Chromium leads to cancer, heart problems and diabetes (Emil *et al.*, 2007). Hexavalent chromium causes lung cancer in humans, respiratory disorders, irritation of the noses, throat and lungs. Prolonged exposure can damage the mucous membranes of the nasal passages leading to ulcers. It causes eye irritations and permanent damage. It is also very toxic and mutagenic when inhaled. It causes allergic contact dermatitis (ACD) (Wikipendia, 2007).

- **Lethal dose (Legal exposure limits)**

The permissible exposure limit (PEC) for water soluble and certain insoluble hexavalent Chromium compounds is 0.05 milligrams of chromium per cubic meter of air (0.05 mg/m^3). The permissible exposure limit for zinc chromate is 0.01 mg/m^3 while for chromyl chloride is 0.15 mg/m^3 (Department of health service, 2007).

The dietary intake guideline for daily intake of chromium has been lowered from 50 to 200 μg for adult, to 33μg for adult male and to 25μg for adult female, but for infants, it is 10 to

40 μg daily. The allowable concentration in drinking water for hexavalent chromium is 0.05 mg/litre.

2.13.3 Lead (Pb)

This is a heavy metal and has an atomic weight of 207.2 g. It is a toxic metal if builds up in the system due to repeated doses (Zarkov, 2007). Sources of lead are from foods that contain lead, water supply with lead contamination and the air we breathe which has been polluted with lead. Other possible sources are exposure to skin absorption from gasoline burns. Lead originates from high pressure lubricants (Lead soap), gasoline agents, tetraethyl lead (TEL) and tetramethyl lead (TML) (Zhang *et al.*, 1997). Construction works, smelter operations, radiators, repair shops and firing places are other sources of Pb.

- **Effects of Lead**

Respiratory and percutaneous absorption are the main routes of exposure. This is caused by organic lead. Inhalation is the most important route of absorption. Lead causes sneezing, irritation of the upper respiratory tract, insomnia, nervous excitation, anxiety states, tremors, hyperflexia, spasmodic muscular contractions, vascular hypertension and hypothermia. The most severe effect is disorientation with hallucinations, facial contortions leading to maniac and violent convulsive seizures leading to coma and death (ILO, 1983; David, 2000). Lead has also been reported to causes Gastro intestinal, kidney and hemoglobin disorders (Lentech, 2007). In addition, (ILO, 1983) the lead alkyl compounds induce itching of ocular membranes, burning and transient redness.

- **Lethal dose**

The lowest reported lethal dose in man (LDLO) is 1470 µg/kg. Organic lead poisoning from gasoline sniffing has been shown to have blood lead levels higher than100 µg/dl. Lead urine concentration of about 350 µg/dl has been observed in severe tetraethyl lead poisoning (ILO, 1983). The inhalation L50 for tetramethyl lead is ten times greater than that for tetraethyl lead (Zhang *et al.*, 1997). Concentration levels that can lead to poisoning whole blood rarely exceed 500 µg/l. In severe organic lead poisoning, the concentration of lead in urine is rarely less than 3500 µg/l (ILO, 1983; David, 2000).

2.1.3.4 Mercury

This is a heavy metal and has an atomic weight of 200.59 g. Mercury has no known physiological or biochemical functions in organisms. It can combine with a methyl group to become methyl mercury. This form of mercury is found in variety of environmental pollution and produces a range of toxicities (Hoekman, 2007).

- **Sources**

Mercury can be found in adhesives, air conditioner, filters, algaecides, antiseptics, batteries manufacturing, broken thermometers, building materials, dental amalgams, germicides, industrial wastes, sewage disposal and skin lightening creams. Mercury is also persistent in the atmosphere as unreactive gaseous element. It is also found in mining products, transportation of mercury, mining and refining of gold and silver ores (Mumby, 2007; McCallum, 2007).

- **Effects of Mercury**

Acute toxicity of either organic or inorganic mercury in the gastro-intestinal tract can produce sloughing away of the mucosa. This result leads to pieces of intestinal mucosa being found in the stool. It produces large loss of fluids and electrolytes. It breaks down barriers in the capillaries resulting in oedema throughout the body. It causes excitement, hyperreflexia and tremor (Hoekman, 2007). In chronic state, mercury causes psychotic state resulting in hyper excitability. It causes deterioration of alveolar bone in the jaw, leading to teeth loosening. Liver and kidney toxicity occurs due to mucosal degeneration (Mumby, 2007). Adrenal dysfunction is caused by mercury toxicity. Allergy, alopecia, Anorexia, loss of self-control, memory loss, nerve fibre degeneration, retinitis, speech disorders, suicidal tendencies and vision loss are also caused by mercury toxicity. Acute lethal dose for mercury compounds for an adult has been documented as being 14 - 57 mg/kg or one to 4 g for a 70 kg person. The minimum lethal dose of methyl mercury, the organic form of mercury is 20 - 60 mg/kg (Willis, 2001).

2.1.4 Contamination of grasslands by heavy metals

2.1.4.1 Natural contamination of grasslands

The contamination of pastures and the accumulation of potentially-toxic metals in grazing animals can occur on soils that are naturally rich in metals. Soils derived from igneous rocks can contain high concentrations of potentially-toxic metals. Leaching of metals from such soils, and the subsequent deposition of the leached minerals in sedimentary rock may lead to the accumulation of metals to potentially-toxic levels (Wilkinson *et al.*, 2003). Moreover, grasslands can be naturally contaminated by water containing salts leaching from the alluvial deposits and evaporation of irrigation water. Selenium and Boron could also contaminate grassland from drainage water underlying the agricultural areas (Lamachia, 2008). In addition, grasslands could be contaminated naturally by Hydrocarbon in the soils (Robson *et al.*, 2004).

2.1.4.2 Accidental contamination of grasslands

Accidental contamination of grassland may occur through radionuclides released into the atmosphere from an explosion at a nuclear station, mine waste water containing Cd, Zn, Cu, Pb and As, and use of fertilizers and sewage sludge containing a variety of heavy metals. Application of organic fertilizers and spraying of pesticides on pastures could lead to grasslands contaminations. Over application of fertilizer in paddock and yard equipments which are not clean may contaminate the grasslands (Rantavaara *et al.*, 2005). Inaccurate spreading of fertilizers and pesticides that leads to over application could lead to grasslands contamination. The choice of type of fertilizer to use, the spreading machine, the inaccurate speed and agitation of the machine, the height, tilt angle and the rate for dropping fertilizer/pesticides are important factors that need to be considered as they could lead to inaccurate application of fertilizers and pesticides, which can result into contamination of the grasslands. Foods having heavy metals thrown on the grassland could contaminate the area (Brownstein, 2007). Use of traditional Chinese medicines having lead and mercury when thrown on the grasslands could contaminate the grasslands (Dubovsky, 2002). The leakage and spills of substances from storage tanks containing products such as petroleum products, acids, metals and organic compounds may contaminate the grasslands as well as the ground water (Wolfang *et al.*, 2005).

2.1.4.3 Anthropogenic Contamination of grasslands

Soils with high organic matter content like forest soils have the lowest heavy metal content, except lead (Pb), because of shielding effect. On the other hand, arable soils have high chromium, copper and Nickel due to input of agrochemicals. Grassland soils have the highest cadmium (Cd) and Zinc (Zn) contents due to geonic reasons. However, metal redistribution in the soils is controlled by pH and land use (Wolfgang *et al.*, 2005). The following human activities could lead to contamination in number of ways. One important activity is mining in which a variety of contaminants have been identified. Acid, Iron, Magnesium, Sulphates, Uranium, and other trace elements leach from piles of coal metallic and non-metallic and contaminate the grazing areas (Wolfgang *et al.*, 2005). Urban activities may also cause contamination as urban runoff wastes may contain heavy metals that can contaminate the streams. Infiltration from detention basins and drainage wells can be another source of ground water contaminants.

Industrial discharge is another activity which may contain mercury, organic compounds and trace elements. Treated effluents in many cases, also get discharged to surface water and cause pollution. Smelters and brickworks may be a chief source of contamination to grasslands, when such places are located near grazing areas. This is because smelter places could emit mercury, cadmium, zinc, copper and lead which can contaminate the grazing area. Road traffic is another source of grassland contamination as it has been shown to cause emission of mercury, copper, zinc and lead (Wolfgang *et al.*, 2005). This is because when it rains, the elements are sent to the grassland and cause pollution. Sewage sludge containing Bacteria, Viruses, Nitrates, Mercury, Cadmium, Phosphates may be sent to grassland and contaminate the areas.

2.1.5 Factors affecting uptake of heavy metals by grazing animals

Animals grazing on major highways and around factories can be contaminated by heavy metals such as lead, mercury, copper and Zinc. In addition, inhalation of airborne particulates can affect the grazing animals. Ingestion of polluted forages harvested from areas contaminated by heavy metals like lead, mercury and chromium can affect the animals (Ward *et al.*, 2005). The main factors affecting the accumulation of potentially-toxic metals by grazing animals are the presence of the metal, its concentration in herbage and at the soil surface, and the duration of exposure to the contaminated pasture and soil. In addition, the elapsed time between the contamination of the pasture and grazing, the quantity of soil ingested together with herbage, the mechanism of absorption of the metal into blood and the presence or absence of antagonistic metals can interact to influence the rate and extent of accumulation of heavy metals in edible body tissues.

2.1.5.1 Selective grazing behavior

Cattle can detect lead in herbage. Lead reduces their grazing time and pasture biting rate. Animals prefer to graze pasture without lead (Strojan and Philips, 2002). The rate of biting by animals is more on immature sward than on mature ones. The swards type, the height of the herbage and morphology of the herbage determine the grazing behavior (Polic *et al.*, 2008). The breed difference, social behavior, adaptation, location of watering points and unique environmental factors affect grazing behavior (Smith and Monteca, 1994).

2.1.5.2 Antagonistic elements

Some of the antagonistic elements that might affect the uptake of heavy metals by grazing animals range from presence of heavy metals, minerals disorders and concentration in the herbage at the soil surface. Antagonism arises from direct competition for absorption sites in both the plant and animal. The magnitude of antagonistic effect depends on the particular combination of ions, soil factors and plant spp. Application of pesticide contribute to antagonistic elements (Whiteland, 2008). The presence of anionic elements in grasslands reduces palatability of forages.

Different mechanisms are responsible at different concentrations. For example, at low dietary concentrations Cd can directly compete with Cu for absorption sites, whereas at high concentrations the metallothioneins induction by Cd can bind Cu and render it unabsorbable (Gawthorne, 1987). Cadmium absorption is affected by the Zn status of animals, and Cd increases Zn accumulation in sheep, perhaps by the stimulation of metallothioneins production (Grace *et al.*, 1993; Lee *et al.*, 1994). Conversely, a high Zn intake reduces Cd absorption in sheep (Chiy *et al.*, 1998). This suggests competition for absorption sites between the two elements. There is a negative effect of Cd in the small intestine on absorption of Fe, even at levels in the diet as low as 2·5 mg Cd/kg DM (Brenner, 1978). At high concentrations metallothioneins induce necrosis of the proximal intestinal absorptive cells, which affects uptake of minerals, such as Fe, for which the distal intestine cannot compensate (Valberg *et al.*, 1977; Elsenhans *et al.*, 1999). Lead is also linked to Fe-deficiency-induced anaemia. As well as Fe, Pb directly interacts with Ca, P, Cu, Mn and Zn, all of which protect against Pb absorption.

2.1.5.3 Mechanisms of absorption

A range of potential sites for absorption of metals exist from the rumen to the small intestine, but in grazing ruminants all metals are subject to the overriding influences of the rumen microbial digestion. The extent of absorption is also dependent on the species of metal ingested, the age of the animal (young animals generally absorb a greater proportion of ingested metal than old animals), the pH of the medium (low pH dissociates ingested compounds) and the rate of passage through the gastrointestinal tract.

- **Mercury (Hg)**

Mercury entering the body through Gastro- Intestinal tract is acted upon by intestinal flora, get decomposed and is excreted as methyl mercury. The mechanism is that, organic mercury gets decomposed to inorganic mercury by intestinal flora in caecum and reabsorption decreases in large intestine. The intestinal flora not only decomposes the organic mercury but also aid in feacal excretion of total mercury in animals (Seko *et al.*, 2001). Organic mercury, possibly methyl mercury, in large intestinal contents, will be reabsorbed if mercury is not decomposed to inorganic by intestinal flora. However, there is possibility that reabsorption of organic mercury is inhibited by incorporation of organic mercury within bacterial cells (Seko *et al.*, 2001).

- **Lead (Pb)**

Lead inhibits heme biosynthesis. Heme is the essential structural component of haemoglobin (hb), Myoglobin and Cytochrome. It binds to Sulfhydryl groups (-SH group) of proteins (Seko *et al.*, 2001). Lead is absorbed in the gastrointestinal tract through passive diffusion. It bypasses the soft tissues and is sequestered in bones. Factors affecting the Pb absorption depend on physical and chemical form of Pb (David and Barnett, 2008).

- **Cadmium (Cd)**

Cadmium gets absorbed through inhalation by 10 - 40% and by Gastro-Intestinal tract (1.5 - 5%). Its distribution initially binds to albumin and blood cells. It subsequently binds to Metallothionein in liver and kidney tissues. Its half life is 10 - 20 years. Its mechanism of toxicity is that, inhalation in lungs causes irritation and inhibition of alpha antitrypsin associated with emphysema (Seko *et al.*, 2001).

- **Chromium (Cr)**

It has been reported that, Niacin bound chromium get absorbed by 672% better than chromium chloride and 311% better than chromium picolinate. Chromium get absorbed in the intestinal mucosa. In human, the site of absorption includes jejunum. Chromium is bound to transferrin that possesses two binding sites A and B with different affinities for Iron (Fe) (Krejpcio, 2001). Chromium from dietary supplement picolinate enters cells via different mechanisms. Release of chromium from chromium picolinate for use in cells requires reduction of the chromic center, a process that can lead potentially to the production of harmful Hydroxyl radicals (Vicent, 2000).

2.2 Agrochemical

An agrochemical is any chemical used in agriculture, including chemical fertilizers, herbicides and insecticides. It also includes hormones and fungicides that improve the production of crops and cellulose derived from plant (Goyer, 1996). Most agrochemicals are mixture of two or more chemicals; active ingredients that provide the desired effects and inert ingredients that stabilize or aid in application.

- **Uses**

Agrochemicals are used mostly to control and reduce risks caused by pests. There are different types of agrochemicals including: Rodenticides which control rodents, insecticides for controlling insects and fungicides for controlling fungus. Herbicides are also used for controlling weeds, while molluscides are for controlling snails and nematocides are for controlling nematodes (Barnes *et al.*, 2007). These agrochemicals enter the food chain through foods, water and garden plants.

- **Effects of agrochemicals**

Most agrochemicals cause chemical sensitivities, cancers, respiratory diseases, chronic bronchitis caused by toxic gases and dusts. Other effects of agrochemicals include, occupational asthma, organic dust toxic syndrome, farmers' lung and silo fillers diseases (Mutel and Donham, 1983). They also cause zoonotic diseases (animal transmitted), increased risks for hearing defects, musculo-skeletal problems and numerous skin conditions (Batchelder, 2001). Stomach cancers, brain, prostate as well as Leukemia, Non-hodgkin Lymphoma, Multiple myeloma may also be caused by agrochemicals. Agrochemicals such as DDT (Dichlorophenyltrichloroacetic acid), Thiodan (Endosulfan), Dieldrin and Lindane are mostly used as insecticides to control pests and insects in animals and plant crops.

2.2.1 Dichlorophenyl- Trichloroacetic Acid (DDT)

This chlorinated hydrocarbon is used as an insecticide. DDT is persistent and contaminates the environment. It occurs as residues in wildlife, drinking water and humans (Windholz, 1983).

- **Effects of DDT to humans and animals**

DDT accumulates in the nerve sheath and causes nerve damage (Cohn *et al.*, 2007). It causes eye irritation if 423 mg/kg is exposed to human for one hour for six (6) days. A dose of 16 mg/kg leads to convulsions while 2 - 85 mg/kg leads to vomiting. DDT and its metabolites can cause tumors at a dose of 0.4 p.p.m. If the amount in milk exceeds the required lethal dose (LD50), DDT causes paralysis and death in infants. High doses of DDT to pregnant women cause premature births. DDT causes infant hypersensitivity. DDT leads to poliomyelitis and other CNS diseases. If DDT accumulates in body tissues of females, it causes effects to liver, kidney, spleen, and spinal cord. It also changes the immune responses of human cells. According to Windholz (1983) 500 mg/kg is an oral lethal dose. The oral dose of 500 mg/kg is equivalent to a 70 kg worker, exposed to 23,000 mg/m^3 for 30 minutes at a breathing rate of 50 litres/minute and 100% absorption. Infant fatal dose is 3.5 mg/kg.

2.2.2 Dieldrin

This is an insecticide, a by product of Aldrin. Aldrin quickly breaks down to dieldrin in the body and in the environment. It is a white powder with a mild chemical odor and does not occur naturally in the environment (Department of Health Service, 2007). Exposure to dieldrin comes from eating contaminated foods like root crops, fish or seafood. It builds up in the body after years of exposure. It is a persistent, bioaccumulatives and toxic pollutant. Dieldrin is used as pesticide in crops like corn, cotton and citrus crops and as wood preservative for termite control.

Since dieldrin is bioaccumulative and does not break down, it becomes persistent in soils where it binds up tightly and evaporates to the air and in plants. It is slowly taken up and stored in fat and leaves. As it becomes more concentrated, it moves up the food chain to humans and wildlife (Department of Health and Human Service, 2007).

Dieldrin decreases the effectiveness of immune system, increases infant mortality, and reduces reproductive success, may cause cancer, birth defects and damage the kidneys. Convulsions may occur due to ingestion of large amounts of dieldrin. Exposure to air polluted with dieldrin causes headaches, dizziness, irritability and uncontrolled muscle movements. Oral exposure to animals leads to liver problems and decreased ability to fight infections. Pregnant animals which ingest dieldrin give birth to babies with low birth weights and skeletal alterations. Dieldrin can be passed to suckling infants. Dieldrin is however, useful as pesticide in crops like corn, cotton, citrus crops and as wood preservative for termite control.

2.2.3 Thiodan (Eudosulfan)

Thiodan (Endosulfan) is an organochlorine compound. It is used as an insecticide to control aphids, leafhoppers, potato beetles, cabbage worms and tsetse fly. It is used extensively on cotton, potatoes and apples (Wikipendia, 2007).

- **Effects**

Endosulfan is one of the most toxic pesticides responsible for many fatal poisoning incidents in the world. It is persistent in the environment. It acts as an endocrine disruptor, causing reproductive and developmental damage in both animals and humans. It is neurotoxic to both insects and mammals, including humans. It is classified as category I "Highly acute Toxic based on LD50 value of 30 mg/kg for female rats, while the World Health Organization (WHO) classifies it as class II. It is moderately hazardous based on a rat LD 50 of 80 mg/kg. It inhibits the Ca^{2+} and Mg^{2+} enzymes, which are involved in the transfer of nerve impulses (Wikipendia, 2007).

- **Acute poisoning symptoms**

These include hyperactivity, tremors, convulsions, and lack of coordination, staggering, difficulty in breathing, nausea /vomiting and diarrhoea and in severe cases, unconsciousness. A dose of 35 mg/kg can led to death in humans. Sub-lethal poisoning has been shown to cause permanent brain damage. Chronic exposure leads to rashes and skin irritation (Wikipendia, 2007). Delay in sexual maturity in boys has been reported and birth defects of male reproductive system like cryptochirdism. Endosulfan can promote proliferation of human breast cancer cells.

- **Lethal dose**

The recommended dose is not more than 74 ppb (parts per billion) in lakes, streams or rivers and not more than 0.1 - 2 ppm (parts per million) on surface of agricultural products, except dried tea, <24 p.p.m. Accurate reference dose for dietary exposure to endosulfan is 0.015 mg/kg for adults and 0.0015 mg/kg for children. For chronic dietary exposure, the doses are 0.006 mg/kg a day for adults and 0.0006 mg/kg for children.

2.2.4 Lindane

This is a synthetic organochlorine (OC) pesticide of Hexachlorocyclohexane (HCH) subgroup. It is a white to yellow crystalline powder with slight musty odor. It consists of a mixture of active ingredients designed to destroy the pests together with many other chemical additives such as solvents combined into usable products. Lindane is used in wood preservation treatments, wall paper pastes, marine and antifouling paints, wooden furniture, fibre textiles. Lindane is also used for lice control and scabies in mixture with shampoos (Batchelder, 2001). However, Lindane causes reproductive effects in animals. It causes high incidences of cancers and related disorders like lungs, kidneys, testicular cancers, tumours, brain gliomas (Barnes *et al.*, 2007).

- **Oral and dermal exposure to Lindane**

Oral exposure to Lindane causes conjunctivitis, nausea, restlessness, headache, dizziness and vomiting with muscle tremors, abdominal pain and diarrhoea. Severe poisoning leads to seizures, convulsions, coma and death. Acute exposure in humans occurs within one hour of the dose. On the other hand dermal exposure which may result from the treatment of scabies and skin parasites may lead to neurotoxicity in man (Buffin *et al.*, 2002). On the overall, chronic exposure leads to degenerative changes in the liver, renal tubules and reduced reproductive capacity in both sexes. Uncontrolled mood swings, headache, depression, confusion and irritability could also be caused by chronic exposure to lindane (Buffin *et al.*, 2002). A dose of 10 - 20 mg/kg could be lethal to humans but higher doses also could be tolerated (Buffin *et al.*, 2002). This is due to physical and physiological variations in man. Other oral doses could be 180 mg/kg. Dangerous acute dose for man has been reported as 7-15 g.

2.3 Summary of the Literature Review

This section summarises the relevant literature on heavy metals. such as Lead. Cadmium, Chromium and Mercury. Their characteristics. uses, sources and their effects on soils, environment and human life. also their mechacanism of toxicity have been discussed. The sources of heavy metals have been identified as mines. smelters. foundries power plants and vehicle emissions. Their ways of entry into body of animals and humans is through food, air, water and atmosphere as industrial gases.

The effects of these metals have been identified as accumulation in plants and animals that lead to adverse effects like neorotoxicity and cancer. Some of the useful metals are chromium III (Cr III) that is required for fat, and sugar metabolism in humans and transportation of amino acids to target organs. Heavy metals contaminate grasslands either, accidentally through organic fertilizer and pesticides spraying, naturally by salty water from alluvial deposits, or anthropologically through mining activities, urban activities and industrial discharges. The main factors which affect the uptake of theses metals by grazing animals are presence of the heavy metal, its concentration in forages and at the soil surface, the duration of exposure to the contaminated pastures and soil, also the time interval between the contamination of the pasture and grazing.

Selective grazing behaviour by animals has been found as detection of polluted pastures which lead to reduced grazing time, and biting rate. However, it should be noted that sward type, and height of herbage also lead to selective grazing. Most heavy metals accumulate in the livers and kidneys of animals that has been grazed on contaminated pastures. This section also reviews on agrochemicals such as DDT, Lindane, Dieldrin and Endosulfan used in agriculture as herbicides, fertilizers and insecticides to improve crop production. The Agrochemicals are mostly used for controling and reducing risks caused by pests.

Their effects have been identified as causing cancer, respiratory diseases, chronic bronchitis, asthma and zoonotic diseases. It can be concluded that, heavy metals are persistent in urban and peri-urban areas of industrial cities, hence, animals grazing around industrial sites and highways are prone to heavy metal contamination through uptake from pastures, soils and water.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Description of the Study Area

The study was conducted in peri-urban areas of Mwanza city in locations prone to pollution by industrial effluents. The study areas were located in the southern (Nyashishi village) and Eastern (Nyamhongolo village) part of Mwanza city. Mwanza city is located in the southern shores of Lake Victoria in Northwest Tanzania. The city covers an area of approximately 1300 km^2, of which 425 km^2 is dry land and 900 km^2 is covered by water. Of the 425 km^2 of dry land, approximately 86.8 km^2 is urbanized while the remaining area consists of forestlands, valleys, cultivated plains, grassy and undulating rocky hill areas (Mwanza city council, 2004).

Mwanza city lies at an altitude of 1140 m above sea level. It is situated at the latitude of $2^0 31'$ just south of equator and at the longitude of $32^0 55'$ East of Greenwich. Mean temperature ranges between 25.7°C and 30.3^{0}C in hot season (September-April) and 15.4°C and 18.6°C in the cooler months (May to August) (Mwanza city council, 2004). The city receives between 700 and 1000 mm of rainfall per year, falling in two fairly distinct seasons; between October and December and between February and May. The city has gently undulating granites and granodiorite physiographic with isolated hill masses and rock outcrops left by retreating icebergs during the meocine era. It is also characterized by well drained sandy loamy soils. The vegetation cover is typically of savannah type with scattered tall trees and grasses (Mwanza city council, 2004).

3.2 Socio-economic Survey

A socio-economic survey was conducted to assess the agricultural practices of farmers and problems facing livestock farmers in the study area. A total of 75 farmers from the two village of Nyashishi and Nyamhongolo were interviewed using a well structured questionnaire (Appendix 1). The interview aimed at capturing information on the type of crops grown, season of cropping, type of agrochemicals used and, their frequency of application, types of livestock kept and their management. The questionnaire was administered through individual interview of the household heads.

3.3 Assessment of Heavy Metals and Agrochemical Residues

3.3.1 Collection of soil samples

Soil samples were collected in both wet and dry season of 2007 and in wet season of 2008. Soil samples were collected from Nyamhongolo in areas near factories, road sides and in the crop fields. The method used for collection of samples was simple random as described by Phiri (2001).

(a) Collection of samples in areas around the factories

The soils were collected at equidistance of five, 10 and 15 m from the factories (Coca cola). Three soil samples were collected at each location, mixed together to obtain one sample of 500 g.

(b) Areas near roadsides

Three soil samples were collected at an equidistance of five, 10 and 15 m from the roadside. Three samples were collected at each location. The samples were mixed to obtain one sample of 500 g.

(c) Areas in the crop fields

Nine soil samples were collected from nine crop fields. These fields were located at 10, 20 and 30 meters from the main road. At each location, three samples were collected and pooled to make one sample of 500 g.

All soil samples were collected using soil auger and a hoe at a depth of 0 - 30 cm from the top soils. The samples were dried at room temperature, sieved and put in polythene bags. The samples were collected in October, 2007 and March, 2008. The soil samples were transported to the laboratory and analyzed for cadmium, chromium, lead and mercury. The analyses were done at the Southern and Eastern African Mineral Centre (SEAMIC), Kunduchi, Dar -es –Salaam, Tanzania using Induced Coupled Plasma (ICP) Method (Montaser and Golightly, 1992).

3.3.2 Collection of forage samples

Forages were collected in wet season in 2007 and 2008. The same areas where soils were sampled in Nyamhongolo, were also sampled for forages. A circular quadrant was thrown to the areas which had high abundance of forages as described by Forbes (1998). The forages were cut at 5 cm from the ground as described by Crowder and Chheda (1982). The forages were cut using knife and sickle. Three forage samples were collected at an equidistance of five, 10 and 15 m from the factories and pooled together to obtain one sample. Similarly three forage samples from the roadside were collected at an equidistance of five, 10 and 15 m and pooled together to obtain one sample. The forages were dried to constant weight at room temperature for three days to stop biological process. The samples were packed in paper bags to avoid bacterial and fungal growth during transportation. Also other forages like weeds, legumes, grasses, shrubs (each weighing 500 g) which were reported to be eaten by cattle were sampled randomly. These were collected from Nyamhongolo, Nyagh'omango and Nyashishi.

3.3.3 Collection of crop residue samples

Rice straws were sampled from nine (9) different rice fields. The fields were located at 10, 20 and 30 m from the main road of Mwanza- Musoma in Nyamhongolo area. Three fields situated 10 meters away from the main road were sampled and then the straws were pooled to make one bulk sample as described by Saville *et al.* (2004). The procedure was repeated for the three fields situated 20 and 30 meters, away from the main road. The three samples from the fields at each location were pooled to make one sample of 500 g.

3.3.4 Collection of concentrate feed samples

Samples were collected for maize bran, cotton seed cake, fishmeal, rice bran and sunflower seed cake. These were collected randomly from Kirumba Market, Mwanza. For each concentrate feed 500 g were collected.

3.3.5 Water sampling

Water samples were collected in dry and wet seasons in 2007. Four samples were taken from water streams near the coca cola factory, i.e. two samples, each of 250 ml were taken at the upper area of the stream at Nyamhongolo, and two samples each of 250 ml were taken at the lower stream at Nyashishi.

3.3.6 Milk sampling

Five samples of cattle milk were taken randomly from farmers in Nyamhongolo and Nyashishi. Two samples each of 250 ml were taken from Nyashishi livestock farmers and three samples each of 250 ml from Nyamhongolo livestock farmers. These were put in a cool box and stored at 4°C until analysis.

3.4 Laboratory Chemical Analysis of the Samples

Samples of soils, forages, crop residues, concentrate feeds, milk and water were analysed to determine the concentration of the heavy metals and agrochemical residues in the samples. The analysis of heavy metals was carried out at the Southern and Eastern Africa mineral centre (SEAMIC), Kunduchi, Dar es Salaam, Tanzania. The analysis of agrochemical residues in forages and crop residues, was done at the Tanzania Pesticide and Research institute, (TPRI), Arusha, Tanzania.

3.4.1 Determination of heavy metal concentration

The concentrations of cadmium, chromium, lead and mercury in soils, forage, water and milk samples were determined by using induced coupled plasma (ICP) method, a modification of the methodology of atomic absorption spectrophotometer (Montaser and Golightly, 1992). This was done following extraction of samples with three parts of hydrochloric acid and one part of nitric acid. About 0.5 g of each sample of soils and forages was weighed using analytical balance as described by Milner and Whiteside (1984). In this method, the elements in question, which must be present in ionic form, were atomized in a flame at a temperature of 6000°C for the ions to be converted to excited state. The atoms absorb light energy of specific wavelength as it enters excited state. As the number of atoms in the light path increases, the amount of light absorbed also increases. By measuring the amount of light absorbed, a quantitative determination of the amount of metal to be analyzed could be made using ULTIMA 2 machine (Montaser and Golightly, 1992). This is the equipment that uses argon gas couples with radion frequency to generate plasma at 6000°C temperature. This machine is attached to software to facilitate reading of the metal concentration.

3.4.2 Determination of Cadmium, Chromium, Lead And Mercury in water

The analysis of Cadmium, chromium, lead and mercury contents in water samples were analyzed using the same procedure as that of soil samples with slight modification. There was no addition of acids like hydrochloric and Nitric acids. The metals in the water were in solution, so direct reading was done and the mineral contents were obtained. The same machine ULTIMA 2 was used to analyze the heavy metals in the water samples.

3.4.3 Determination of Cadmium, Chromium, Lead and Mercury in milk

The milk samples were dried to powder at 90 -100°C in sunbath. Digestion by hydrochloric acid was done using two ml of HCl acid and 20 ml of milk sample for one (1) hour. Filtration was done to remove residues. A volume of 20 ml of solution was obtained and the reading in the ULTIMA 2 machine was done to obtain the metal contents.

3.4.4 Agrochemical analysis

The concentration of D.D.T, Thiodan, Dieldrin and Lindane in forages and crop residues was determined as follows. Samples were chopped and stored in plastic bags and kept in the freezer. The samples were thawed, and then analyzed. Thirty (30) grams of samples were mixed with sodium sulphate ($Na_2 SO_4$) and put in centrifuge bottles. Sixty (60) ml of ethyl acetate (ETAC) was added into the bottles. The samples were shaken for one minute; the extracts were centrifuged for one minute at 1300 revolutions per minute and the solutions were decanted. The analysis was done by injecting one µl into gas chromatography equipped with Electron Capture Detector (ECD) which is the detector for the gas chromatography used during analysis of halogenated compounds (organochlorine). The samples were calculated against concentration of standards as described by Anastassiades *et al.* (2003).

3.5 Statistical Analysis

The data obtained from the socio-economic survey were coded and analyzed using the statistical package for social science (SPSS) (2003), whereby means, frequencies, percentages and standard deviation were generated. The data for the concentration of cadmium, chromium, lead and mercury in water, soils, forage, concentrate feeds and milk were analyzed using SAS (2001) statistical software. Analyses of variances were carried out using the following statistical models:

For soil and forage samples the model was $Y_{ijk} = \mu + A_i + B_j + AB_{ij} + e_{ijk}$, whereby

Y_{ijk} = the concentration of i^{th} metal in the k^{th} sample obtained from j^{th} location .

μ = the overall mean.

A_i = the effect of i^{th} metal (i.e. Pb, Cr, Cd and Hg).

B_j = the effect of j^{th} location (i.e. road side, industrial area and crop field).

AB_{ij} = the effect associated with the interaction between i^{th} metal and j^{th} location.

e_{ijk} = random error.

A t- test was carried out as described by Montegomery (1984) to compare the concentration of the heavy metals in soils during the dry season and wet season.

For concentrate feeds the model was $Y_{ijk} = \mu + A_i + B_j + AB_{ij} + e_{ijk}$, whereby

Y_{ijk} = the concentration of i^{th} metal in the k^{th} sample from j^{th} concentrate type.

μ = the overall mean.

A_i = the effect of i^{th} metal (i.e. Pb, Cr, Cd and Hg).

B_j = the effect of j^{th} concentrate type (i.e. maize bran, rice bran, sunflower seed cake, cotton seed cake and fish meal).

AB_{ij} = the effect associated with the interaction between i^{th} metal and j^{th} concentrate type.

e_{ijk} = random error.

For DDT the model was $Y_{ijk} = \mu + A_i + B_j + AB_{ij} + e_{ijk}$, whereby

Y_{ijk} = the concentration of DDT in i^{th} forage for the k^{th} sample obtained from j^{th} location .

μ = the overall mean.

A_i = the effect of i^{th} forage (i.e. *Cynodon spp*, rice straw).

B_j = the effect of j^{th} location (i.e. road side, industrial area and crop field).

AB_{ij} = the effect associated with the interaction between i^{th} forage and j^{th} location.

e_{ijk} = random error.

CHAPTER FOUR

4.0 RESULTS

4.1 Socio – economic Survey

4.1.1 Socio-economic characteristics of the respondents

The results in Table 1 show that the majority (98.7%) of the respondents were males. The age of the respondents ranged from 21 to 80 years, but most of the respondents (92%) were between 31 and 70 years old. More than half of the farmers had primary education. The majority of the farmers owned the land they tilled. Over half of them owned more than one field and the farm plots ranged in size from 3 to 10 acres. The desire to own more land was expressed by over 50% of the respondents. Many of them (54.7%) pointed prestige, while the rest mentioned large family size as the primary reason for needing more land. Majority of the farmers grew maize and paddy as single crops. Most (96%) of the respondents reported that they do not use fertilizer, while a few used it. The Majority (84%) of the respondents reported that they do not use agrochemicals in their crop fields, while a few admitted to use agrochemicals. Some grew a mixture of maize and beans, while others, grew maize and cassava. These crops were used mostly for production of food for humans and very little was used as animal feeds. Most of the farmers grew the crops in wet seasons (November-April).

Table 1: Household characteristics of the respondents

Variable	Frequency	Percentage of the respondents
Sex		
Male	74	98.7
Female	1	1.3
Age		
21-30	3	4.0
31-70	69	92.0
71-80	3	4.0
Education		
No formal education	34	45.3
Primary school	40	53.3
Secondary school	1	11.3
Ownership of land		
Owned fields	43	57..3
Hired	32	42.7
Number of fields		
1-2	34	45.4
3-5	9	12.0
no fields	32	42.7
Size of fields		
1-2 acres	7	9.1
3-5 acres	30	39.0
5-10 acres	34	44.2
> 10 acres	6	7.8
Interest for owning more land		
Interested	39	52.0
Not interested	36	48.0
Reasons for owning more land		
Large family size	34	45.3
Prestige	41	54.7
Crop grown as single crop		
Maize	48	64
Paddy	1	1.3
None	26	34.7
Crops grown as mixture		
Maize and cassava	31	41.3
Maize and beans	11	15.0
None	33	44.0
Use of agrochemicals and fertilizers		
Farmers using fertilizers	3	4.0
Not using fertilizer	72	96.0
Farmers using agrochemicals	11	14.3
Not using agrochemicals	64	85.2
Use of the crops		
Human food	64	85.7
Animal feeds	11	14.3
Seasons the crops grown		
Wet	43	57.3
Dry	32	42.7

4.1.2 Livestock Management

Table 2 summarizes the type, ownership and herd size of cattle kept in the study area. The majority of the livestock were owned by males while in about one third of the households, cattle were owned by both husband and wife. They kept mostly local cattle (Zebu), with the majority (69.4%) of them having less than ten cattle.

Table 2: Types and ownership of cattle kept

Variable	Frequency	Percentage of respondents
Ownership		
Husband	52	69.3
Both	22	29.3
Wife	1	1.3
Type of stock		
Crossbred cattle	1	1.3
Local cattle (Zebu)	74	98.7
Herd Size		
1-9	52	69.4
10-30	9	11.9
>30	14	18.4

Table 3 shows that most of the farmers (72%) grazed their cattle while few (25.3%) tethered them. Feeds were mostly obtained from communal lands. During the dry season, crop residues were grazed *in situ* by cattle in most of the households (58.7%).

Table 3: Feeding practices and disease control measures for cattle

Variable	Frequency	Percentage of respondents
Grazing system		
Grazing	54	72.0
Tethering	19	25.3
Zero grazing and tethering	2	2.6
Source of forages		
Communal lands	69	92.0
Private plots	6	8.0
Crop residues use		
Grazed *in situ*	44	58.7
Not used	31	41.3
Concentrates		
Users	10	13.3
Non-users	65	86.7
Type of concentrates used		
Rice bran	40	52
Maize bran	25	32.5
Cotton seed cake	6	7.8
Sunflower seed cake	4	5.2
Water source		
Small dams	39	52
Rivers	35	46.7
Tape water	1	1.3
Disease/parasites		
Worms + tick borne	28	36.4
Worm + fleas	21	27.3
Abortion + worms	5	6.5
Lumpy skin + tick borne diseases	15	19.5
No diseases	6	7.8
Control Methods		
Helminthiosis-deworming	27	18.4
Tick borne diseases-dipping	38	64.0
Lumpy skin diseases-vaccination	10	17.04

Very few farmers (13.3%) used concentrates to supplement their cattle using rice bran and maize bran. Most of the farmers got water for their animals from small dams while others got it from rivers. In most households, cattle were affected either by worms and ticks (36.4%) or ticks and fleas (27.3%). Some of the farmers (19.5%) reported lumpy skin diseases to be the major problem affecting their animals. The control measures taken were deworming, dipping and vaccination, for worms, ticks and lumpy skin diseases, respectively. However, less than 19% of the farmers practiced these control measures (except dipping which was practiced by 64% of the farmers).

4.2 Concentration of Heavy Metals in Soils, Forages, Concentrates, Water and Milk

4.2.1 Comparison of heavy metal concentration in soils sampled from road sides, industrial areas and crops fields

The concentration of heavy metals in the soil samples is shown in Fig. 1 and Appendix 2(i). The soil samples from the areas near roads had the highest concentration of the four heavy metals (Pb, Cr, Hg and Cd). These were followed by soil samples from the industrial areas and lastly crop fields. Among the four elements, Pb and Cr contents were found in high concentrations while Hg and Cd contents were the lowest in all sites.

Lead

The concentration of Pb in soils ranged from 10.7 to 18.6 mg/kg. The amount of Pb was significantly ($P < 0.05$) higher in soil samples obtained from areas near roadsides than in those from industrial areas. Similarly, the Pb content in soils from crop field I (located 10 m off the road) was significantly ($P < 0.05$) higher than those from crop fields II and III, located 20 and 30 m off the road, respectively. Also the soil samples from crop field III had significantly ($P < 0.05$) lower Pb content than those from crop field II.

Chromium

The content of Cr in the soil samples ranged from 5.1 to 10.4 mg/kg. As it was for Lead, the Chromium concentration in the soil samples from the road side was significantly ($P < 0.05$) higher than in those from the industrial areas. Among the crop fields, soil samples from crop fields II had significantly ($P<0.05$) higher Cr content than those from crop field I while those from crop field III had the lowest.

Mercury

Mercury concentration ranged from 0.16 mg/kg in soil samples from crop fields III to 3.45 mg/kg in soil samples from the road side. The Hg concentration in the road side soils was significantly ($P <0.05$) higher than those from the industrial areas. Among the crop fields, crop field II had significantly ($P<0.05$) higher Hg content while crop field III had the lowest Hg content.

Cadmium

The concentration of Cd in the soils did not differ significantly ($P > 0.05$) among the soil samples from the different sites. However, soils sampled from the road sides had slightly higher Cd content (0.3 mg/kg) than those from the industrial areas and crop fields.

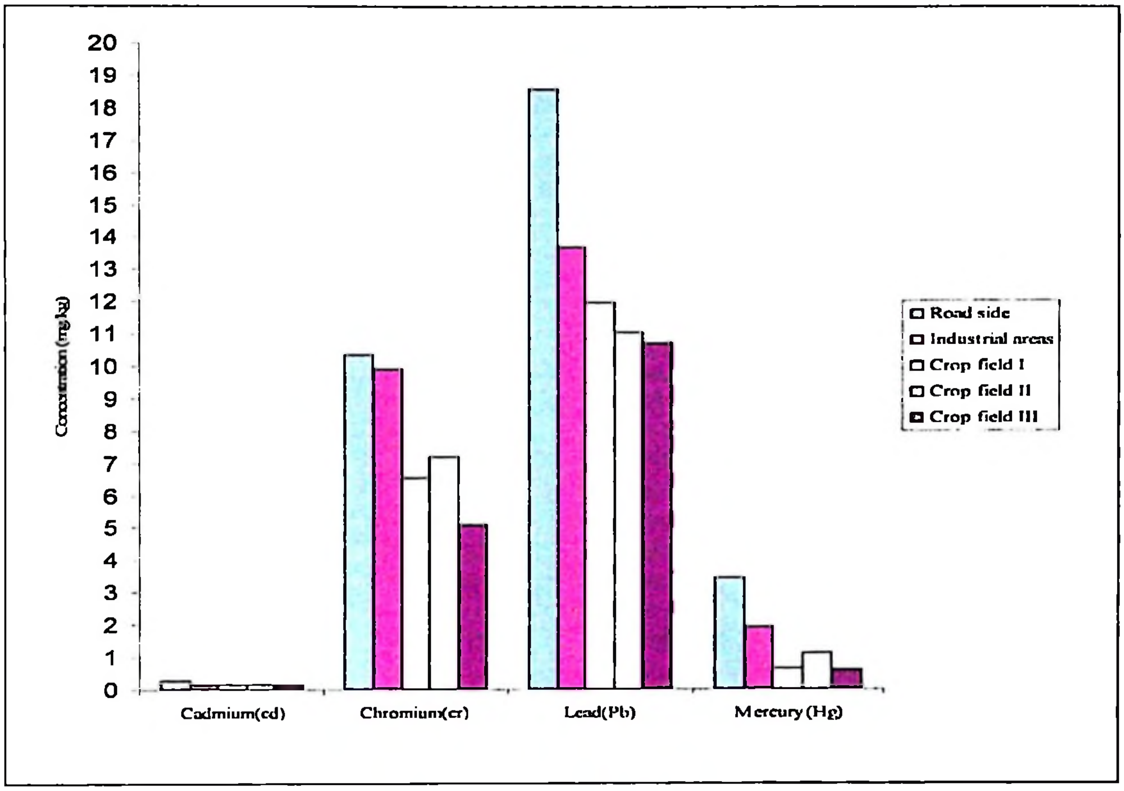

Figure 1: Concentration of heavy metals in soils of Nyamhongolo Village

4.2.2 Comparison of heavy metal concentration in soils sampled during the dry and wet seasons

As it is shown in Fig. 2 and Appendix 2(ii) the concentration of Lead was significantly ($P<0.001$) higher in soils sampled in the dry period than in soil samples collect during the wet season. Similarly the concentration of Cr in the soils sampled during the dry season was significantly ($P<0.001$) higher than those sampled in the wet season. On the other hand, Cd concentration in the soils sampled in the dry season was significantly ($P<0.001$) lower than those of wet season. The Mercury concentration in the soils sampled during the dry season was high, while in wet season Hg was not detected.

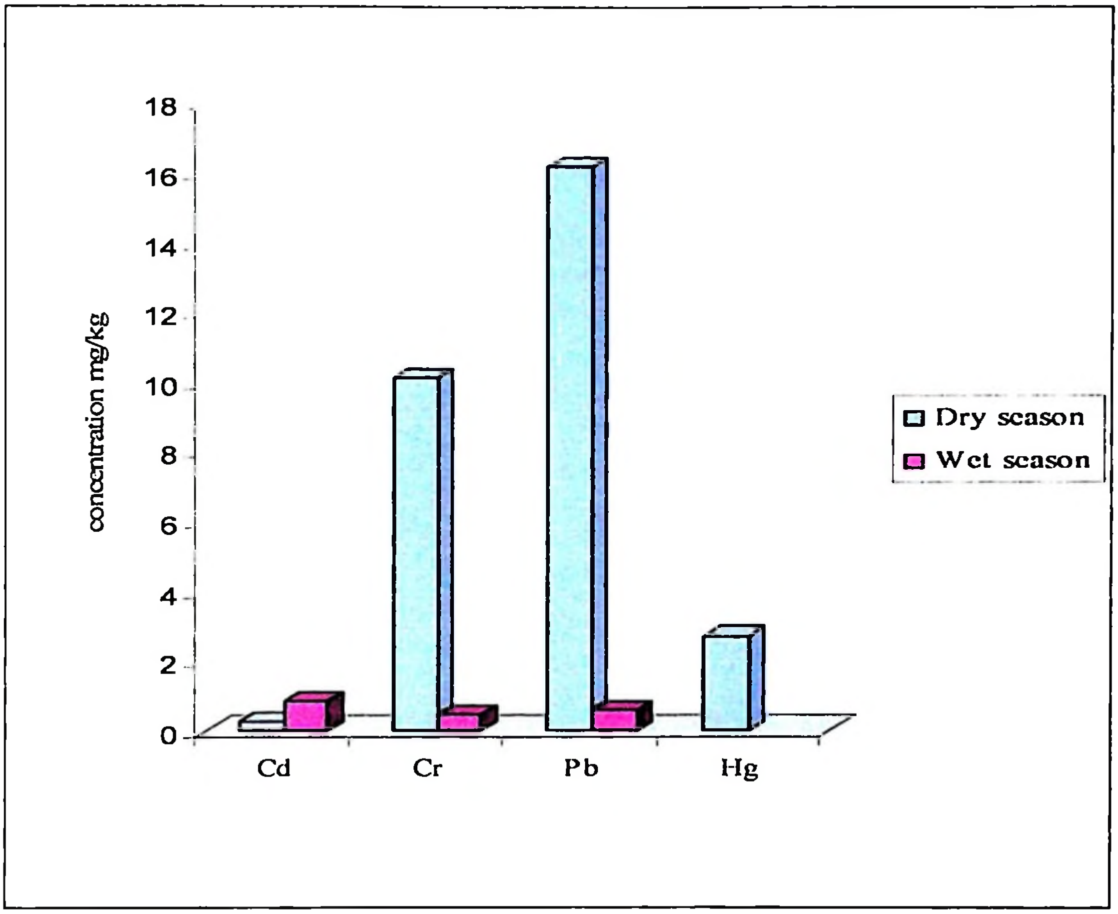

Figure 2: Concentration of heavy metal in soils during the dry and wet seasons

4.2.3 Comparison of heavy metal concentrations in *Cynodon spp* and *Oryza sativa* from road side, industrial area and crop fields

Among the heavy metals, the concentration of Cr in Cynodon and rice straw was the highest, followed by that of Pb and Cd (Fig.3) and Appendix 2(iii). When *Cynodon spp* and rice straws are compared the results show that on average rice straw had higher contents of Cr, Cd and Pb than *Cynodon spp*.

Chromium

The results show that the content of chromium in rice straws from crop field I was significantly ($P < 0.05$) higher than those of crop field II and crop field III. However, the concentration of the same chemical in *Cynodon spp* was significantly ($P < 0.05$) higher in the samples from industrial area than in *Cynodon spp* from the road sides.

Lead

The concentration of Pb in rice straws from crop field I and crop field II did not differ significantly ($P > 0.05$). The concentration of Pb in rise straw from crop field III was significantly ($P < 0.05$) lower than that of the samples from crop field I and II. The Pb content in *Cynodon spp* from the industrial area was significantly ($P < 0.05$) lower than in those from the road side.

Cadmium

The concentration of Cd in rice straws did not differ significantly ($P > 0.05$) among the crop fields. However, the concentration of Cd in rice straws from crop fields III was slightly higher than those of crop field I and II. The concentrations of Cd in *Cynodon spp* from road sides and industrial areas were lower than those in rice straws, but not significantly ($P > 0.05$) different from each other.

Mercury

The concentration of Hg from all samples was very small (< 0.01 mg/kg) and did not differ among the samples of rice straws and *Cynodon spp* from different sites.

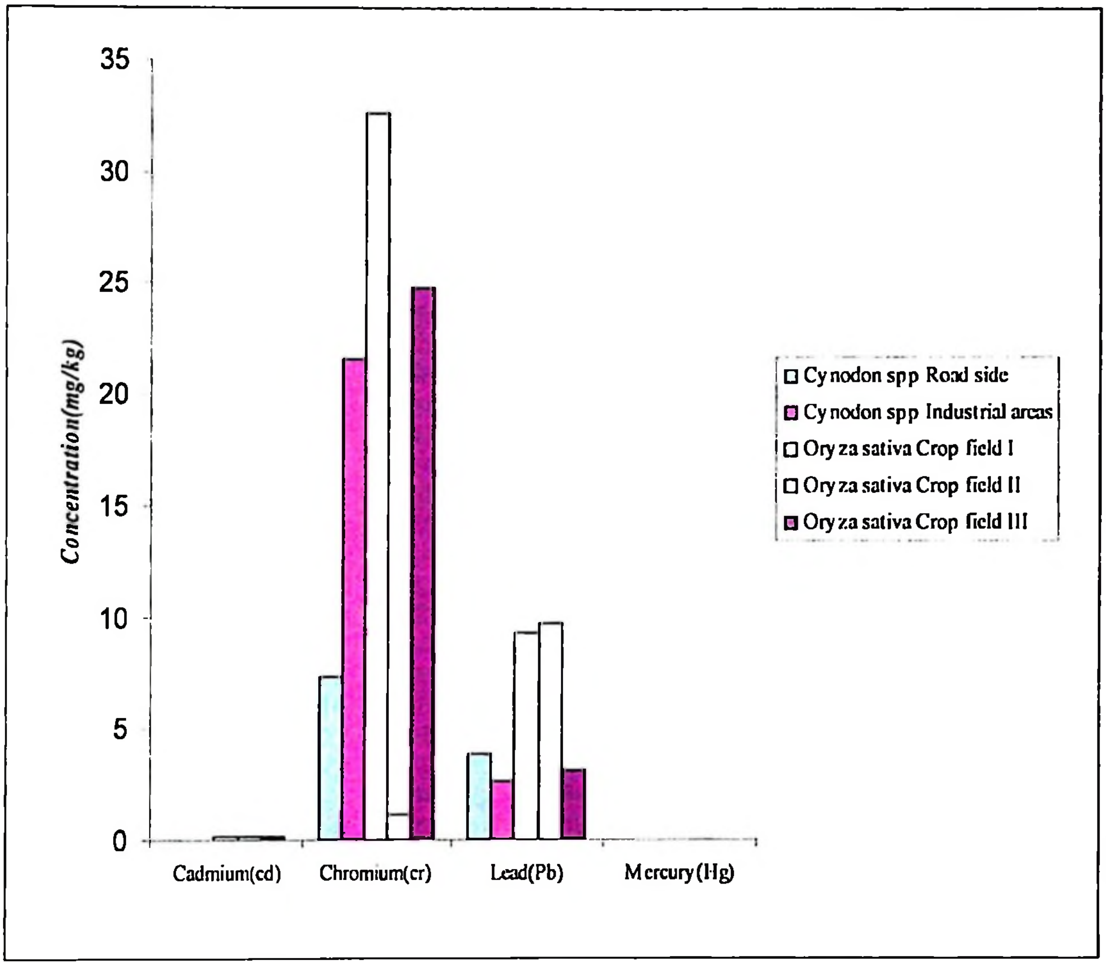

Figure 3: Concentration of heavy metals in *Cynodon spp* and *Oryza sativa* in Nyamhongolo Village

4.2.4 Heavy metal concentration in different forages

Concentration of Pb, Cr, Hg and Cd in different forages is presented in Table 4. The results show that the concentrations of Lead were the highest among the four elements. The highest concentration of Pb was observed in *Commelina spp* (312.65 mg/kg) while the lowest was found in *Oxytenanthea abyssinica* (1.2 mg/kg). Chromium content was the second highest and ranged from < 0.01 mg/kg to 11.26 mg/kg in *Cynodon dactylon* and *Cucumig spp*, respectively. The results further indicate that the content of Cd in the forages was the third highest and ranged from 0.00 in *Sida acuta*, *cucumig spp* and *indigofera spp* to 0.24 mg/kg in *Agerantum coryzoides*. With regard to Mercury a significant amount was observed only in *Psidium guajava* (0.23 mg/kg) while the rest of the forages had more or less the same concentration (< 0.01).

Table 4: Heavy metal concentration in different forages

Scientific name	Common name	Concentration (mg/kg)			
		Cd	Cr	Pb	Hg
Psidium guajava	Guava	< 0.01	2.51	15.77	0.23
Desmodium uncinatum	silver leaf desmodium	< 0.01	0.36	1.44	< 0.01
Penisetum purpureum	elephant grass	0.145	8.55	75.91	< 0.01
Acacia spp	Three thorned acacia	0.19	0.75	1.52	< 0.01
Hypperhenia spp	Jaragua grass	0.03	0.52	1.43	< 0.01
Ipomea aquatica	Water Spinach	0.08	1.95	65.38	< 0.01
Oxytenanthea abyssnica	Wild bamboo	< 0.01	0.45	1.2	< 0.01
Agerantum coryzoides	Goat weed	0.24	0.56	1.68	< 0.01
Manihot glaziovii	tree cassava	0.15	0.045	1.35	< 0.01
Azardiracta	Juss meliaceae	0.15	1.05	1.8	< 0.01
Commelina spp	Wondering jew	0.075	1.725	312.465	0.01
Mangifera indica	Mango	< 0.01	0.32	1.44	< 0.01
Mussa spp	Banana	<0.01	0.52	1.75	<0.01
Melia azardiracta	Ceylon mahogany	0.04	2.73	55.79	< 0.01
Panicum maximum	Guinea grass	< 0.01	2.02	50.45	< 0.01
Cynodon dactylon	Bermuda grass	<0.01	<0.01	105.82	< 0.01
Phragmites australis	Mianzi	< 0.01	4.26	21	< 0.01
Sida acuta	Wire weed	< 0.00	5.06	31.11	< 0.01
Cucumig Spp	Salasala	< 0.00	11.26	58.47	< 0.01
Indigofera Spp	Indigoes	< 0.00	8.36	16.6	< 0.01
Cyperus papyrus	Papyrus	0.157	7.40	40.35	0.01

4.2.5 Concentration of heavy metals in different concentrate feeds from Kirumba market, Mwanza, Tanzania

Fig. 4 and Appendix 2(iv) show the contents of Cr, Cd, Hg and Pb in different concentrate feeds. The content of Pb in all concentrates was the highest, followed by that of Cr and Cd.

Lead

Fishmeal had significantly ($P<0.05$) higher Pb content than the rest of the feeds. Moreover, Pb content in cotton seed cake was significantly ($P<0.05$) higher than in sunflower cake, rice straw and maize bran. On the other hand, sunflower cake had significantly ($P<0.05$) higher Pb content than rice bran while maize bran had the lowest concentration of Pb.

Chromium

The concentration of Cr in fishmeal was significantly ($P<0.05$) higher than the Cr content of the rest of the feedstuffs. Similarly Cr content in sunflower seed cake was higher than that of cotton seed cake, rice bran and maize bran. The content of Cr in cotton seed cake, rice bran and maize bran were not significantly different.

Cadmium

The concentrations of Cd in fish meal and cotton seed cake were significantly ($P<0.05$) higher than in the rest of the feedstuffs. But cadmium contents in sunflower seed cake, rice bran and maize bran did not differ significantly.

Mercury

The level of mercury in all the concentrates was insignificant.

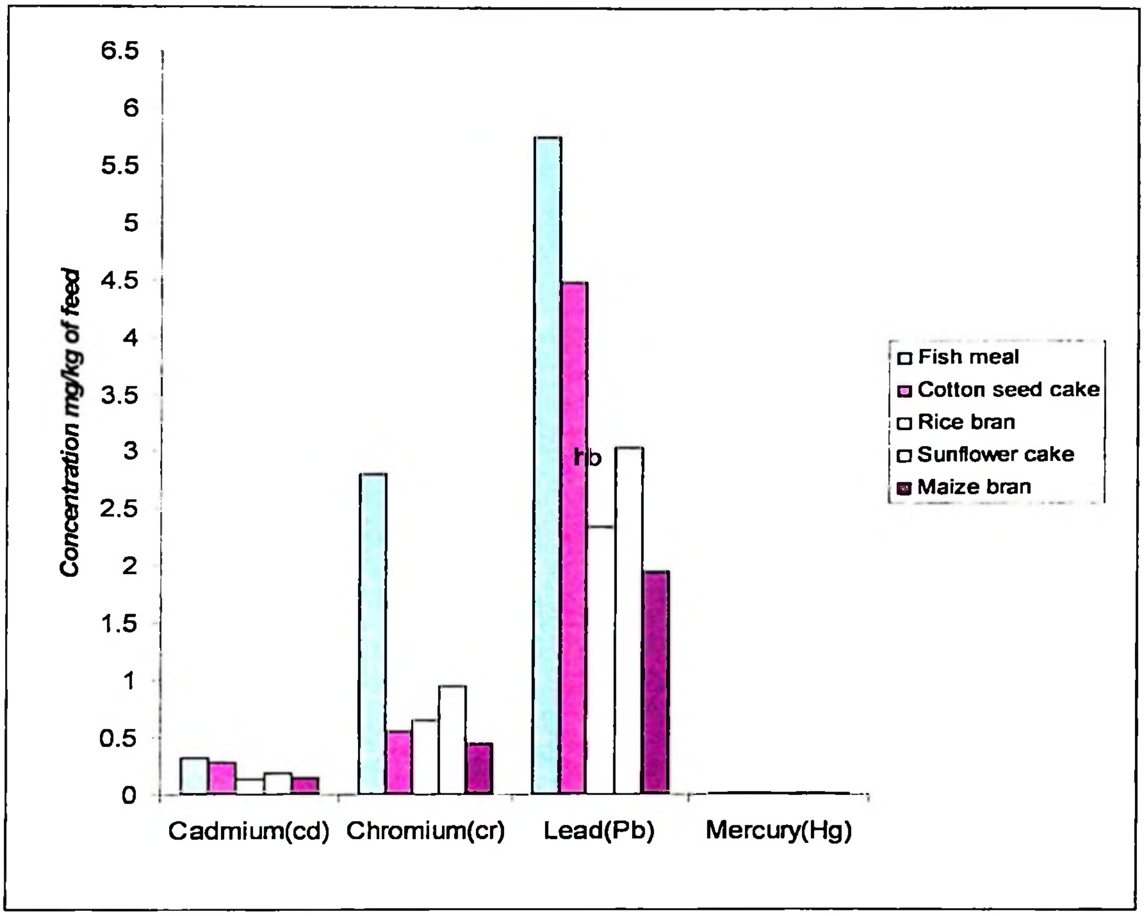

Figure 4: Concentration of heavy metals in different concentrate feed stuff at Kirumba market

4.2.6 Heavy Metal concentration in Milk and Water

The concentrations of different metals in water and milk are shown in Table 5. The concentrations of Pb, Cr and Cd were higher in lower stream (Nyashishi-Buhongwa River) than in the upper stream (Nyamhongolo River). The result indicates that the amount of Lead was significantly ($P<0.05$) higher in water than the concentrations of the rest of the elements. The concentration of Cd, Cr and Hg was slightly higher in dry season than in wet season. Similarly, the concentration of Pb in milk was significantly ($P< 0.05$) higher than the concentrations of other chemicals (Cd, Cr and Hg).

Table 5: Mean (± SE) concentration (mg/kg) of different heavy metals in water and milk during the dry and wet seasons

		Water (mean ± S.e.)		Milk (mean) ± s.e.)	
Location	**Element**	**Wet season**	**Dry season**	**Wet season**	**Dry season**
Nyamhongolo river	Cd	0.0 ± 0.00	0.0100 ± .0013	0.0100 ± .0025	NA
	Cr	0.0 ± 0.00	0.0100 ± 0.0013	0.0100 ± 0.0025	NA
	Pb	0.597 ± 0.37	0.125 ± 0.0013	0.0280 ± 0.0025	NA
	Hg	0.0	0.0100 ± 0.0013	0.0100 ± 0.0025	NA
Nyashishi Buhongwa river	Cd	0.106 ± 0.12	NA	NA	NA
	Cr	0.691 ± 0.69	NA	NA	NA
	Pb	0.970 ± 0.00	NA	NA	NA
	Hg	0.0	NA	NA	NA

NA = Data not available since samples were not collected during the dry season.

4.3 Agrochemicals Concentration in *Cynodon* spp and *Oryza sativa* from Nyamhongolo Village

Among the agrochemicals analyzed (DDT, Thiodan, Dieldrin and Lindane), only DDT was detected in appreciable amount (Fig.5) and Appendix 2(v). The concentration of DDT in rice straws from crop field II was significantly ($P<0.001$) higher than that of *Cynodon spp* from areas near roads and factories and rice straws from crop field I and III. The concentration of DDT from crop field III was the lowest. The concentration of DDT in *Cynodon spp* from road sides was significantly ($P<0.05$) higher than that of those from industrial area. All forage samples did not contain Thiodan, Dieldrin and Lindane.

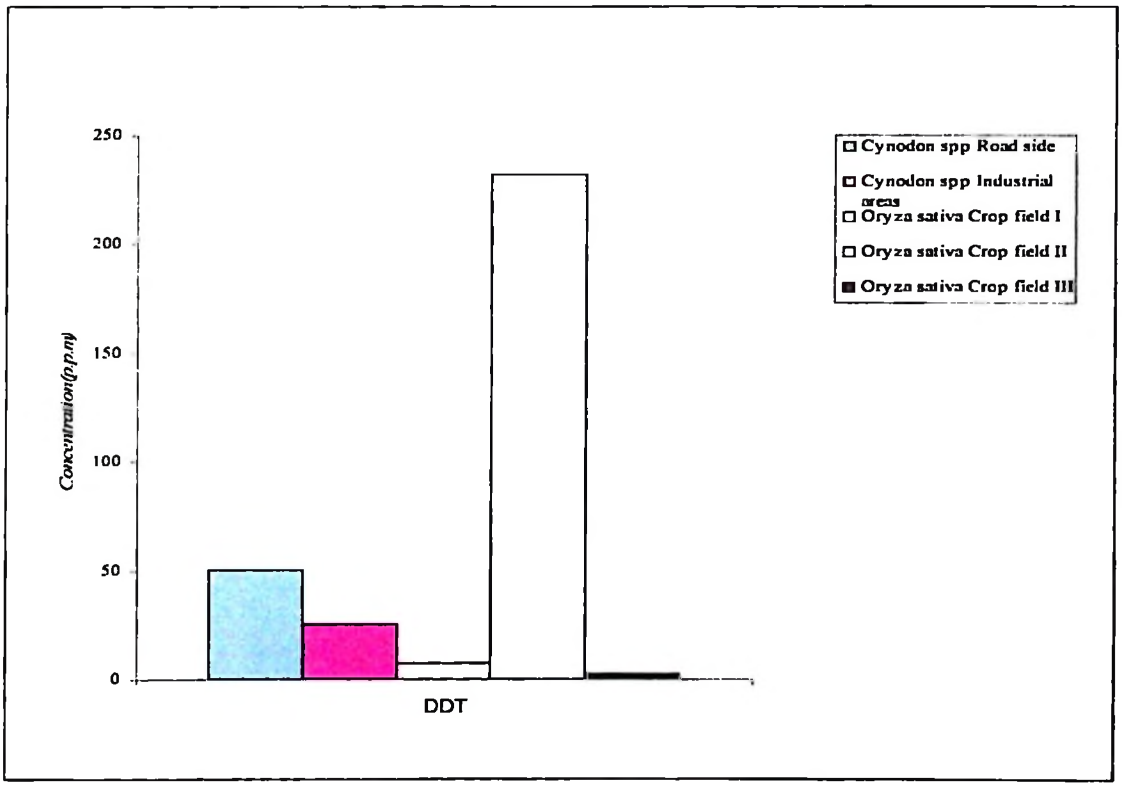

Figure 5: Occurrence of agrochemicals (DDT) in *Cynodon spp* and *Oryza sativa* in Nyamhongolo village

CHAPTER FIVE

5.0 DISCUSSION

5.1 Socio-Economic Survey

The observed high proportion of male headed households in this study is similar to the observations made in agro-pastoral communities in other parts of Tanzania (Ngowi *et al.*, 2008). The dominance in ownership of livestock by males in the study area is consistent with other studies made elsewhere in East and central Africa (Ellis and Freeman, 2004). Zebu cattle were the main breed kept by the farmers in the study area, an observation also reported by Rege *et al.* (2008). This is because many people believe that the Zebu cattle are resistant to endemic diseases such as tick-borne diseases and helminthiasis. The principal rearing system of cattle was herded grazing on communal lands. The practice involves frequent shifting of the animals to areas which are seen to have sufficient forages. This scheme of rearing is common in many parts of East Africa (Bellingham and Comes, 2003). Crop residues in the study area were used *in situ* during the dry season since the animals were freely grazed, a practice done in agro-pastoral and pastoral areas in Tanzania. This is contrary to Urio (2008) who reported that crop residues such as maize stovers and bean haulms are baled and then stall fed to milking cows. According to Gertenbach and Dugmore (2004), feeding of ruminants with such poor roughages is appropriate and can help to ameliorate the shortage of pastures during the dry season, since they are good converters of such roughages to meat and milk.

Most farmers in the study area offered their animals with limited supply of supplementary feeds, since they keep a local breed. In contrast, in other areas, dairy cattle are supplemented with grains, silage and oil cakes. Usually, farmers provide supplementary feeds to dairy cattle rather than meat producing cattle. Similar observation have been made by Aganga *et al.* (2005) who reported that Mollases-urea block, maize bran/sorghum and wheat bran are supplemented to dairy animals. Small dams and rivers were the main source of water for livestock. Provision of water to animals from rivers could make the animals drink polluted water as some rivers collect water from industries and other different sources contaminated by heavy metals (Annual Water Experts Conference, 2008).

5.2 Heavy Metal Concentration

This thesis was aimed at assessing the levels of potential environmental pollutants in the study areas by looking on heavy metals that are widely regarded as principal industrial wastes i.e. Lead, Chromium, Cadmium and Mercury. The concentrations of these elements were significantly ($P < 0.05$) higher in soil samples obtained from areas along the roads compared to samples from industrial areas. The high contents of these elements in soils near road sides owe their sources from the passing motor vehicles. This is in agreement with other studies (Luilo and Othman, 2003). According to Wilkinson *et al.* (2003) cars emit colloidal Pb and uncombusted Pb particulates containing tetra-alkyl lead, motor oil, Cd from tyres and Zn, Cu, Mn, Cr and other metals from wear of moving metallic parts in the car. These car emissions contaminate the soils and the pastures near the roads. Lead and zinc levels have been found to correlate with average daily traffic in the roads (Luilo and Othman, 2003).

The high levels of heavy metals, Pb, Cr and Cd observed in the rice straws, especially those from the crop field I (located 10 m from the road) is in agreement with Matsamura, (2004) who observed high levels of heavy metals in areas near factories, due to industrial pollution. Also it concurs to the observation by Parkpian *et al.* (2003) who showed that plants growing nearer to the highway are usually exposed to more heavy metal accumulations than those away from the highway. The levels of the heavy metals were higher in samples sampled during the dry season in soils and forages than in wet season. This is consistent with the observation made by Harrison (2008) who reported 0.008 - 0.05 mg/kg of Lead in wheat in wet season and 10 mg/kg of Lead in dry season.

Lead

The levels of Lead in the study area were high and were in close agreement with other researchers (Davis *et al.*, 1983, Makokha *et al.*, 2008) who found Pb content to range between 15 - 106 mg/kg. The soils of the area had such high amount probably due to being located near the highway, factories and the Lake Victoria, which is polluted by industrial wastes (Matsamura, 2004). The case of high Lead content in water observed in this study is in agreement with the findings reported by Makokha *et al.* (2008) and Klotz and Daniels (2007). These authors found lead content to range between 0.14 and 1.5 mg/kg in water. The high lead content in water in the study area was probably caused by the industrial discharge from the factories, as it has been reported by other studies (Matsamura, 2004). The forages in the study area also had high levels of lead content and this is in agreement with Antonkiewcz and Jaiewcz (2002) and Makokha *et al.* (2008), who reported levels between 240 and 0.0029 mg/kg in forages. These forages in the study area had high levels of Lead, probably because they were sampled in polluted areas. According to Matsamura (2004), many areas around Lake Victoria are highly polluted with Industrial discharges, road traffic and mining activities. Fish meal from the study area had high Lead content. This is in consistent with Turmen *et al.* (2008) and Makokha *et al.* (2008) who observed levels of 0.0033 and 0.033 mg/kg of Lead in fish, respectively. The high level of Lead in fish meal from the study area was because the fish were obtained from the Lake Victoria which is highly polluted (Matsamura, 2004). Milk from the study area had also high content of Lead. This is in agreement with Yan *et al.* (2008) who reported levels of 0.1 mg/kg of Lead in milk. It seems that milk was obtained from cows which grazed on polluted pastures.

Chromium

Chromium content in soils of the study area was high. This is in contrary to the observations made by Ajit *et al.* (1993) who found 0.1 mg/kg Cr in soils. The high Cr content in the study area could be the result of polluted water from the industries and sewage wastes as reported by Matsamura, (2004). Similarly the Cr content in the forages were high and this is contrary to other observers (Garcia *et al.*, 1999) who reported Cr levels in the range of 0.029 - 0.367 mg/kg in forages. The high Cr content in the study area might have come from polluted industrial effluents, and mining areas as reported by other researchers (Matsamura, (2004). High levels of Cr were also observed in fish meal in the present study. This also is contrary to other studies (Turmen *et al.*, 2008) which reported the concentration of 0.001 mg/kg Cr in fish meal. On the other hand, water had low Cr levels, this differed from the results obtained by Shaker *et al.* (2005) who reported levels of 0.1 mg/kg. The high levels of Cr observed in water were probably due to nearness of the sampling location to the Lake Victoria which is polluted with heavy metals as reported by Matsamura (2004).

Cadmium and Mercury

Cadmium and Mercury contents in the soils, forages and fish in the study area were low. This is contrary to the findings of other researchers (Chandri *et al.*, 2001; Turmen *et al.*, 2008) who reported levels of 0.24 mg/kg Cd in forages, 3.37 mg/kg Hg in soil and 0.001 mg/kg Cd in fish.

5.3 Agrochemicals Concentration in *Cynodon spp* and *Oryza sativa*

The high levels of DDT observed in the study area are in contrast to other findings (Mary *et al.*, 1993) which reported levels of 0.1 mg/kg of DDT. However, the levels in the present study are in close agreement with the results obtained by Rupa *et al.* (1989) who found 500 mg/kg in forage samples. The high DDT levels found in the study area is due to the practice of spraying DDT in stagnant water near the industrial streams to control mosquitoes, the vector for malaria parasites. It seems that the DDT sprayed in the water stream eventually flowed into the crop fields and forages. Therefore, animals grazing in communal lands and cereal crop fields in Mwanza peri-urban areas are at high risk of ingesting DDT residues. This posses a public heath concern because of the possible movement of the chemical from the forages to animals and ultimately to humans through consumption of livestock products.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The aim of this study was to assess the levels of heavy metals and agrochemicals in ruminants' feeds, water and milk in areas around factories, roads. and crop fields. The results showed that the soils from areas near roads had the highest contents of heavy metals, followed by those from industrial areas. The concentration of Lead in the soils around the roads and industries was higher than that of chromium, which in turn, was higher than that of mercury and cadmium. The high levels of Lead observed in the soils were reflected in forages. water and milk. Chromium content in rice straws was higher that Lead content. The levels of Cd and Hg were below the toxic levels in all samples. Fish meal. cotton seed cake and maize bran collected at Kirumba market all contained high levels of Pb, Cr and Cd. making their use rather risky. Higher levels of Cr, Pb and Cd were found in rice straws than in *Cynodon spp* obtained from the industrial areas and roadsides indicating unsafe use of the straws as livestock feeds. Higher levels of Pb and Cr were observed in samples collected in the dry season than in those of wet season. The Dichlorophenyl Trichloroacetic Acid (DDT) was found in crop residues at levels four times higher than in forages within the same vicinity. The high DDT content in rice straws could be linked to the extensive use of the chemical by the Malaria eradication project.

6.2 Recommendations

(i) Livestock keepers should not graze or cut grass from the areas along the roadsides and industrial areas, so as to prevent their livestock from being contaminated by both heavy metals and agrochemicals.

(ii) Rice straws from peri-urban areas of Mwanza city should be used with caution so as to avoid excess intake of DDT, Lead and Chromium.

(iii) Concentrates from Kirumba market should be used sparingly because of fear of high content of heavy metals.

(iv) Further research should be done on the study area on how to reduce the levels of the heavy metals and agrochemical (DDT) found in the soils and livestock feeds for the safety of both animals and human lives.

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APPENDICES

Appendix 1: Questionnaire on Assessment of Heavy Metals and Agrochemical residues in Ruminants feeds and milk: A case study of Urban and Peri - urban areas of Mwanza City

1.0. General

1.1. Questionnaire No ....

1.2. Name of enumerator ....

1.3. Date ....

1.4. Village ....

1.5. Average altitude ....

1.6. GPS Co-ordinates [Easting (Latitude) .... Southing (Longitude)] ....

1.7. Ward / Location ....

1.8. District ....

2.0. Household

2.1. Name of interviewee..

2.2. Gender: Male / Female

2.3. Age (..............................)

2.4. Education ....

3.0. Field crop production

Do you own any field for crop production?

a) Yes b) No

If yes,

3.1. How many fields do you have? ....

3.2. How much land do you own (acres)? ....

3.4 What crops do you often grow every year/season

Sole crop (Monoculture)	**Combination (mixed cropping)**
1.	1.
2.	2.
3.	3.
4.	4
5.	5.
6.	6.

3.5 Do you apply pesticides in your crop fields Yes/No

3.6 If Yes mention the name of the pesticide..

3.7 How frequently do you apply the pesticide ....

3.8. Use of different crops

Crop	**Uses**	
	Crops	**Residues**
1.		
2.		
3.		
4.		
5.		
6.		

4.0. How do you utilize crop residues when you have harvested your crops? (Tick- ☐ all possible answers)

a) Grazed in situ by my own animals

b) Grazed in situ by other peoples' animals

c) Collected and brought home for animal feeding

....

....

....

5.0. Livestock

5.1. Number:

5.1.1. Improved .... Cows .... Calves .... Yearling .... Bulls ....

5.1.2. Local .... Cows .... Calves .... Yearling .... Bulls ....

5.2. Ownership: who owns:-

Livestock	Husband	Wife	Both	Others
Cattle				
Sheep				
Goat				
Chicken				
Pig				
Others (mention)				

5.4. How do you feed your livestock?

a) Zero grazing b) free range

c) Combination of both a & b d) Tethering e) Headed grazing

5.5. If you **free graze** only. where do you send your animals to?

....

5.6. If you **free graze** only, do you consider areas where forages are obtained to have sufficient for forage supply throughout the year?

a) Yes b) No

5.7.1. Explain any coping strategies with forage deficit

....

5.7.2. Do you offer supplementary feeds? Yes / No

5.7.3. Which ones (Mention)

....

5.7.4. What is the source of the supplementary feed?

....

5.8. Please mention some forages and their availability according to season (Wet / Dry – Month)

	Month	**Season**
Grass		
Legume		
Tree / shrub		

5.9 Source of water for your livestock: a) Tap ----------- b) Boreholes -----------
c) Rivers ------------

6. What are the major diseases/parasites that affect your animals? Mention

....

7. What are the copping strategies?..

THANK YOU FOR YOUR CO-OPERATION IN THIS EXERCISE AND FOR ENLIGHTENING ME ON YOUR CROP / LIVESTOCK PRODUCTION ACTIVITIES IN THIS AREA

Appendix 2: Heavy metals and agrochemical in samples

(i) Heavy metals concentration in Soils of Nyamhongolo Village

Location	Sample	Concentration (Mg/kg)			
		Cd	Cr	Pb	Hg
Roadsides	Soil	0.3	10.35	18.06	3.45
Industrial area	soil	0.16	9.92	13.76	1.92
Crop field (i)	soil	0.116	6.56	11.96	0.64
Crop field (ii)	soil	0.16	7.02	11.04	1.12
Crop field (iii)	soil	0.16	5.12	10.72	0.16

(ii) Comparison of heavy metal concentration in soils during dry and wet seasons

Location	Sample	Concentration mg /kg			
Dry season		Cd	Cr	pb	Hg
Roadside	Soil	0.3	10.35	18.6	3.35
Industrial area	Soil	0.16	9.92	13.76	1.92
Crop field 1	Soil	0.16	6.56	11.96	0.64
Crop field 11	Soil	0.16	7.2	11.04	1.12
Crop field111	Soil	0.16	5.12	10.7	0.16
Wet season					
Buhongwa	Soil	0.67	0.46	0.598	-
Nyashishi	Soil	0.33	0.46	0.598	-
Igoma	Soil	1.000	0.46	0.598	-

(iii) Concentration of heavy metals in *Cynodon Spp* and *Oryza sativa* in Nyamhongolo Village

Location	Sample	Concentration(mg/kg)			
		Cr	Cr	Pb	Hg
Roadside	*Cynodon spp*	<0.01	7.36	3.91	<0.01
Industrial area	*Cynodon spp*	<0.01	21.06	2.06	<0.01
Crop field (i)	*Oryza sativa*	0.16	32.64	9.28	<0.01
Crop field (ii)	*Oryza sativa*	0.19	1.14	9.09	<0.01
Crop field (iii)	*Oryza sativa*	0.17	24.84	3.14	<0.01

(iv)Concentration of heavy metals in different concentrate feed stuff at Kirumba market

Location	Sample	Concentration (mg/kg)			
		Cd	Cr	Pb	Hg
Kirumba market	Fish meal	0.32	2.8	5.76	<0.01
Kirumba market	Cotton seed cake	0.28	0.56	4.48	<0.01
Kirumba market	Rice bran	0.13	0.65	2.34	<0.01
Kirumba market	Sunflower cake	0.19	0.95	3.04	<0.01
Kirumba market	Maize bran	0.15	0.45	1.95	<0.01

(v)DDT Concentration in forages and crop residues

Location	Sample	Concentrations DDT P.P.M
Road side	*Cynodon spp*	50.201610
Industrial area	*Cynodon spp*	25.367810
Crop field (I)	*Oryza sativa*	7.361998
Crop field (ii)	*Oryza sativa*	232.066660
Crop field (iii)	*Oryza sativa*	2.611402