UNIVERSITY OF NAIROBI

ANALYSIS OF HEAVY METALS IN SELECTED FOODSTUFFS FROM DIFFERENT ESTATES IN NAIROBI METROPOLITAN AREA

IMWENE KENNEDY OMUKADA

I14/32852/2014

A Project submitted in partial fulfillment of the requirements for the award of the Degree of Bachelor of Science in Analytical Chemistry of the University of Nairobi.

2018

DECLARATION

I declare that this project is my original work and has not been submitted elsewhere for research. Where other people's work or my own work has been used, this has properly been acknowledged and referenced in accordance with the University of Nairobi's requirements.

Signature ……………………………………Date………………………………………….

IMWENE KENNEDY OMUKADA

I14/32852/2014

This project has been submitted for examination with my approval as the University Supervisor.

Signature ……………………….....................Date………………………………………….

DR. VINCENT O. MADADI

DEPARTMENT OF CHEMISTRY

DEDICATION

This project is dedicated to my dear parents, the late Mr. Pascal Omukada Odisa and Mrs. Anjeline Ateng'e, my brothers Evans, Hannington, Kelvin, Ian, my sister Bridgit, my dear wife Esnas and to my children Cynthia, Gloria, and Clarence.

ACKNOWLEDGEMENT

I wish to acknowledge and appreciate my supervisor, Dr. Vincent O. Madadi (Phd) for the supervision, constructive comments, encouragement and guidance he provided me throughout my research. His invaluable support and advice is unforgettable.

My special appreciation goes to the butcheries in Mlolongo, Kibera, Pangani and Ruaka, my colleague students in research project and not forgetting the pesticide Lab University of Nairobi technical team Mr. Enock Osoro, Mrs. Masese and to Mr. Mwangi the Analytical Lab technician University of Nairobi-Chiromo. And finally my most appreciation to almighty GOD for his help in spiritual and moral hope

ABSTRACT

This study investigated heavy metals contamination in sugar, maize flour, cattle milk, chicken eggs, meat and liver for both cattle and goat from four locations within the Nairobi Metropolitan area. 33 samples were collected in duplicates from 10th August 2018 to 17th August 2018. The samples were wet digested and analyzed for heavy metals using Atomic Absorption Spectrometer. The concentration of **Chromium (Cr),** ranges (beef 63.33±2.9 mg/kg to 76.66±0.98 mg/kg, goat meat 69.81±0.00 mg/kg to 84.50±0.49 mg/kg, cow liver 78.23±2.40 mg/kg to 89.6±2.1 mg/kg, goat liver 82.9±0.58 mg/kg to 90.4±1.90 mg/kg, hen eggs 29.1±0.53 mg/kg to 37.4±1.20 mg/kg, maize flour 25.42±0.36 mg/kg to 29.28±0.01 mg/kg, cattle milk 6.0±0.09 mg/kg to7.35±0.25 mg/kg, sugar 16.21±0.62 mg/kg to 21.8±0.68 mg/kg). **Cadmium (Cd)** ranges (beef 0.37±0.18 mg/kg to 0.60±0.05 mg/kg, goat meat 0.32±0.01 mg/kg to 0.57±0.07 mg/kg, cow liver 0.62±0.08 mg/kg to 0.79±0.03 mg/kg, goat liver 0.64±0.13 mg/kg to 0.87±0.14 mg/kg, chicken eggs 0.20±0.01 mg/kg to 0.39±0.18 mg/kg, maize flour 0.13±0.10 mg/kg to 0.25±0.07 mg/kg, cattle milk 0.03±0.01 mg/kg to 0.04±0.01 mg/kg, sugar 0.22±0.01 mg/kg to 1.48±0.02 mg/kg). **Nickel (Ni)** (beef 3.5±1.50 mg/kg to 10.8±1.30 mg/kg, goat meat 19.73±1.23 mg/kg to 23.2±0.52 mg/kg, cow liver 30.52±2.05 mg/kg to 47.03±1.84 mg/kg, goat liver 47.7±1.40 mg/kg to 57.9±2.40 mg/kg, hen egg 5.03±0.14 mg/kg to 9.63±0.02 mg/kg, maize flour 2.97±0.18 mg/kg to 3.17±0.27 mg/kg, cattle milk 1.17±0.03 mg/kg to 1.82±0.17 mg/kg, sugar 4.01±0.06 mg/kg to 6.7±0.02 mg/kg).

The data suggests that the concentration of most of these heavy metals was above the permissible exposure limit recommended by the WHO. This raises concern due to bioaccumulation and chronic effect of these metals on health. In view of present investigations, to avoid heavy metal residues entry to food chain through contaminated feed and water, hence immediate measures must be carried out for the treatment and detoxification of industrial and domestic effluents which may reduce potential risks to human life.

Keywords: *Foodstuff contamination, heavy metal pollution, Nairobi Metropolitan*

LIST OF TABLES

TABLE OF FIGURES

ABBREVIATION

W H O	World Health Organization
UNEP	United Nations Environmental Program
AAS	Atomic Absorption Spectrometer
UNCSD	United Nation Conference on Sustainable Development

L liter

UNITS OF MEASUREMENT

Ppm	parts per million
Ml	milliliter
Kg	kilogram
L	liter

g grams

mg milligram

mg/l milligram per liter

º C degree celsius

v/v volume per volume

CHAPTER ONE

- ## INTRODUCTION
    - ### Background of the study

A heavy metal is a chemical element that has a relatively high density of >5g/cm3 and is toxic at low concentrations, example include Chromium, Cadmium, Nickel (Tiller.,1989). With increasing industrialization, more metals are entering into the environment.

Exposure of farm animals to heavy metals constitutes a major public health concern considering that these animals are often reared for their meat and milk products (Okareh & Oladipo, 2015).

The essential metals in trace levels play vital role when present in human body. Ions of transition metals essential for life include manganese, iron, nickel, cobalt, zinc, copper, and chromium. Metals are useful for metabolic activities acting as catalyst. Trace metals are micronutrients required in trace level in plants as well as animals. Micro level imply requirement only in small concentration.

Heavy metal toxicity is one of the major current environment health problems and is potentially dangerous because of bio-accumulation through the food chain (Okareh & Oladipo, 2015) and this can cause hazardous effects on livestock and human health (Malakootian et al., 2009). Trace heavy metals like Cadmium can exist in the association with macronutrients. This association can influence the proper work of the metals by pairing. The main source of toxicity nowadays is food. Food processing methods are commonly responsible for the contamination of human food by toxic metals.

The maximum permissible level of toxic metal in human food has been established by the WHO expert committee on food additives recommended a provisional maximum tolerable daily intake for Cd, Co, Ni, Cu, and Zn from all sources of food, air, water as (1-2, 3.5-4, 2-4, 8-15 mg/kg) of body mass respectively.

1.1.1 Sugar

Sugar factory is of the biggest factory manufacturing sugar for consumption of mankind. The factory uses fertilizers to produce sugarcane and chemicals to process cane juice. Heavy metals in sugar cane are a function of physical and chemical nature of the soil as well as plants which absorb these metals from deposits on the parts of their roots by wet or dry deposition from polluted environment (Yadata, 2014).

1.1.2 Hen Eggs

The birds are bred to fulfill the ever increasing requirement of animal protein for the majority of the world population, Many developing countries have adopted intensive poultry production to meet the demand of animal protein. Fresh eggs are among the most important and nutritious food in the daily diet, moreover, eggs are included in several food products for different functions. Global environment is polluted with heavy metal which leads to an increased interest in metal contamination of food stuffs and amongst them eggs which represent an important part of human's diet especially in children (Hashish, Abdel-Samee, & Abdel-Wahhab, 2012).

1.1.3 Maize Flour

Maize is one of the most widely grown cereals in the nation, is an energy-rich food, including (Draszawka, 2014)vitamins A and the complex B, proteins, fats, and carbohydrates. As in sugar, maize flour factory uses fertilizers to produce maize and chemicals to process maize flour. Maize is an energy-rich food, including vitamins A and the complex B, proteins, fats, carbohydrates, and starch in its composition (Article, 2018).

1.1.4 Meat and Liver

Meat and Liver are very important human food, they represent the main source of protein in the diet of consumers, are very rich of nutrients including microelements, the chemical composition of meat and liver depends on both the kind and degree of the feeding animals. Metals in general can be classified as toxic (cadmium, mercury) and of essential (cobalt, copper, zinc, iron etc).(Ijaz Javed, Bilal Aslam, Faqir Muhammad, Muhammad Zargham Khan, Zia-ur-Rahman, Mahmood Ahmad, 2013)

1.1.5 Cattle Milk

Milk is known as an excellent source of Calcium and it can supply smaller amount of Zinc and every small contents of Iron and Copper. Agriculture constitutes one of the very important non-point sources of metals pollutants. Milk has a positive influence on human health. It is considered as nearly complete food since they are good source of proteins, fats, vitamin supplements and major minerals (Muhib et al., 2016).

- **Statement of the Problem**

Due to the growing concern about food quality across the globe, many deaths have been reported as a result of using contaminated food. Contamination can be natural or anthropogenic. Human activities such as Agricultural practice, sewerage, and industrial waste discharges in the rivers, lakes, seas and oceans enhances water and food pollution, which accumulate and cause high blood pressure, cancerous changes, kidneys damage, liver and brain diseases(Sids & Publications, 2017) . Due to this, foodstuff which include different brands of sugar, brands of milk, four local (kienyeji) and one hybrid eggs, Cattle meat and liver and goat meat and liver were chosen as an area of interest to monitor the amount of heavy metals(Cr, Cd and Ni,).

- **Hypothesis**

Null hypothesis: There is no significance levels of heavy metals in different foodstuff samples.

Alternative hypothesis: There is significance levels of heavy metals in different foodstuff samples.

- ## Research Objectives

1.4.1 Overall objective

To assess the extent of heavy metals contamination in selected foodstuff samples from different estates of Nairobi metropolitan area.

1.4.2 Specific objective

1) To quantitatively measure the concentration of trace metals in selected foodstuff samples from farms and industries of Nairobi metropolitan area.

1.4.3 The significance of these study:

1) To add the information about the industrialization aspect in accommodating metals ions.

- **1.5 Justification of the study**

The environment has continued to degrade as a result of pollution due to increased population and industrialization (Guerra, Trevizam, Muraoka, Marcante, & Canniatti-brazaca, 2012).that contribute to disposal of agrochemicals and industrial effluent into aquatic system (Ahmed, 2018).Disposal of domestic waste, agrochemicals and industrial waste into rivers leading into contamination of water bodies which is used for food processing as well as used by animals. When such water are consumed by human beings, animals or used in Agricultural use, the heavy metals accumulates in the body leading to chronic health effect (Guerra, Trevizam, Muraoka, Marcante, & Canniatti-brazaca, 2012). Therefore , foodstuff which include cattle meat and liver, goat meat and liver, cattle milk, hen eggs, maize flour and Sugar were identified for determining the level of heavy met.

- # CHAPTER TWO

- ## 2 LITERATURE REVIEW

- ### 2.1 Heavy metals in samples

Heavy metals are naturally occurring elements, and are present in varying concentrations in all ecosystems. They are found in elemental form and in a variety of other chemical compounds. Those that are volatile and those that become attached to fine particles can be widely transported on very large scales. Each form of compound has different properties which also affect what happens to it in food web, and how toxic it is.

Human activities have drastically changed the biochemical cycles and balance of some heavy metals. Between 1850 and 1990 production of copper, lead and zinc increased 10-fold (Nriagu, 1995 and Cacar., 1996). The metals classified as heavy metals include: Cu, Co, Cr, Cd, Fe, Zn, Pb, Sn, Hg, Mn, Ni, Mo, V, W (Belt, Bay, Proper, Basin, & Quark, 2017). Heavy metals get into water bodies through industrial effluents, sewerage discharges as well as agricultural run-off (Malakootian et al., 2009). The strongest toxic properties are characteristic for inorganic metals compounds, which dissociate well and are easily soluble because they can easily penetrate through cell membranes and get into internal organs. These metals accumulate mainly in the kidneys the adrenal glands, liver. Lungs, hair and skin and eventually may cause high blood pressure, cancerous changes, kidneys damage, liver and brain. In some cases they may also lead to mental disorders and loss of brain function (Mahurpawar, 2015).

Water pollution due to discharge of untreated industrial effluents into water bodies is a major problem in the global context (Ahmed, 2018). The problem of water pollution is being experienced by both developing and developed countries. Human activities give rise to water pollution by introducing various categories of substances or waste into a water body. The more common types of polluting substances include pathogenic organisms, oxygen demanding organic substances, plant nutrients that stimulate algal blooms, inorganic and organic toxic substances (Fosu-mensah, Addae, Yirenya-tawiah, & Nyame, 2017).

Wastewater from industries and sewage spillage from burst pipes in urban centers in Kenya are released into streams and wetlands which finally discharge into the surrounding lakes. With the prevailing hard economic situation in the country, most of the trade waste effluents are released into the environment untreated or partially treated. Industrialists have adopted the use of substandard treatment methods that partially treat and sometimes forego the effluent treatment process.

- **2.2 Heavy metal pollution**

Heavy metals are metallic chemical elements that have relatively high density and are toxic at low concentration (Pam, Ato, & Offem, 2013). These metals include the transitional metals, some metalloids, Lanthanides and actinides such as Chromium, arsenic, Cadmium, Lead, Mercury and Manganese. Metals generally exist in a positively charged form and can bind on to negatively-charged organic molecules. Heavy metals cannot be degraded or destroyed, therefore their stability make them as the persistent toxic substance in the environment (air and water). Since human health is greatly dependent on air and water, these metals pose health hazard to general public. The presence of heavy metal in water as contaminants is an indication of global industrialization attributed to large scale of inappropriate disposal and untreated of wastewater containing heavy metals from anthropogenic sources (Lokhande, Singare, & Pimple, 2011).

Most heavy metals such as mercury and Lead are silent toxic metals that have no known vital or beneficial effect on organisms, and their exposure and accumulation over a long period of time in the bodies of animals can cause serious illness. Heavy metals are stable and persistent environmental contaminants since they cannot be degrade or destroyed. Therefore, they tend to accumulate in the soil, Seawater, freshwater and sediments. In small quantities, certain heavy metals are nutritionally essential for a healthy life; iron, copper, manganese, and zinc. Some of these are referred to as the trace elements. These elements, or some form of them, are commonly found naturally in foodstuffs, in fruits and vegetables, and in commercially available multivitamin products. Heavy metals are commonly found in industrial processes that produce products such as pesticides, batteries, alloys, electroplating metal parts and textile dyes. Heavy metal naturally enters human body through ingestion, inhalation and absorption in small extent as trace elements. Trace elements are essential to maintain the metabolism of human body. However, trace amount of heavy metal are dangerous because they tend to bio-accumulate and bio-magnify. Bio-accumulation and bio-magnification increase the concentration of heavy metal in a biological organism or targeted organ over time until they become hazardous to health (Mahurpawar, 2015). This may lead to deficiencies in some nutrients and also result in diseases as, cancer, skin disorders, respiratory abnormalities, abdominal and intestinal problems, central nervous system damage, blood disorders and reproductive failure (Sids & Publications, n.d 2007). Acute exposure to high concentration of heavy metal can cause nausea, anorexia, vomiting, gastrointestinal abnormalities and dermatitis. From the perspective of human health, each of the heavy metal imparts different effects and symptoms (Al-qutob, Asafra, Nashashibi, & Qutob, 2014).

Rapid industrial growth throughout the world exerts negative impacts to the environment. Discharge of contaminated effluents without adequate consideration and treatment into the aquatic environment creates such implication.

Industrial wastewater which are associated with manufacturing of automobile, purification of metals, electroplating, galvanizing, coating, paint, electronics, pharmaceutical, and battery manufacturing are the most common source of heavy metal pollution. Arsenic, Cadmium, Copper, Chromium, Lead, Mercury, Nickel and Zinc are normally found in heavy metals contaminated wastewater (Lokhande et al., 2011).

Water serves as a medium of transport for pollutants, heavy metal damaging effects on both living organisms and the environment have been observed (Farag, 2000). Through aqueous medium, the pollutants can bio-accumulate and bio-magnify over time since they enter the biological system and ultimately they will reach high concentration. When this toxicity by heavy metal becomes significant in the tropic level, once it reaches human as the final consumer in the food web, the health will be compromised.

2.2.1 Chromium

The level of Chromium in the Air and in water is generally low. However contaminated well water may contain some dangerous Chromium (IV). Chromium is used in metal alloys and pigments for paints, cement, paper, rubber, and other materials. Low-level exposure to Chromium can irritate the skin and cause ulceration. Long-term exposure can cause kidney and liver damage, and also circulatory and nerve tissues (Okareh & Oladipo, 2015). Chromium often accumulates in aquatic environment posing danger to life, thereby extending danger of consuming aquatic animals such as fish that may have been exposed to high levels of Chromium. Chromium (III) is an essential nutrient in food consumed by human beings, and it's shortage may cause heart failure conditions, disruption of metabolisms and diabetes. However, the uptake of too much Chromium (III) can cause health effects as well, for example skin rashes. Chromium (IV) is highly toxic and poses real danger to human health. People who smoke tobacco also have higher chances of exposure to Chromium (Ijaz Javed, Bilal Aslam, Faqir Muhammad, Muhammad Zargham Khan, Zia-ur-Rahman, Mahmood Ahmad, 2013). Inhalation of Chromium (VI), causes nose irritations and nose bleeding. Other health problems that are caused by Chromium (VI) are: skin rashes, stomach upsets and ulcers, respiratory problems, weakened immune systems, kidney and liver damage, alteration of genetic material and lung cancer.

2.2.2 Cadmium

Cadmium is a soft, bluish-white metallic element that occurs naturally in the Earth's crust. It is often found as a mineral combined with other elements such as Oxygen, Chlorine and Sulphur. The only Cadmium mineral is greenockite (CdS), which exists as a coating on the Zinc Sulphide ore. Small amounts of Cadmium are found in Zinc, Copper, and Lead ores. It is generally produced as a by-product from the smelting of these metals, particularly Zinc (Agency, n.d.). The main use of Cadmium is electroplating of other metals or alloyed with other metals to form easily fusible compounds which can be used as coatings for other materials and welding and also in soldering process (Pam et al., 2013). Cadmium compounds are also used in printing, in textile, in television phosphors, photography, lasers, in semiconductors, solar cells, in dental amalgams and as pesticides. Cadmium compounds and proper disposal of waste from factories (Belt et al., 2017).Method of Cadmium exposure includes; the Air we breathe in has Cadmium particles or dust and this usually happens to people working where batteries are made and place where metals are processed, soldered or welded and smoking cigarette,

Drinking water and eating foods which are contaminated with Cadmium compounds. The lowest levels of Cadmium in food are in fruits and drinks while the highest level is in leafy vegetables and potatoes. Also eating foods containing little amount of iron or other nutrients can lead to Cadmium accumulation in the body since iron inhibits absorption of Lead and Cadmium in the body (Rapheal & Adebayo, 2011).The common symptom of Cadmium poisoning include degenerative diseases such as cancer, diabetes, arthritic syndromes, heart diseases, kidney diseases and others (Baetz & Kenner, 1973). Cadmium hardens and toughens the tissues and ages the body. It is associated with hardening of arteries, hardening and destruction of the kidney and all the organs (Appenroth, 2010).

Cadmium toxicity is associated with low sperm count, impotence in men, reduced fertility in women, and increased interest in sex by replacing some of the more feminine that they need, deep feminine mineral like Manganese, Selenium and others are replaced by or blocked in some way by Cadmium(Sarkar, Ravindran, Krishnamurthy, & Campus, 2013).

2.2.3 Nickel (Ni)

A metal is considered as an essential nutrient in cases where animals or plants cannot complete their life cycle in its absence and also it cannot be substituted with any other element (Air, From, & Of, 1984). Nickel was established as an essential nutrient for the completion of the life cycle.

Nickel in the environment occurs in the water bodies and in other atmospheres, usually in trace amounts. The release of municipal and industrial effluents significantly contributes Nickel (Ni) content to the soil and water but relative concentration depends on the source of effluent. Due to uncontrolled industrial and municipal discharges into the rivers are becoming highly polluted with Nickel (Ni) and other toxic metals, which sediment in the river bed to toxic levels. Nickel (Ni) is added into the atmosphere primarily as pollutant particle, released along with other metals from the chimneys and air flows from metallurgical sites as well as cement clinkers (Farag, 2000). which ultimately settle down on the soil, water or plant surfaces.

Toxicity of Nickel in plants rely on a range of transition (heavy) metals as essential micronutrients for normal growth and development. These elements are essential for most redox reactions which in turn, are fundamental to cellular functions. However, these transition metals including Nickel (Ni), above the permissible limit, interfere with the functions of many cellular components, thereby, altering the normal metabolism, causing cellular injuries, and in the extreme cases cause death of plant.

CHAPTER THREE

- ## MATERIALS AND METHODS
  - ### SAMPLING

3.1.1 Sampling locations

The study area chosen for study were the informal settlement of Kibera, Mlolongo, Pangani, and Ruaka estates of Nairobi metropolitan area of Kenya, for local eggs samples and both cattle and goat meat and liver, branded sugar, branded maize flour and branded cattle milk were sampled.

- ### Study Area

Figure 3.1: Sample Sites (Yellow Boxes)

3.1.2 Meat and liver samples of both goat and cattle weighed using analytical balance

SAMPLES	KIBERA	MLOLONGO	PANGANI	RUAKA
Cattle meat	2 grams	2 grams	2 grams	2 grams
Goat meat	2 grams	2 grams	2 grams	2 grams
Cattle liver	2 grams	2 grams	2 grams	2 grams
Goat liver	2 grams	2 grams	2 grams	2 grams

Table 31: Weights for meat and liver samples measured

Figure 3.2: Meat and Liver Samples.

- A chart showing how heavy metals find their way into farm *animals*

Figure 3.3: Schematic diagram showing heavy metals flow

3.1.3 Local chicken eggs and one hydride egg Samples weighed using analytical balance

SAMPLES	KIBERA	MLOLONGO	PANGANI	RUAKA
Local egg	**5 grams**	**5 grams**	**5 grams**	**5 grams**
Hybrid	**0**	**0**	**0**	**5 grams**

Table 32: Weights for chicken samples measured

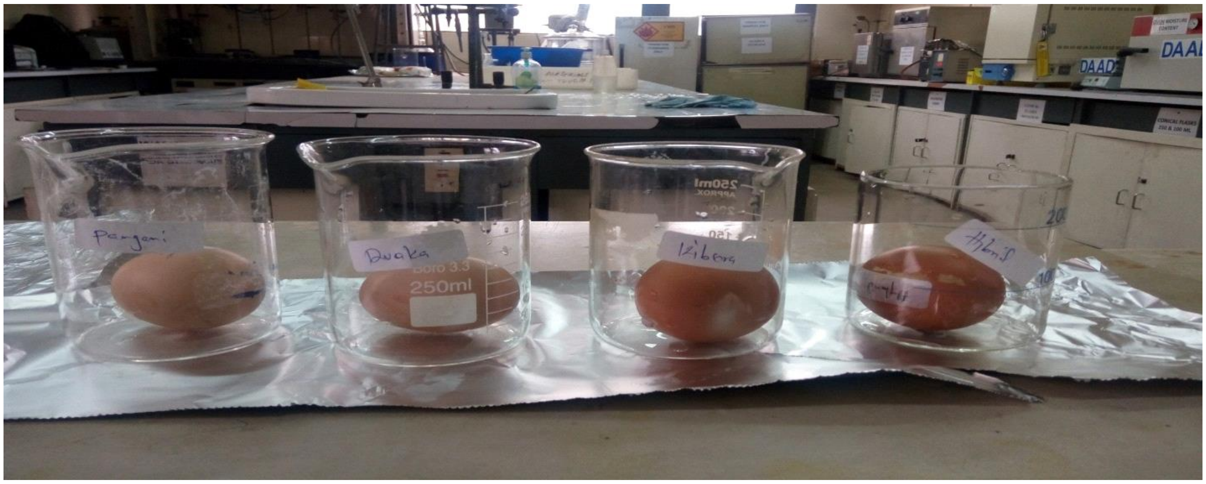

Figure 3.4: Image of raw Chicken eggs collected for analysis

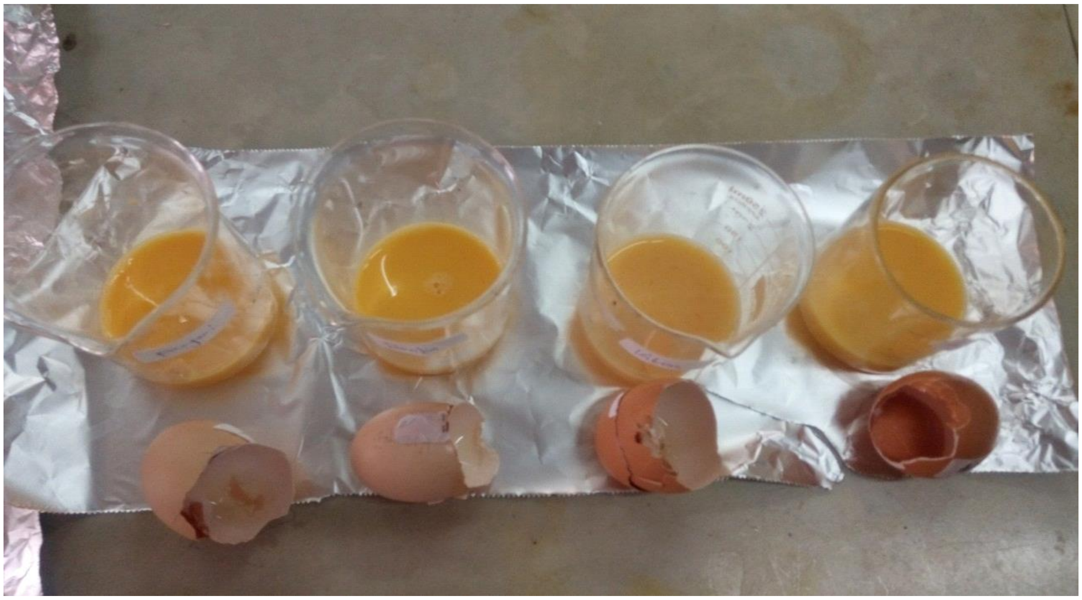

Figure 3.5: Eggs preparation for heavy metals analysis

3.1.4 Brands of Sugar Samples weighed using analytical balance

SAMPLE	**WEIGHT**
Kabras sugar	**5 grams**
Sony sugar	**5 grams**
Nitro sugar	**5 grams**
Local sugar	**5 grams**

Table 33: Weights for sugar samples measured

Figure 3.6: Brands of Sugar Samples collected for analysis

3.1.5 Maize flour Samples weighed using analytical balance

SAMPLES	WEIGHT
Pembe flour	**5 grams**
Diplomat flour	**5 grams**
Soko flour	**5 grams**
Grade II(Local flour)	**5 grams**

Table 34: Weights for maize flour samples weighed

Figure 3.7: Brands of Maize flour Samples collected for analysis

3.1.6 Brands of cattle milk samples measured using measuring cylinder

BRANDS	Mlolongo(atm milk)	Brookside	Gold crown	Lato
WEIGHT	20ML	20ML	20ML	20ML

Table 35: Weights for cattle milk samples measured

Figure 3.8: Brands of Cattle Milk Samples collected for analysis

- **SAMPLE TREATMENT AND ANALYSIS**

3.2.1 Heavy metal analysis (digestion)

Chemicals and Reagents Used

Analytical grade chemicals such as Hydrochloric acid, Per chloric acid, 70% Nitric acid, detergent and double distilled water for washing and rinsing glassware were provided by the University of Nairobi Pesticides Laboratory

3.2.2 Meat and liver samples preparations for both cattle and goat

The samples were cut to small pieces using clean knife and grounded into a fine particles using a ceramic pestle and mortar. Into clean 250ml volumetric flask washed by a detergent and rinsed by both HNO3 acid and distilled water, 2 grams of each sample of both meat and liver from the four areas were weighed in duplicate and put into the clean volumetric flask.

Acid mixture (10ml, 70% high purity HNO3 and 3ml-69% HCl, 1:3 V/V) was added to each flask containing 2 grams samples of meat and liver. The mixture was then digested at 90ºC till the transparent solution was achieved, 1.0 ml of concentrated HClO4 acid was added to each sample to aid in breaking down organic compounds. After cooling, the digested samples were filtered using Whatman 042 filter paper and the filtrate were diluted to 50ml with deionized water.The filtrate were then run in Atomic Absorption Spectrophotometer (AAS) for analysis after calibration using standard solutions. Appropriate hollow cathode lamps were used for each element (Kennedy.,1990) The target metals were Chromium (Cr), Cadmium (Cd), and Nickel (Ni)

3.3.3 Local eggs and Hybrid egg samples preparations

5 grams of samples in duplicate from four areas of study (8 samples) were digested with a mixture of 50ml of nitric acid(HNO3) and HCl (aqua regia mixture of the ration 3:1) in 250ml Erlenmeyer flask cleaned by detergent and rinsed by both HNO3 acid and distilled water and boiled on a hot plate for 30 minutes. 5ml of HClO4 acid to aid in breaking down the organic compounds and the digestion process was continued until the solution became clear. After the digestion process, the samples were filtered using Whatman 042 and diluted into 50ml and transferred into clean plastic bottles washed and rinsed by HNO3 acid and distilled water. Finally the filtrates were run into Atomic Absorption Spectrophotometer (AAS) for analysis after calibration using standard solutions. Appropriate hollow cathode lamps were used for each element (Kennedy.,1990). The targeted metals were Chromium (Cr), Cadmium (Cd), and Nickel (Ni).

3.3.4 Brands of Sugar samples preparations

Each brand of sugar sample was finely powdered with mortar and crucible. The finely powdered sugar sample was weighed.5 grams of each brand of sugar samples were weighed in duplicate and put into a clean 250ml Erlenmeyer flask cleaned by detergent and rinsed by both HNO3 acid and distilled water. A mixture of 50ml of HNO3 Acid and HCl (aqua regia in the ratio 3:1v/v) was added to each flask and they were heated until a brown fumes disappeared. A mixture of water and HClO4 in the ration of 50:50(5ml:5ml=10ml) was added until digestion was complete. The sample solution was filtrated using Whatman 042, and the filtrate was diluted to 50ml and transferred to a clean plastic bottle was by detergent, rinsed by both HNO3 acid to remove any traces of metals and rinsed by distilled water. The filtrate was ready for analysis in an Atomic Absorption Spectrophotometer (AAS) was used for the analysis after calibration using standard solutions. Appropriate hollow cathode lamps were used for each element (Kennedy., 1990). The targeted metals were Chromium (Cr), Cadmium (Cd), Nickel (Ni).

3.3.5 Brands of Maize flour Samples preparations

5 grams of each brand of maize flour samples were weighed in duplicate and put into eight separate flasks cleaned by detergent and rinsed by both HNO3 acid and distilled water. A mixture of HNO3 and HCl acids in the ration 3:1 v/v (50ML) was added into each flask containing the sample and heated until the digestion was over. 1.0 ml of concentrated HClO4 acid was added to aid in the breaking down the organic compounds. The solution was filtered and diluted to 50ml and the filtrate transferred into a clean plastic bottles washed and rinsed by both HNO3 acid and distilled water. The filtrate was ready for analysis in an Atomic Absorption Spectrophotometer (AAS) was used for the analysis after calibration using standard solutions. Appropriate hollow cathode lamps were used for each element (Kennedy., 1990). The targeted metals were Chromium (Cr), Cadmium (Cd), and Nickel (Ni).

3.3.6 Brands of milk samples preparations

20ml of each brand of milk was weighed in duplicate totaling to eight samples and put into a clean Erlenmeyer flask washed by detergent and rinsed by both HNO3 Acid and distilled water to remove the trace of heavy metals. The samples were then digested using 10 ml of analytical grade concentrated HCl and HNO3 in the ratio of 1:3 v/v (60ml) (aqua regia reagent mixture) at a temperature of 90ºC for about 45 min to Leach out the heavy metals. 1.0 ml of concentrated per chloric acid was added to aid breaking down the organic compounds. The sample was then cooled and filtered using whatman filter paper number 042. The solution was then quantitatively diluted using distilled water to 50ml.

The filtrate was ready for analysis in an Atomic Absorption Spectrophotometer (AAS) was used for the analysis after calibration using standard solutions. Appropriate hollow cathode lamps were used for each element (Baetz & Kenner, 1973). The targeted metals were Chromium (Cr), Cadmium (Cd), and Nickel (Ni).

Samples preparation

Figure 3.9: Some of the Samples collected for analysis

Figure 3.10: Digestion of Samples in a fume chamber

Figure 3.11: Filtration process of Samples after digestion

CHAPTER FOUR

• RESULT AND DISCUSSION

• 4.1 HEAVY METAL ANALYSIS

Figure 4.1: Analysis of heavy metals in samples collected using AAS

4.1.1 Chromium (Cr)

From the analysis of foodstuff samples collected, it was evident that the Chromium ion was present in all samples. This showed that there was either poor disposal of Chromium wastes from the processing industries or is being highly produced by nature, then eventually in human consumables. The result gotten was summarized in the Table 4-1

The results for Absorbance and concentration (ppm) from the standards used to calibrate the machine (AAS).

Conc.(ppm)	**0**	**0.2358**	**0.5244**	**0.9573**	**1.5635**	**1.9675**	**2.5015**
Absorbance	**0**	**0.0013**	**0.0033**	**0.0063**	**0.0105**	**0.0133**	**0.017**

Table 4. 1: Concentrations and Absorbance of the standards for Chromium

- The curve of Absorbance against concentration (ppm) from the standards used to calibrate the machine (AAS).

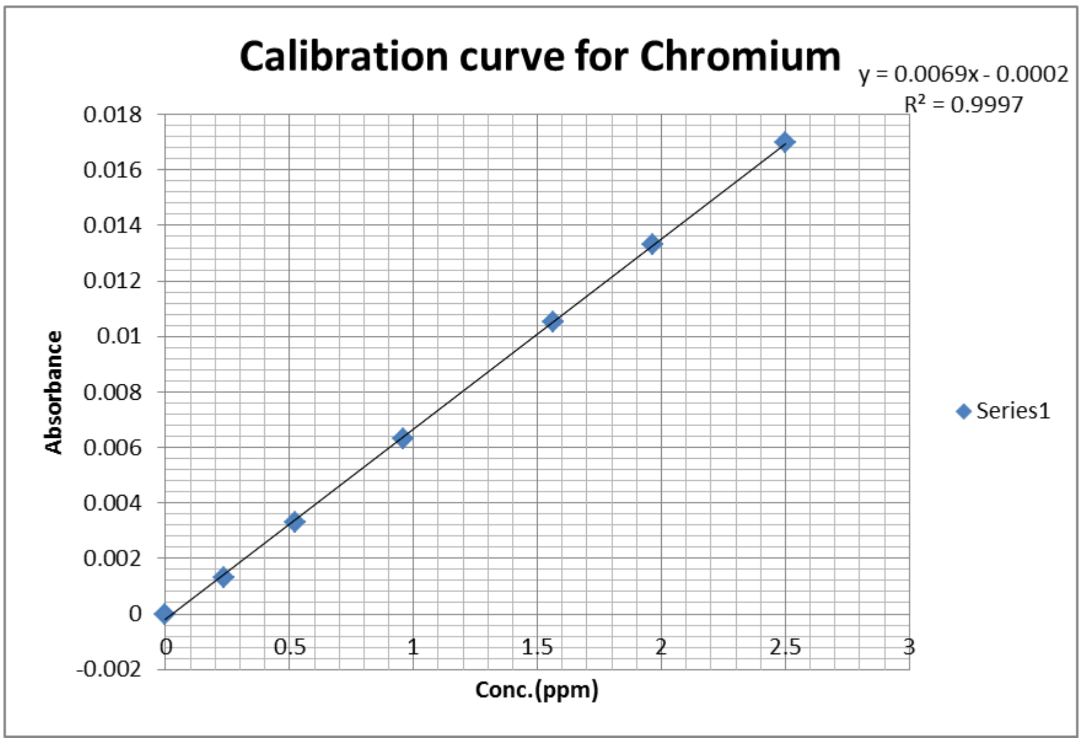

Figure 4.2: Calibration curve for Chromium standards

Chromium concentration for meat and liver samples ranges from beef (63.32±2.87 to 76.66±0.99)mg/kg, goat meat(69.8±0.002 to 84.5±0.49)mg/kg, cow liver(78.2±2.4 to89.5±2)mg/kg, goat liver(82.9±0.6 to 90.4±1.9)mg/kg from four different sample sites are given in table 4.2 below.

Location	**Beef**	**stdev**	**Goat meat**	**Stdev**	**Cow liver liver**	**stdev**	**Goatliver liver liver**	**Stdev**
Kibera	73.093	±0.76	76.9105	±0.51	89.548	±2.03	86.9385	±4.81
Mlolongo	76.6645	±0.99	84.5035	±0.49	88.7545	±5.58	90.434	±1.94
Pangani	63.325	±2.87	69.8085	±0.002	78.233	±2.39	82.9025	±0.59
Ruaka	67.3005	±1.14	72.4845	±2.89	78.2685	±5.96	83.691	±2.15

Table 4. 2: Results for Chromium analysis

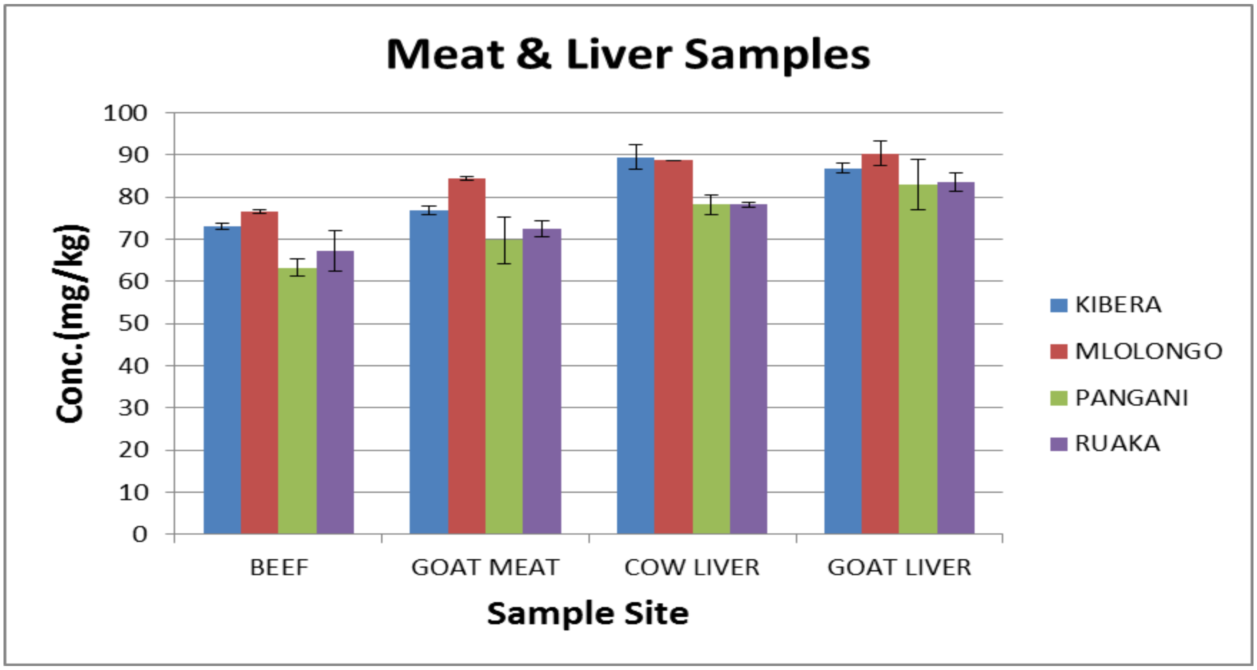

Figure 4.3: Levels of Chromium in Meat & Liver samples from different sites

Chromium Concentration for chicken Eggs Samples ranges from (29.06±0.5 to 37.4±1.2) mg/kg from four different sample sites and one hydrid egg are given in table 4.3 below.

LOCATION	MEAN	STDEV
KIBERA	34.1285	±0.75
MLOLONGO	34.933	±2.36
PANGANI	29.0665	±0.53

RUAKA	30.78	±0.13
HYBRID	37.38	±1.16

Table 4. 3: Results for chromium analysis in Egg samples

Figure 4.4: Levels of Chromium in eggs samples from different sites

Chromium Concentration for brands of different Maize Flour ranges from (25.4±0.36 to 29.28±0.01) mg/kg from a supermarket are given in table 4.4.below

SUPERMARKET	**MEAN**	**STDEV**
PEMBE	29.2845	±0.01
DIPLOMAT	27.1855	±0.94
SOKO	26.632	±0.26

GRADE II(LOCAL)	25.416	±0.36

Table 4. 4: Results for chromium analysis in maize flour

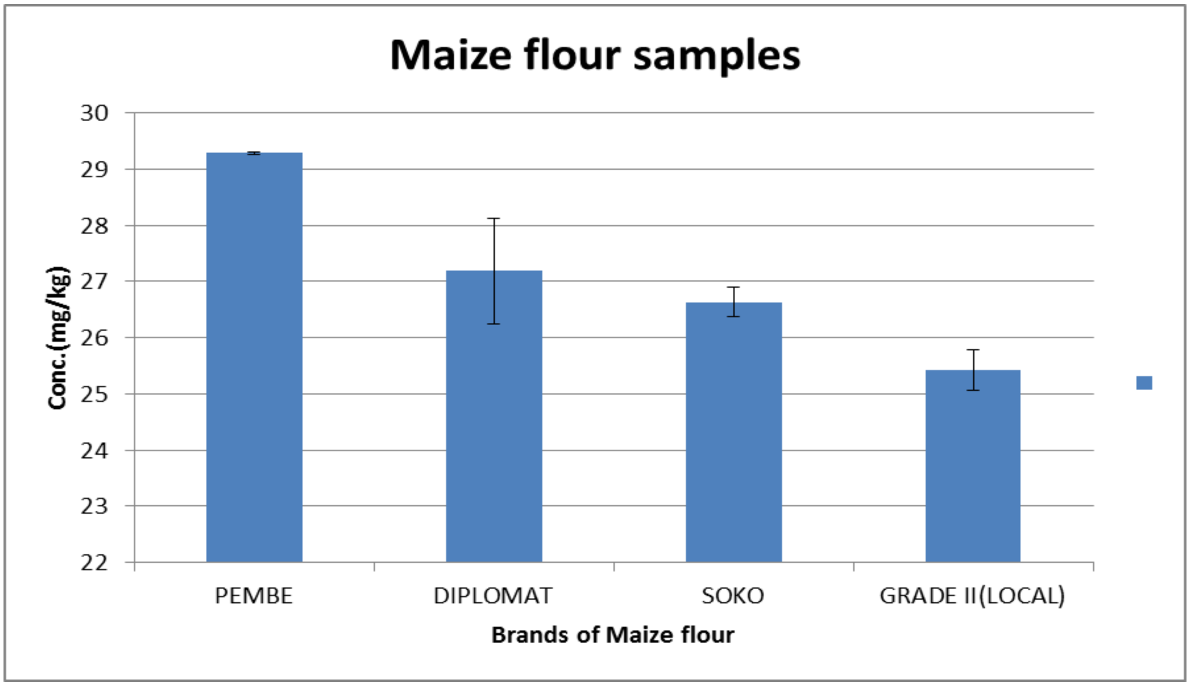

Figure 4.5: Levels of chromium in maize flour samples from different sites

Chromium Concentrations for different brands of Cattle Milk Samples ranges from (6.0±0.09 to 7.35±0.25) mg/l from a supermarket are given in table 4.5.below

SUPERMARKET	**MEAN**	**STDEV**
MLOLONGO(ATM)	7.212	±0.19

BROOKSIDE	6.649	±0.14
GOLD CROWN	6.0085	±0.09
LATO	7.353	±0.25

Table 4. 5: Results for chromium analysis in cattle milk samples

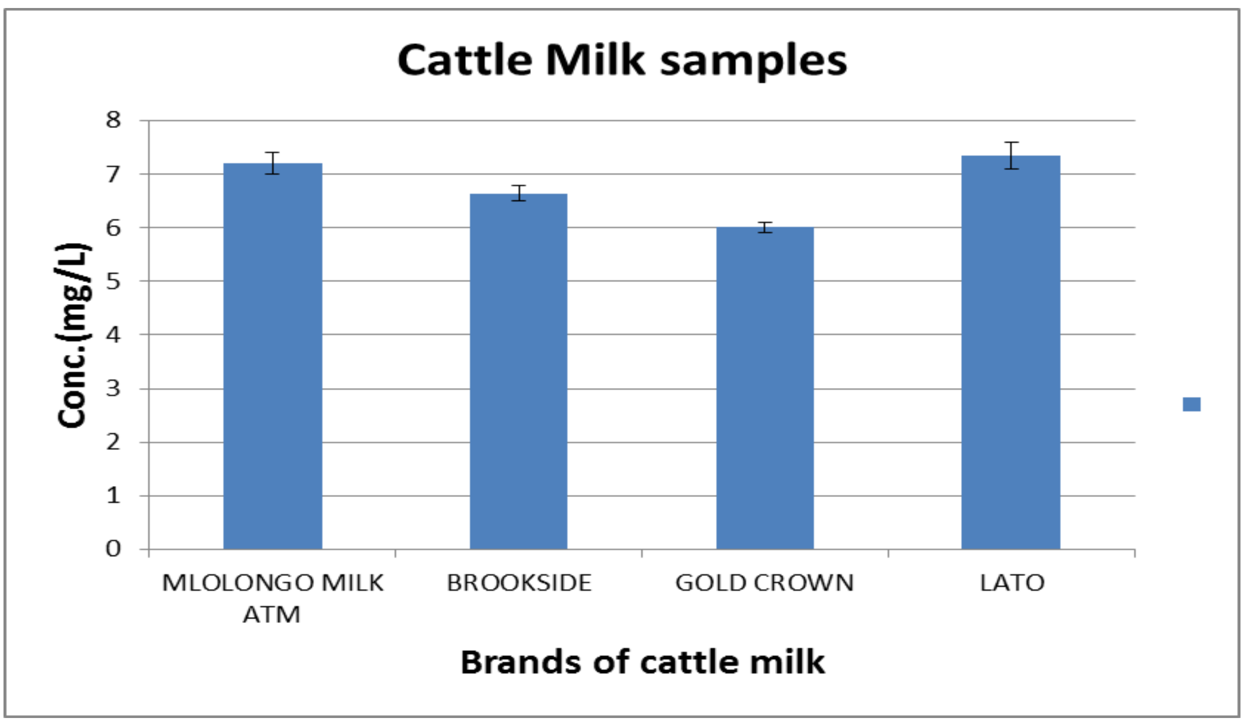

Figure 4.6: Levels of Chromium in Cattle milk samples from different sites

Chromium Concentrations for different brands of Sugar Samples ranges from (16.24±0.62 to 21.83±0.68) mg/kg from a supermarket are given in table 4.6.below

SUPERMARKET	**MEAN**	**STDEV**
KABRAS	19.082	±0.19
SONY	16.2395	±0.62
NITRO	19.325	±1.67
LOCAL	21.8305	±0.68

Table 4. 6: Results for chromium analysis in Sugar samples

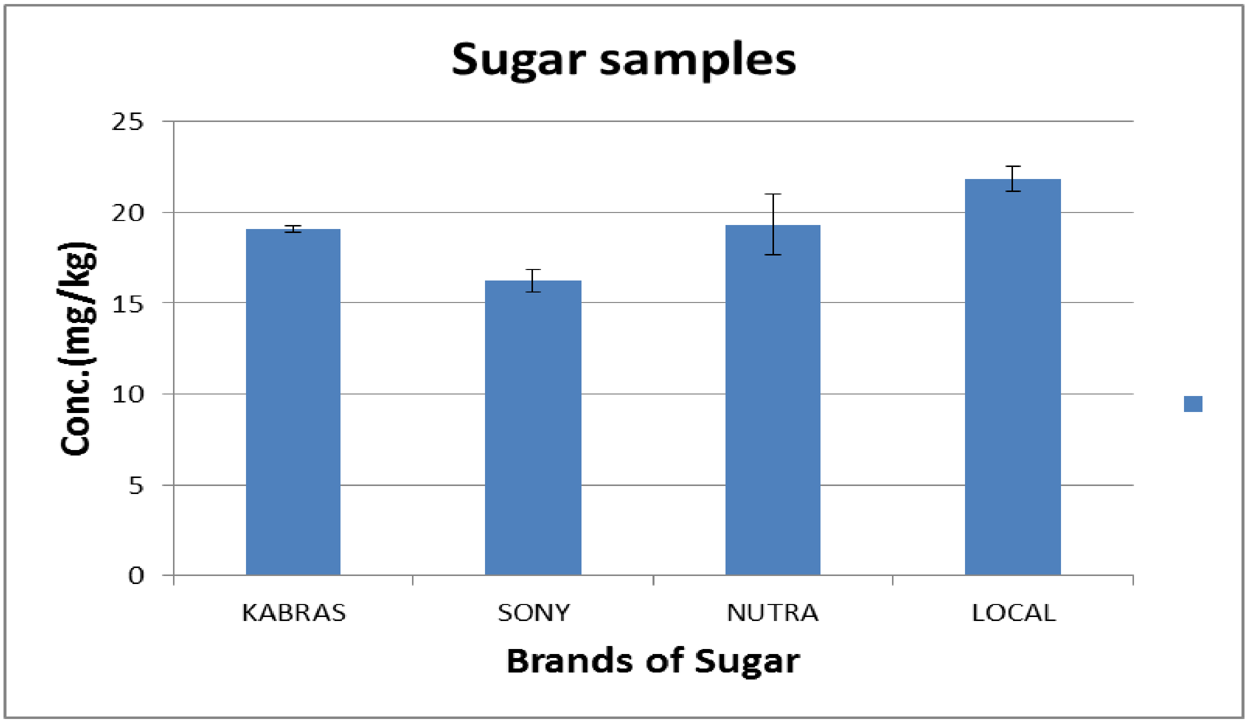

Figure 4.7: Levels of Chromium in Sugar samples from different sites

4.1.2 Cadmium (Cd)

From the analysis of foodstuff samples collected, it was evident that the Cadmium ion was present in all samples. This showed that there was either dissolution of minerals from industries or from nature, then eventually into human consumables. The result gotten was summarized in the Table 4.7 below

Conc.(ppm)	0	0.1007	0.1997	0.2532	0.2948	0.5014
Absorbance	0	0.0105	0.0208	0.0264	0.0307	0.0522

Table 4. 7: Concentrations and Absorbance of the standards for Cadmium

The curve of Absorbance against concentration (ppm) from the standards used to calibrate the machine (AAS).

Figure 4.8: Calibration curve for Cadmium Standards

Cadmium Concentrations for meat &liver Samples ranges from beef (0.37±0.18 to 0.6±0.05) mg/kg, goat meat(0.32±0.006 to 0.57±0.07) mg/kg, cow liver(0.61±0.08 to 0.78±0.02)mg/kg, goat liver(0.64±0.13 to 0.86±0.14) mg/kg from different sampling sites are given in table 4.8.below

location	**Beef**	**stdev**	**Goat meat(mean)**	**stdev**	**Cowliver liver(mean)**	**stdev**	**Goatliver liver(mean)**	**Stdev**
kibera	0.41392	±0.18	0.38691	±0.16	0.739095	±0.0	0.74202	±0.0

						1		4
Mlolongo	0.603505	±0.05	0.325655	±0.006	0.78672	±0.02	0.69246	±0.04
pangani	0.37441	±0.18	0.572385	±0.07	0.70065	±0.01	0.86482	±0.14
ruaka	0.39009	±0.07	0.34096	±0.07	0.615025	±0.08	0.64172	±0.13

Table 4. 8: Results for Cadmium analysis in meat & liver samples

Figure 4.9: Levels of Cadmium in Meat & Liver samples from different sites

Chromium Concentration for local chicken Eggs Samples ranges from (0.28±0.06 to 0.39±0.18) mg/kg from four different sample sites and one hydrid egg(0.19±0.01)mg/kg are given in table 4.9 below

location	**Mean**	**STDEV**
kibera	0.283495	±0.02
mlolongo	0.3938	±0.18
pangani	0.27977	±0.06
ruaka	0.30748	±0.02
hybrid	0.195025	±0.01

Table 4. 9: Results for Cadmium analysis in egg samples

Figure 4.10: Levels of Cadmium in Eggs samples from different sites

Cadmium Concentration for different brands of Maize Flour ranges from (0.13±0.1 to 0.25± 0.07)mg/kg from a supermarket are given in table 4.10 below

Supermarket	**Mean**	**STDEV**

Pembe	0.245185	±0.07
Diplomat	0.131555	±0.101
Soko	0.231235	±0.014
Grade ii (local)	0.193415	±0.103

Table 4. 10: Results for Cadmium analysis in Maize flour samples

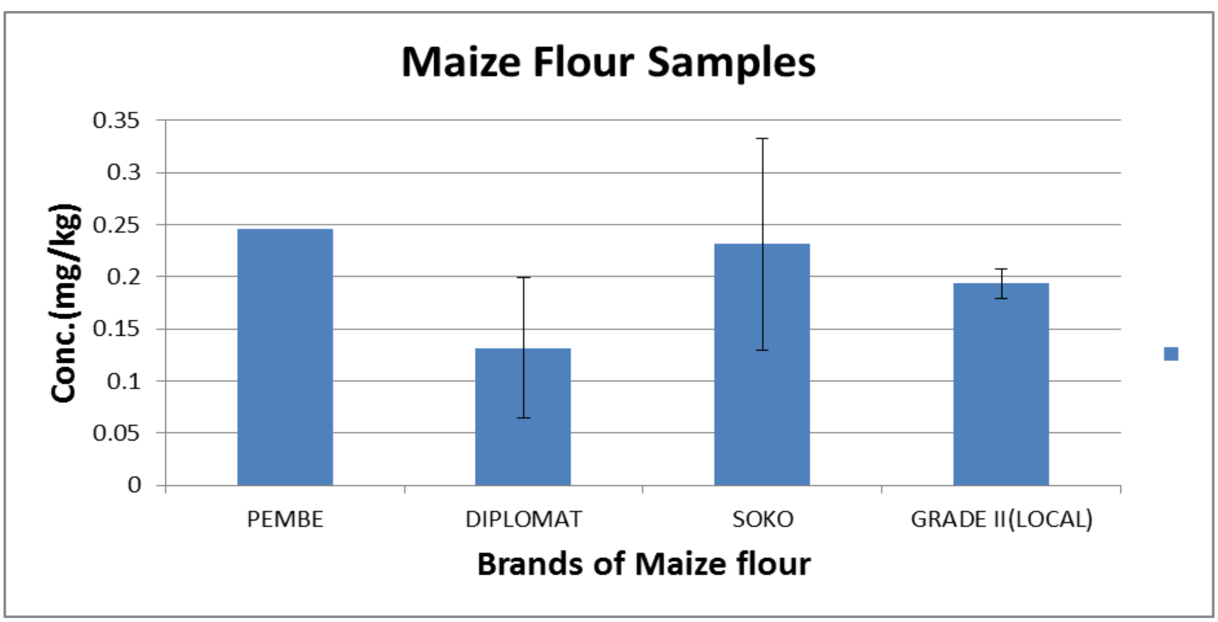

Figure 4.11: Levels of Cadmium in Maize flour samples from different sites

Cadmium Concentrations for different brands of Cattle Milk Samples ranges from (0.027±0.005 to 0.037±0.008) mg/l from a supermarket are given in table 4.11 below

Supermarket	**Mean**	**STDEV**
Mlolongo(ATM)	0.032537	±0.003
Brookside	0.027115	±0.005
Gold crown	0.03702	±0.008
Lato	0.035061	±0.011

Table 4. 11:Results for Cadmium analysis in Cattle Milk samples

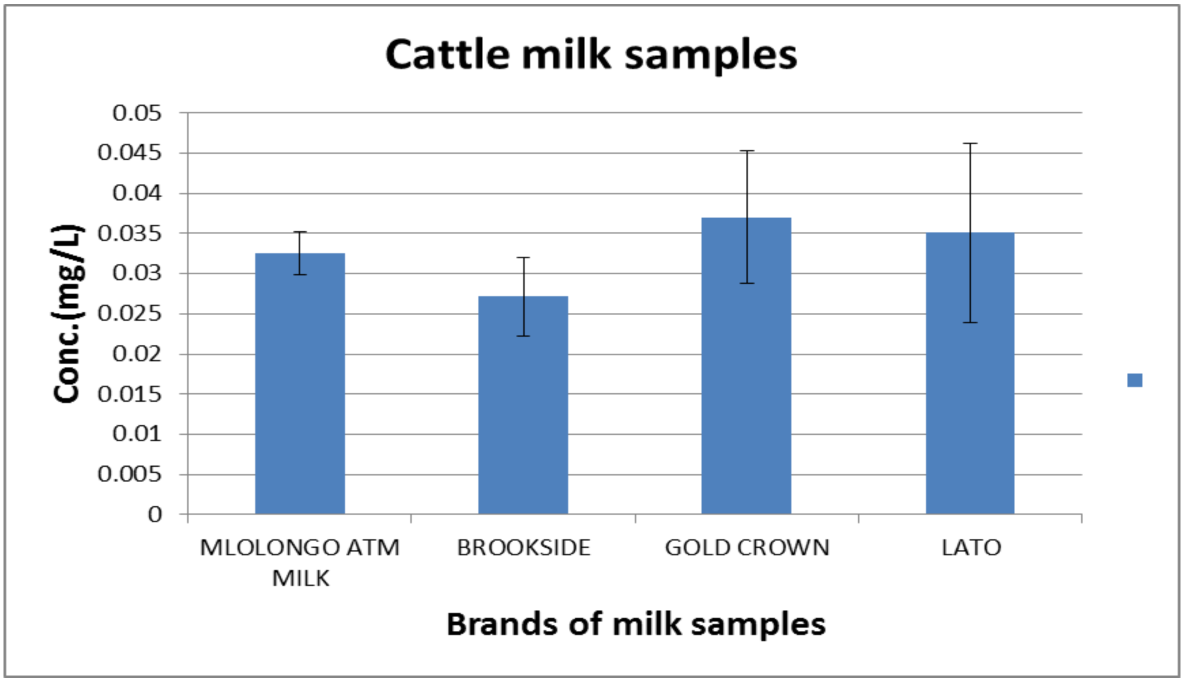

Figure 4.12: Levels of Cadmium in Cattle Milk samples from different sites

Cadmium Concentrations for different brands of Sugar Samples ranges from (0.22±0.007 to 1.48±0.03) mg/kg from a supermarket are given in table 4.12 below

Supermarket	**Mean**	**STDEV**
Kabras	0.954895	±0.009
Sony	0.32039	±0.012
Nitro	0.223285	±0.007

Local	1.48235	±0.025

Table 4. 12: Results for Cadmium analysis in Sugar samples

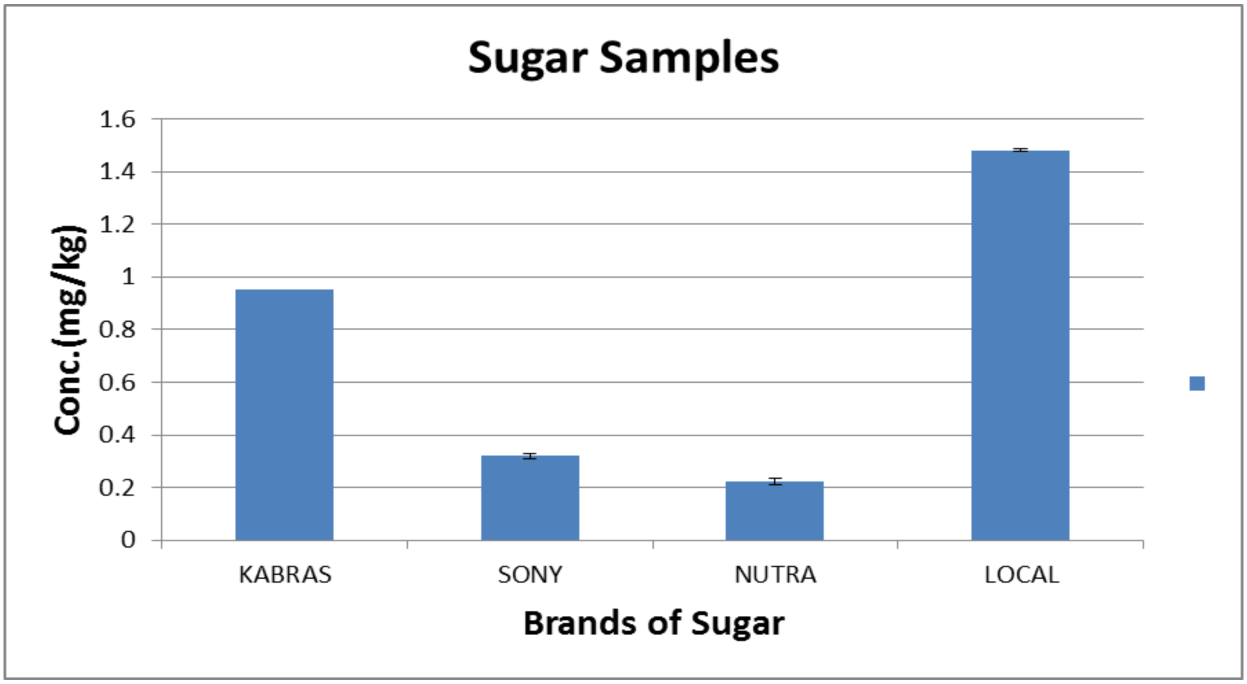

Figure 4.13: Levels of Cadmium in Sugar samples from different sites

4.1.3 Nickel (Ni)

From the analysis of foodstuff samples collected, it was evident that the Nickel (Ni) ion was present in all samples. This showed that there was either dissolution of minerals from industries or from nature, then eventually into human consumables. The result gotten was summarized in the Table 4.13 below.

Concentrations and Absorbance of standards for Nickel

Conc.(ppm)	0	0.1916	0.2544	0.2911	0.5164	0.5792	0.794	0.9092	1.014
Absorbance	0	-0.0002	0.001	0.0017	0.006	0.0072	0.0113	0.0135	0.0155

Table 4. 13: Concentrations and Absorbance of the standards for Nickel

The curve of Absorbance against concentration (ppm) from the standards used to calibrate the machine (AAS).

Figure 4.14: Calibration curve for Nickel Standards

Nickel Concentrations for meat &liver Samples ranges from beef(3.5±1.5 to 10.4±1.3)mg/kg, goat meat(19.7±1.23 to 23.2±0.5)mg/kg, cow liver(30.5±2.1 to 47.02±1.84)mg/kg, goat liver(47.7±1.4 to 57.9±2.4) mg/kg from different sampling sites are given in table 4.14 below

Location	**Beef**	**stdev**	**Goat meat**	**stdev**	**Cowliver liver**	**stdev**	**Goat liver**	**stdev**
Kibera	10.375	±1.31	19.7295	±1.23	47.0275	±1.84	47.7345	±1.42
Mlolongo	3.5068	±1.46	20.901	±0.22	37.3125	±1.77	51.16115	±1.09

Pangani	6.0565	±0.71	23.195	±0.52	42.133	±4.09	56.666	±0.52
Ruaka	4.6997	±0.82	22.46	±0.66	30.5155	±2.05	57.9105	±2.35

Table 4. 14: Results for Nickel analysis in Meat & Liver samples

Figure 4.15: Levels of Nickel in Meat & Liver samples from different sites

Nickel Concentration for chicken Eggs Samples ranges from (5.1±0.14 to 9.63±0.025) mg/kg from four different sample sites and one hydrid egg are given in table 4.15 below

Location	**Mean**	**STDEV**
Kibera	8.2945	±0.52
Mlolongo	6.3885	±0.013
Pangani	5.029	±0.14

Ruaka	9.6255	±0.025
Hybride	5.3505	±0.77

Table 4. 15: Results for Nickel analysis in Egg sample

Figure 4.16: Levels of Nickel in Eggs samples from different sites

Nickel Concentration for brands of different Maize Flour ranges from (2.96±0.18 to 3.17±0.27) mg/kg from a supermarket are given in table 4.16 below

Supermarket	**Mean**	**STDEV**
Pembe	3.121	±0.16
Diplomat	3.17	±0.27
Soko	2.9695	±0.18

Grade ii(local)	3.0939	±0.105

Table 4. 16: Results for Nickel analysis in Maize flour sample

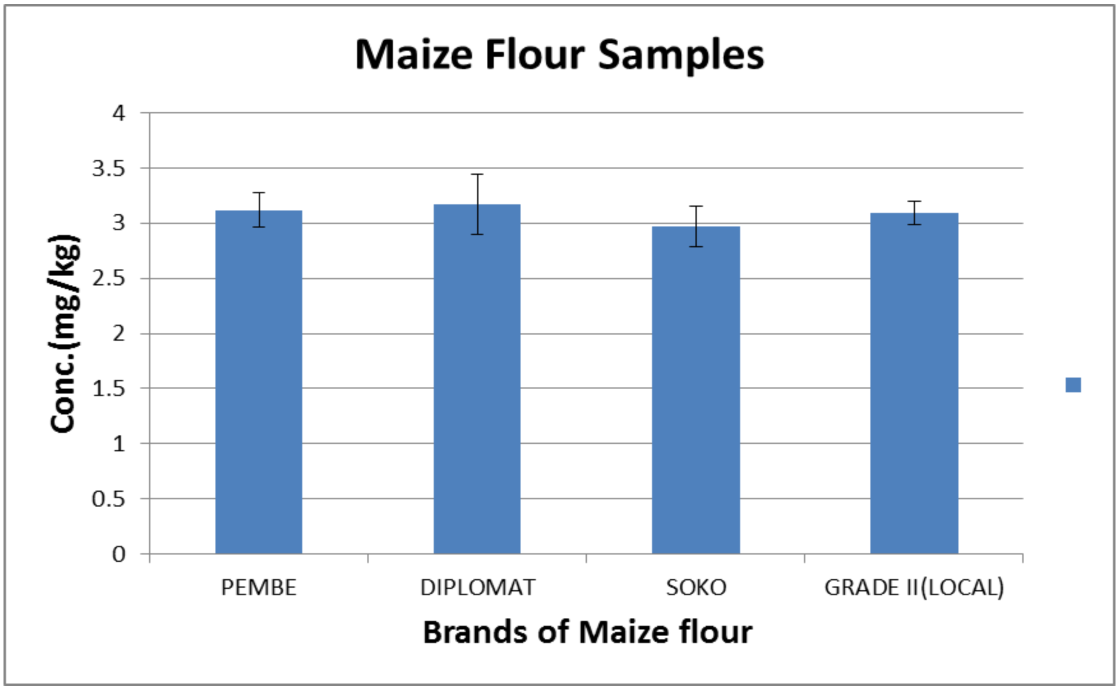

Figure 4.17: Levels of Nickel in Maize flour samples from different sites

Nickel Concentrations for brands of Cattle Milk Samples ranges from (1.2±0.04 to 1.8±0.18) mg/l from a supermarket are given in table 4.17 below

Supermarket	**Mean**	**STDEV**
Mlolongo(ATM)	1.43005	±0.05

Brookside	1.17415	±0.04
Gold crown	1.5001	±0.022
Lato	1.8152	±0.18

Table 4. 17: Results for Nickel analysis in Cattle Milk sample

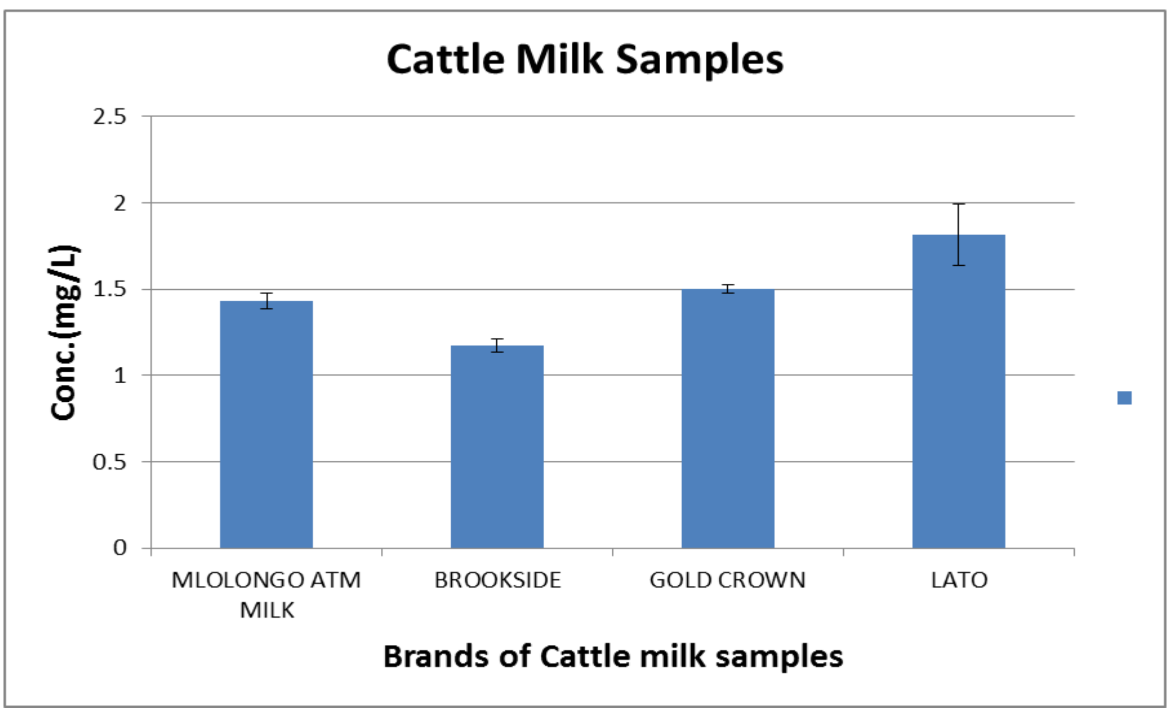

Figure 4.18: Levels of Nickel in Cattle Milk samples from different sites

Nickel Concentrations for different brands of Sugar Samples ranges from(4.0±0.06 to 6.7±0.023) mg/kg from a supermarket are given in table 4.18 below

Supermarket	**Mean**	**STDEV**
Kabras	4.0165	±0.06
Sony	4.7638	±0.03
Nitro	6.70035	±0.023
Local	4.9975	±0.200

Table 4. 18: Results for Nickel analysis in Sugar sample

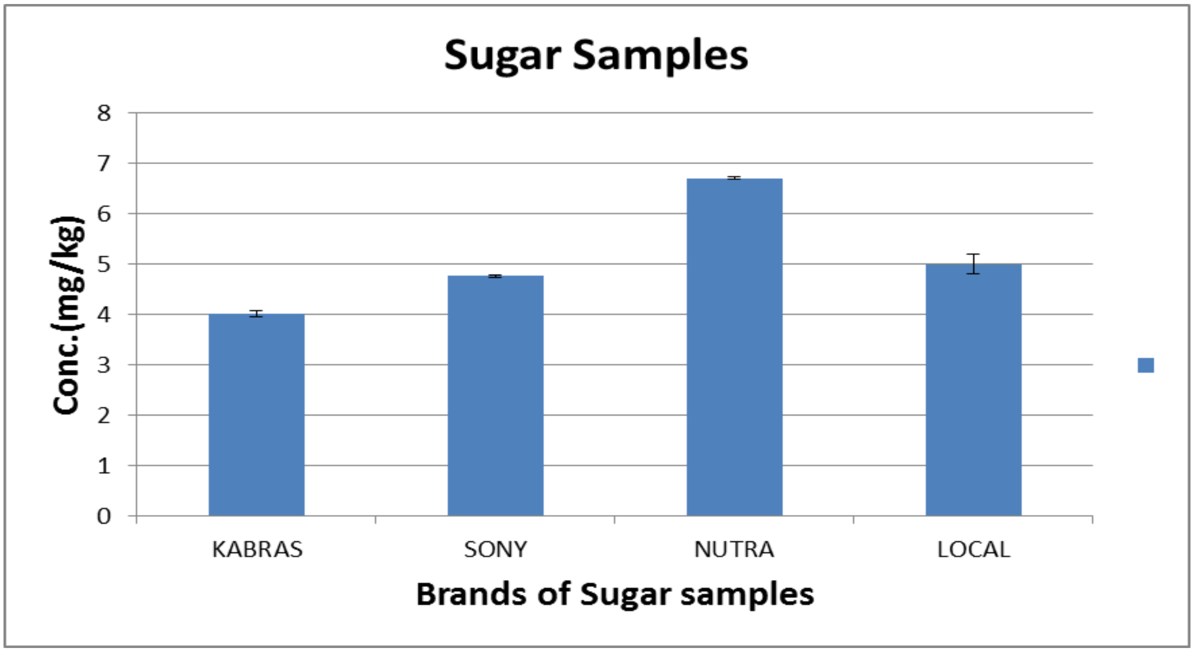

Figure 4.19: Levels of Nickel in Sugar samples from different sites

CHAPTER FIVE

- ## CONCLUSION AND RECOMMENDATIONS
  - ### 5.1 Conclusions

It is concluded that all collected samples were contaminated from heavy metals, Cr, Cd, and Ni was bio-accumulated. The toxic elements Cr and Cd are of particular concern as most of the detected concentrations in the samples exceeded both local and international guideline values. Their effect on the local population due to prolonged consumption of these contaminated foodstuffs is unknown and deserves further detailed investigation of water and feed used to feed cattle, goat, chicken and also water used for sugar and maize flour production in processing industries. The data indicated that the concentration of heavy metals Chromium (Cr), and Nickel (Ni) had a concentration that was above the permissible exposure limit while Cadmium was within permissible limit for food by the CODEX Alimenteriaus commission, that is, **Chromium** (0.3-2.0mg/kg), **Cadmium** (0.05-0.5mg/kg), and **Nickel** (2.0-4.0mg/kg). The analysis also showed a significant difference in the concentrations of heavy metals of all samples collected from Nairobi metropolitan area, hence it had effect on people living in these areas.

- ### Recommendations

It is therefore, recommended from this work, that Cattle and Goat to be slaughtered for consumption be put in lairage where recent exposure will be reduced and screening before slaughter for heavy metals residue should be done. Also, Nickel and Chromium, release into the environment which might directly or indirectly find their way into the foodstuff hence causing threat to human life should be discouraged through proper advocacy program.

- **Relevance of the Study**

The Kenya constitution 2010, vision 2030 and National food and Nutrition security policy 2011 advocate for appropriate measures, including research, food quality and safety. This study has produced important set of data that can be used by the Government of Kenya to improve on foodstuff safety in Nairobi metropolitan area in order to meet the aspirations of the Kenya National constitution.

REFERENCES

- Agency, S. C. (n.d.). Soil chemical behaviour of cadmium pigments from paints.
- Ahmed, A. (2018). Heavy metal pollution – A mini review, *6*(3), 179–181. https://doi.org/10.15406/jbmoa.2018.06.00199
- Air, E., From, E., & Of, S. (1984). Locating and estimating air emissions from sources of nickel, (March).
- Al-qutob, M., Asafra, A., Nashashibi, T., & Qutob, A. A. (2014). Determination of Different Trace Heavy Metals in Children ' s Plastic Toys Imported to the West Bank / Palestine by ICP / MS-Environmental and Health Aspects, (September), 1104–1110.
- Appenroth, K. (2010). Definition of " Heavy Metals " and Their Role in Biological Systems, *19*, 19–30. https://doi.org/10.1007/978-3-642-02436-8

- Article, O. (2018). Fast method to determine the elements in maize flour : reduction in preparation time and reagent consumption Método rápido de determinação de elementos em farinha de milho : redução do tempo de preparação e consumo de reagente.

- Baetz, R. A., & Kenner, C. T. (1973). Determinaiion of Heavy Metals in Foods. *Journal of Agricultural and Food Chemistry*, *21*(3), 436–440. https://doi.org/10.1021/jf60187a013

- Belt, G., Bay, K., Proper, N. B., Basin, E. G., & Quark, T. (2017). Metals (lead , cadmium and mercury) Key Message, (July), 1–32.

- Draszawka, B. (2014). World Scientific News 5 (2014) 26-34, *5*, 26–34.

- Farag, A. (2000). HEAVY METALS IN DRINKING WATER AND THEIR ENVIRONMENTAL IMPACT ON HUMAN HEALTH, 542–556.

- Fosu-mensah, B. Y., Addae, E., Yirenya-tawiah, D., & Nyame, F. (2017). Heavy metals concentration and distribution in soils and vegetation at Korle Lagoon area in Accra ,. *Cogent Environmental Science*, *2016*(July), 1–14. https://doi.org/10.1080/23311843.2017.1405887

- Guerra, F., Trevizam, A. R., Muraoka, T., Marcante, N. C., & Canniatti-brazaca, S. G. (2012). Heavy metals in vegetables and potential risk for human health, (February), 54–60.

- Hashish, S. M., Abdel-Samee, L. D., & Abdel-Wahhab, M. A. (2012). Mineral and heavy metals content in eggs of local hens at different geographic areas in Egypt. *Global Veterinaria*, *8*(3), 298–304.

- Ijaz Javed, Bilal Aslam, Faqir Muhammad, Muhammad Zargham Khan, Zia-ur-Rahman, Mahmood Ahmad, T. K. and M. K. S. (2013). Heavy Metal Residues in Goat Meat During Winter and Summer Seasons. *Indo American Journal of Pharmaceutical Research*, *3*(12).

- Lokhande, R. S., Singare, P. U., & Pimple, D. S. (2011). Toxicity Study of Heavy Metals Pollutants in Waste Water Effluent Samples Collected from Taloja Industrial Estate of Mumbai, India. *Resources and Environment*, *1*(1), 13–19. https://doi.org/10.5923/j.re.20110101.02

- Mahurpawar, M. (2015). Effects of heavy metals on human health, *0530*.

- Malakootian, M., Nouri, J., & Hossaini, H. (2009). Removal of heavy metals from paint industry ' s wastewater using Leca as an available adsorbent, *6*(2), 183–184.

- Muhib, M. I., Chowdhury, M. A. Z., Easha, N. J., Rahman, M. M., Shammi, M., Fardous, Z., … Alam, M. K. (2016). Investigation of heavy metal contents in cow milk samples from area of Dhaka, Bangladesh. *International Journal of Food Contamination*, *3*(1), 1–10. https://doi.org/10.1186/s40550-016-0039-1

- Okareh, O. ., & Oladipo, T. . (2015). Determination of Heavy Metals in Selected Tissues and Organs of Slaughtered Cattle from Akinyele Central Abattoir, Ibadan, Nigeria. *Journal of Biology,Agriculture and Healthcare.*, *5*(ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)), No.11, 2015. Retrieved from http://www.iiste.org/Journals/index.php/JBAH/article/viewFile/23244/23700

- Pam, A. A., Ato, R. S., & Offem, J. O. (2013). Evaluation of heavy metals in soils around auto mechanic workshop clusters in Gboko and Makurdi , Central Nigeria, *5*(11), 298–306. https://doi.org/10.5897/JECE2013.0295

- Rapheal, O., & Adebayo, K. S. (2011). Assessment of trace heavy metal contaminations of some selected vegetables irrigated with water from River Benue within Makurdi Metropolis , Benue State Nigeria, *2*(5), 590–601.

- Sathyamoorthy, K., Sivaruban, T., & Barathy, S. (2016). Assessment Of Heavy Metal Pollution And Contaminants In The Cattle Meat. *Journal of Industrial Pollution Control*, *32*(1), 350–355. Retrieved from http://www.icontrolpollution.com/articles/assessment-of-heavy-metal-pollution-and-contaminants-in-the-cattle-meat-.php?aid=75164

- Sids, O., & Publications, U. (n.d.). INTRODUCITON C . I . Pigment Yellow 53 CAS N ° : 8007-18-9, 1–69.
- Yadata, D. (2014). Physicochemical Characterization and Determination of Trace Metals in Sugar Manufactured from Sugar Cane. *Food Science and Technology*, *2*(7), 101–105. https://doi.org/10.13189/fst.2014.020702