Chapter One

Introduction

1.1 Background to the Study

Natural elements known as heavy metals are distinguished by their large atomic masses and high densities[1]. Recent changes have expanded the criteria to include naturally occurring elements with atomic numbers larger than 20 [2,3]. By way of asteroid collisions, heavy metals were physically sent from heaven[1]. Most heavy metals are chemically bound in carbonate, sulphate, oxide, or silicate rocks or can also be found in their metallic, elemental form in the earth's crust, where they are typically found in very low quantities, at low ppb ranges (noble metals) and up to 5% (iron)[1]. Their leaching and mitigation into soil, rivers, and groundwater was caused by weathering and erosion. When the Earth's mantle was still relatively young, about 4-5 billion years ago.

Heavy metals sunk to Earth's core at the time when its mantle was still liquid, forming the core, which is now primarily composed of the heavy metals iron and nickel[1]. A heavy metal is typically defined as having a density of at least 5 g cm^3 in order to distinguish it from other, "light" metals. Certain heavy metals, such as copper, selenium, or zinc, are necessary trace elements that perform a number of vital roles in biological processes that power the entire human metabolism[4]. Many of these heavy metals, such as iron, zinc, tin, lead, copper, tungsten, etc., are important in technology. One such heavy metal is cobalt, which serves as the core atom in the vitamin B_{12} complex and is also a major role in the reductive branch of the propionic acid fermentation pathway[5]. It also necessary for cell division, blood production and the development of the nervous system,

It is crucial to note that the heavy metal family contains a few trace elements that are crucial for numerous biological functions. These elements are primarily found in period 4 of the periodic table. As the core, oxygen-aine, atom of the blood pigment heme coordinate with

Fe(ll), iron plays a significant part in our respiratory system[6]. Especially as the main atom in hemocyanin in molluscs and arthropods, copper serves a comparable role in the transfer of electrons and oxygen[7].

In turn, zinc plays a crucial role as a component of zinc linger enzymes[8]. Selenium is referred to as an antioxidant and also takes part in hormone synthesis[9]. Cobalt has been proven to be significant in the biosynthesis of complex chemicals and several processes in cellular metabolism[10]. Vanadium and manganese are crucial for the control and operation of various enzymes, whereas chromium, arsenic, and nickel, which are commonly known to be hazardous, are also allocated to specific metabolic tasks[11].

With the exception of arsenic, which was just recently identified as a natural component in herring caviar, where it was demonstrated to replace phosphorus in lipids that resemble phosphatidylcholine, or so-called arsenolipids[12]. When present in excess or if their homeostasis is disturbed by specific conditions, micronutrients as zinc, copper, iron, and manganese can also have negative effects[17,18]. However, these ions typically perform significant and advantageous roles in human metabolism. In enzymatic pathways, heavy metal ions can function as cofactors or inhibitors. About 50% of all enzymes are thought to need a metal cofactor in order to be active and functional[18,20].

Recently, many heavy metals have been used as the main atom in specially crafted "bioinorganic" catalysts for certain chemical reactions[13]. A few elements, such as gold, silver, iridium, rhodium, or platinum[15], are considered to be valuable in lieu of this. While several of them, such as mercury, cadmium, arsenic, chromium, thallium, and lead, are known to represent the "dark side of chemistry," they nonetheless have harmful effects even at low concentrations[13]. Due to the fact that some heavy metals can be used to commit serious crimes, they have earned a dubious amount of popularity[16].

Even in nations like Nigeria, which are rapidly industrializing, exposure to ambient heavy metals is prevalent across Africa. Many of these metals are known to be neurotoxic, but monitoring of this exposure is minimal. Heavy metals are also classified based on how bio-accumulative they are along the food chain and how poisonous they are to living things. According to some scholars, the contentious word "heavy metals" should be changed to "potentially toxic elements"[21]. Examples of harmful metals from both industrial and natural sources include cadmium (Cd), lead (Pb), nickel (Ni), chromium (Cr), mercury (Hg), and metalloids like arsenic (As). It is widely recognized that xenobiotic metal exposure can result in neurological, gastrointestinal, respiratory, cardiovascular, reproductive, renal, and haemopoietic disorders[22,23]. Some heavy metals inhibit the sensitivity of malignancies to treatment and promote the development of cancers through several pathogenetic links[24].

These metals produce oxidative stress, which increases the level of oxidative damage in a cell and promotes the development of cancer. The World Health Organization (WHO) and European Medical Agency (EMA) have established the acceptable limits of several heavy metal ions, which vary from ppt to ppm. As recently displayed on the WHO website[25], arsenic (As), cadmium (Cd), lead (Pb), and mercury (Hg) are among the ten chemicals that pose the greatest threat to human health as of 1 June 2020. Even though these elements' toxicity is widely known, the numerous technological, medical, and agricultural applications pose a serious threat to people's health.

1.2 Statement of the Problem

The occurrence of lead poisoning, which claimed 163 lives in Zamfara villages in Northern Nigeria in 2010[52] (including 111 children).This was brought on by widespread Pb pollution of drinking water supplies and soil as a result of unlawful and illegal mining of gold ores, which appeared to have high levels of Pb. Children's blood was found to contain high levels of Pb, and many of these kids had experienced headaches, vomiting, abdominal pain, seizures, and even death[48].

These negative consequences are brought on either directly by anthropogenic activity or indirectly by exposure to the hazardous metals in the environment. It is important to note that exposure to a variety of xenobiotics (heavy metals, pesticides, and other poisons) at the same time may have an additive effect[11,12].

Hexavalent chromium, arsenic, cobalt, nickel, antimony, vanadium, and mercury are among the heavy metals thought to cause cancer. Other heavy metals are thought to cause mutagenesis, malformations, allergies, and endocrine disruption (silver, copper, zinc, and selenium). Others (e.g., thallium) lead to neurological and behavioural alterations, particularly in the case of children, central nervous system damage (mercury, lead, thallium, manganese, and tin), bone marrow damage, and osteoporosis (cadmium); are hepatotoxic and/or nephrotoxic (cadmium, cadmium, mercury, heptavalent manganese); cause heart rhythm disturbances (thallium); or negatively affect the immune system (lead)[26].

1.3 Justification of the Study

Nigeria is going through slow economic and financial changes, which is unusual for many emerging nations. Along with its well-established oil industry, which unpleasantly releases many different types of pollution, Nigeria also has increased mining operations, careless waste disposal and burning, illegal oil refineries, and terrorist insurgencies, all of which are expected to increase the levels of heavy metal contaminants in the country's environment [49].

Environmental pollution and contamination have been a major worry due to Nigeria's early industrialization stage and the inadequate implementation of environmental protection legislation and regulations. Heavy metals may have harmed human organs after being exposed to them and become deposited there. Depending on the exposure level, some diseases of the body can be affected directly or indirectly.

A study demonstrates that heavy metals and metalloids contaminate various Nigerian foods, crops, and vegetables from both natural and anthropogenic sources[51].

The combustion of fossil fuels, non-exhaust sources such the deterioration of car brakes and tyres, and a variety of other human activities are all responsible for the accumulation of heavy metals in the atmosphere. Nigeria has a high rate of heavy metal exposure, which broadens the scope of the numerous heavy metals under investigation. However, gastrointestinal absorption of mercury is about 7% to 15%, as opposed to 80% when inhaled[27]. This contrast demonstrates the hazard of inhaling mercury vapour, which can happen when working with silver ore, gold, or during amalgam dental work. Higher blood levels of mercury are associated with infertility, as it affects renal function and creates neurological problems[28].

The health of people is significantly impacted by the heavy metal lead. However, the source of the poisoning may be unimaginable in terms of wall paints or binders in sewer pipes[29,30] . Human poisoning is frequently related with lead gasoline, mining, and battery recycling. Osteomalacia is brought on by the loss of calcium and aberrant bone metabolism caused by lead and cadmium. Lead exposure is particularly harmful for children under the age of six because it interferes with the growth, development, and differentiation of nerve cells and damages bone tissue. According to the National Health and Nutrition Examination Survey (NHANES), blood lead levels (BLLs) 10 g/dl were present in approximately 88% of children aged 1 to 5 years in the 1980s. The numbers have been rapidly declining ever since. Based on the 98th percentile of the 2011–2014 NHANES data[31], a new reference value of 3.5 g/dl has just been suggested to the American Center for Disease Control and Prevention (CDC).

Smoking has been proven to significantly enhance the risk of cadmium exposure to cardiovascular disease. According to a study, cadmium in tobacco contributes to cardiovascular disease[32]. It is well known that foods including nuts, oilseeds, organ meat, and leafy vegetables have high cadmium content[33]. In China, rice is the principal food via which cadmium is consumed. Additionally, the destruction of Chinese e-waste exposes nearby residents to greater cadmium concentrations, and individuals who consume rice produced nearby exhibit a 60% rise in hazard quotient[34]. Cadmium contamination of food can occur naturally, as well as the result of sewage intrusion, fertilizer runoff from farms into water bodies, and groundwater. These factors can result in the presence of cadmium in fish and oysters. The liver and kidneys store a third of the total quantity of Cd (II) in the human body. Complete avoidance is advised due to the dangers of cadmium, which can cause major health problems even after brief contact. Chronic exposure to cadmium ions has been linked to a number of harmful effects, including anemia, sleeplessness, renal damage, bladder and prostate malignancies, and osteoporosis[35]. Drinking water in Kanpur, India, has chromium (VI) concentrations that are higher than average by about 390 times, which can lead to gastrointestinal, skin, and eye issues[36].

A well-known poison and carcinogen is arsenic. It is present in the soil, water, and air. A study looked into the relationship between child birth weight and drinking water arsenic consumption. Children's weight was significantly impacted by an increase in arsenic dose by roughly 57g[37]. Some regions have geothermal activities that encourage high arsenic levels. Wood has been treated with the CCA (copper-chromium-arsenic) preservation chemical in several countries. As a result, heavy-steel contaminants are present in the soil. As a result, CCA is the source and cause of heavy metals in food, along with arsenic[38]. Another study looked at arsenic levels in water, soil, and food, and found that they were significantly higher than the WHO's recommended limit for drinking water (10 g/l)[39]. But the cumulative effects of consuming arsenic via wheat, water, and animal products are something to which residents of afflicted areas are constantly exposed[39]. Studies have shown that contamination of the essential dietary components is the main cause of unfavorable outcomes. Another observation showed that residents of South-East, Nigeria who consumed vegetables and rice infected with high ratios of heavy metals, exceeded perfect limits for Pb, Ni, and Cd[40]. Human activities such as traffic, enterprise, and routine include traffic, enterprise, and routine. Honey poisoning by toxic metals, especially Ni and Cr, is a result of human activities like traffic, business, and modern agriculture. This scenario takes place while honeybees collect nectar from the flora of serpentine soils with elevated Ni concentration[41]. The main source of Ni (II) exposure for people living in Taiwan has been identified as paddy rice production in serpentine sites[42]. In addition, cocoa and chocolate contain nickel[43]. It is important to note that while some bacterial and plant enzymes depend on Ni(II) ions, the amount of nickel pollution in the environment is rising[43]. The highest levels of nickel in vegetables were found in Europe in Italy, but the values found did not pose a threat to either human or animal health[44]. A study of the dietary intake of Cd, Cr, Pb, Cu, and Ni also revealed that the amount of nickel in meat was ideal, with Pb and Cd being the greatest risk[45].

1.4 Aim and Objectives of the Study

Aim of the Study

The aim of this study was to assess the level/concentration of potentially toxic elements such as cadmium, lead, arsenic, mercury and nickel from the blood of unwell or diseased (already diagnosed) persons in University College Hospital, lbadan, Oyo State.

Specific Objectives

The specific objectives of this study were to;

i. assessing the levels of heavy metals in the blood of already diagnosed unhealthy persons to correlate it with their ailments.

ii. compare the levels of these heavy metals present in various or common ailments

1.5 Research Questions

1. Are these diseases origin traceable to the intake of man such as food, water, and air being polluted with heavy metals?
2. Do environmental pollution by heavy metals has effect or thus it causes these diseases in man?
3. Do these heavy metals have great consequence on the ecosystem?

1.6 Significance of the Study

Metals dissolved through different forms as soil pollutants, water pollutant and air pollutants, they entered into food chain and finally ending in humans. These leading to severe damages to the cellular system which may later result to cancer. According to the reports of the International agency for research on cancer nonessential heavy metals (As, Cd, Cr (Vl)) are major cancer- causing agents[47].

Due to highly pollution experiencing in urban cities such as Ibadan which has been polluted. The air, water soil and food have been polluted with different kinds of pollutants such as pesticides, heavy metals and other toxins. The richness and usefulness of heavy metals within the human-ecological system has also acknowledged significantly the negative implications of these metals, especially in the food chain[48]. A recent revelation indicates that about 2 million people in South western Nigeria alone could potentially be poisoned by lead (Pb) and mercury (Hg), emanating from illegal mining operations[50].

1.7 Scope of the Study

There were many heavy metals but this study is only assess these As, Ni, Pb, Hg and Cd in the blood of certain already diagnosed persons in University College Hospital, Ibadan North, Ibadan, Oyo state.

1.8 Limitation of the Study

This study considers the determination of heavy metals only in blood samples of already diagnosed patients. The high cost of laboratory analysis was also a major set-back in this research. Other biological samples would have been collected in addition to the blood and more numbers of persons would have been involved.

1.9 Operational Definition of Terms

Biomonitoring: is the process of measuring chemicals directly in human specimens like blood to determine how exposed an individual is to them in the environment.

Xenobiotics: A chemical substance found within an organism that is not naturally produced or expected to be present within the organism.

Pathogenetic\Pathogenesis: Is the process by which a disease or disorder develops. It can include factors which contribute not only to the onset of the disease or disorder, but to its progression and maintenance.

Haemopoietic: Pertaining to the formation of blood or blood cells.

Anthropogenic: Pollution or environmental changes originating from human activity.

Mutagenic: Anything that causes an alteration or change of the DNA cell which may be harmful or causes disease such as cancer.

Carcinogen: A substance capable of causing cancer in living.

Endocrine Disruption: An exogenous substance or mixture that alters the function of endocrine system and consequently causes adverse health effects.

Diseased Person/Unhealthy Person: A person suffering from an illness

Homeostasis: The ability of a system or living organism to adjust its internal environment to maintain a state of dynamic constancy such as the ability of warm-blooded animals to maintain a stable temperature.

Environmental Pollution: Is the presence of a pollutant in the environment; air, water and soil, which may be poisonous or toxic and will cause harm to living things in the polluted environment.

Endnotes

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Chapter Two

Literature Review

2.1 Chemicals of Concern

Chemicals are part of our daily life. All living and inanimate matter is made up of chemicals and virtually every manufactured product involves the use of chemicals[1]. Many chemicals when properly used can significantly contribute to the improvement or quality of life, health and well-being[1]. While others are highly hazardous and can negatively affect our health and environment when improperly managed. List of ten (10) major chemicals of concern were compiled by WHO, which includes many heavy metals: Air pollution, Arsenic, Asbestos, Benzene, Cadmium, Dioxin and dioxin-like substances, Inadequate or excess fluoride, Lead, Mercury, and highly hazardous pesticides[1].

The major minerals which present in high levels such as Na, K, Mg, and Ca are crucial to the metabolism and activity of the human body. The minor minerals which present in lower levels such as Mn, Fe, Co, Cu, and Zn are also essential as metabolic agents as well as enzymes catalysts. The trace heavy and toxic metals (As, Al, Ag, Se, Pb, Ba, Cr, V, Cd, Hg, Ni, Tl, and Sr) should not be present in the human body[2,3,4]. Although the human body needs certain minerals to maintain a healthy condition, too much of one mineral may become toxic. Moreover, toxic and heavy metals are highly dangerous even in trace levels and may cause chronic or acute poisoning. Basically, heavy metals are unarguably the transition and post transition metals, and the examples which are common in various literature are lead (Pb), cadmium (Cd), vanadium (V), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), arsenic (As), nickel (Ni), manganese (Mn), tin (Sn), zinc (Zn), and mercury (Hg). The availability and accessibility of these metals and metalloids through natural and anthropogenic pathways Figure 2.1 remain a major global concern in the ecosystem[5,6,7].

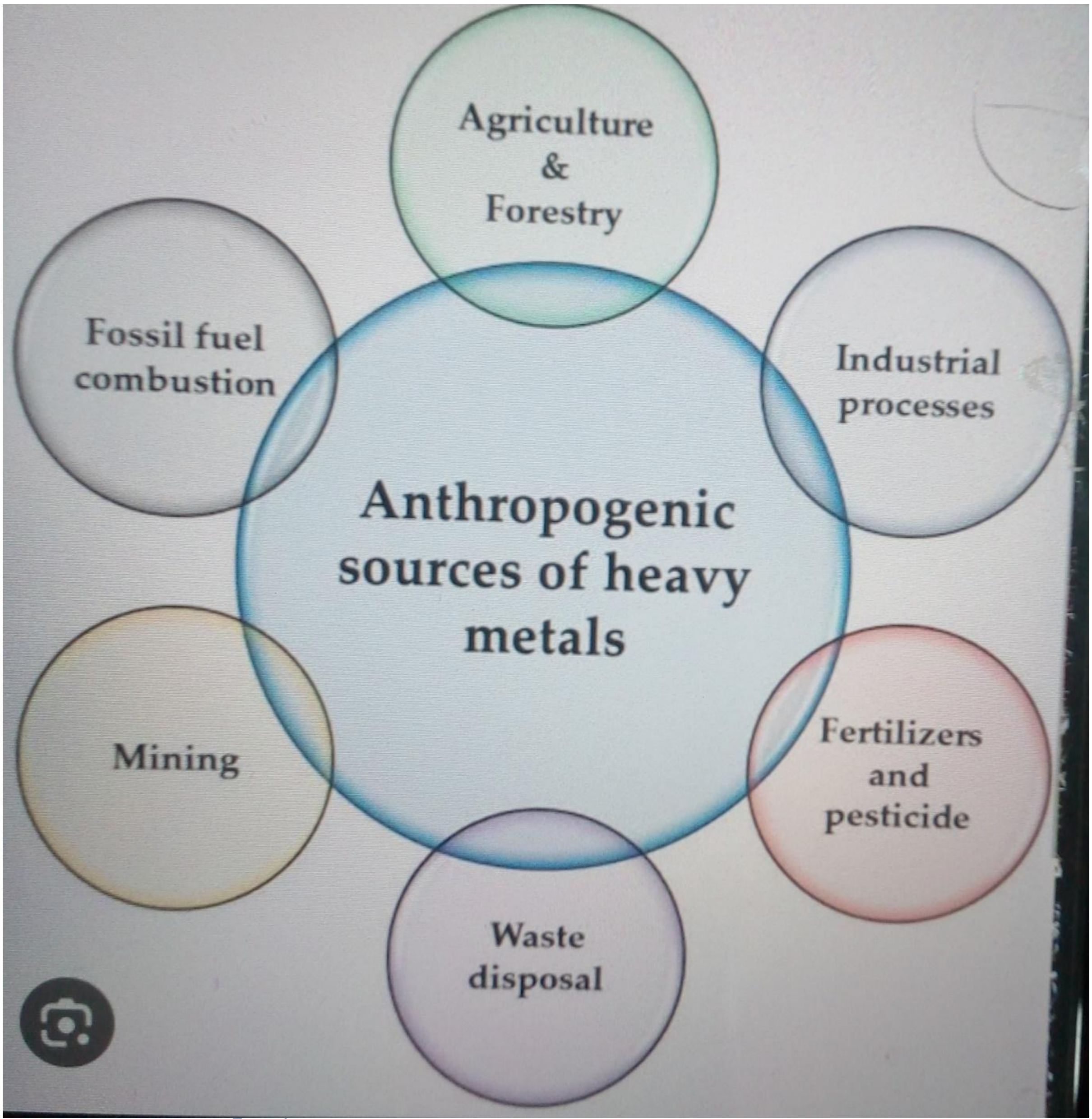

Figure 2.1 Anthropogenic Sources of Heavy Metals

Source[1]

The chemistry of heavy metals is a major contribution to their implications within the human-ecological context. Because metals are non biodegradable and have a lengthy half-life, biological species are unable to decompose them, and therefore remain in the body parts and surroundings, portraying health risks[8]. In terms of usefulness, the universe had been largely blessed by the abundance of heavy metals and the roles they play both in keeping the equilibrium and sustainability of ecosystem functions[9,10,11].

In Nigeria recent cases of heavy metals poisoning and significant pollution of heavy metals makes continuous monitoring worthwhile. The determination of heavy metals in the various environmental segments, such as air, water, and soil were lot of importance due to their carcinogenic and toxic nature. Heavy metal toxicity is one of the principal abiotic stressors on plants, based on heavy metal physiochemical features[12].

2.2 Human Exposure to Heavy Metals

Humans are exposed to heavy metals by occupational exposure or consuming foods that contain these elements. Humans are exposed to heavy metals through inhalation, ingestion, or contact with the skin .Multiple exposure can be more pronounced and tremendous morbidity. Children are more susceptible than adults. Short exposure results to acute toxicity while long term exposure of little amount results into chronic toxicity. Heavy metal toxicity can have several consequences in the human body. It can affect the central nervous function leading to mental disorder, damage the blood constituents and may damage the lungs, liver, kidneys and other vital organs promoting several disease conditions[13]. Also, long term accumulation of heavy metals in the body may result in slowing the progression of physical, muscular and neurological degenerative processes that mimic certain diseases such as Parkinson's disease and Alzheimer's disease[13]. Repeated long-term contact with some heavy metals or their compounds may even damage nucleic acids, cause mutation, mimic hormones thereby disrupting the endocrine and reproductive system which may eventually leads to cancer[14].

Cadmium exposure is through nickel/cadmium batteries and artist paints; lead exposure is through wine bottle wraps, mirror coatings, batteries, old paints and tiles and lanolin amongst others as in Figure 2.2. Infants are more susceptible to the endangering effects of heavy metals.

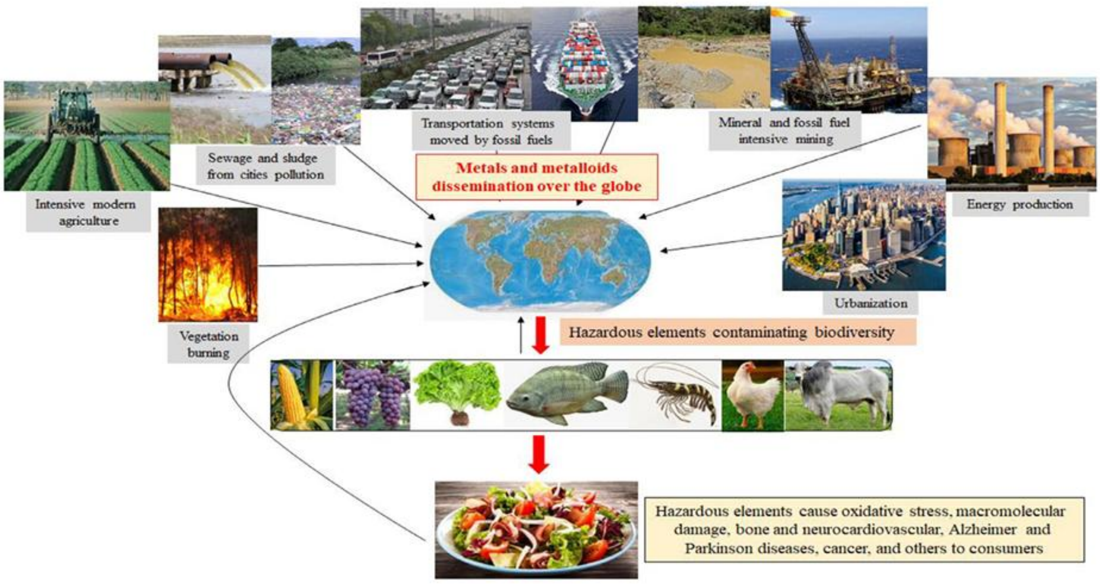

Figure 2.2: The Anthropogenic Activities correlated with the spread and increase concentration of metals and metalloids over the ecosystems and becoming hazardous elements to living being including man

Source[8]

2.3 Classification of Heavy Metals

Heavy metals are widely grouped into essential and non-essential elements. The essential ones include iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), cobalt (Co), nickel (Ni), molybdenum (Mo) and selenium (Se). They are required by living organisms for fundamental metabolic activities. Many of them serve as cofactors that are functionally and structurally important for enzymes and enzyme-catalysed biochemical reactions that are true for many life forms.

Non-essential heavy metals include lead (Pb), cadmium (Cd), mercury (Hg), arsenic (As), tin (Sn), aluminium (Al), silver (Ag), gold (Au), antimony (Sb), bismuth (Bi), palladium (Pd), platinum (Pt), vanadium (V), strontium (Sr), tellurium (Te), titanium (Ti), Uranium (U), and chromium (Cr), particularly the hexavalent form (Cr VI)[15]. The non-essential heavy metals have no specific benefits to the living systems and many of them are toxic at low concentrations.

Mineral resources and elements such as copper, chromium, iron, manganese, and zinc, among others, are essential for both animals and humans because they are involved in a variety of metabolic functions, enzyme activities, receptor sites, hormonal function, and protein transport at specific concentrations[16]. Another group of elements, such as arsenic, cadmium, lead, and mercury, are non-essential and play no useful role in plants, animals, or people. They are of no nutritional purpose since they are exceedingly poisonous[17]. The heavy metal exposure sources can be grouped into 2: the anthropogenic and natural sources. Example of natural sources includes weathering of minerals, erosion and volcanic activities, forest fires and biogenic activities and particles released by vegetations. Examples of anthropogenic source are listed in Table 2.1.

Table 2.1: Sources of Some Heavy Metals

Elements	Anthropogenic Source
As	Pesticides,wood preservatives, biosolids,ore mining and smelting
Cd	Paints and pigments, plastic stabilizers, electroplating, phosphate fertilizers
Cr	Tanneries, steel industries, fly ash
Cu	Pesticides, fertilizers, biosolids ore mining and smelting
Hg	Au-Ag mining, coal combustion, medical waste
Ni	Effluent, kitchen appliances, surgical instruments, automobile batteries
Pb	Aerial emission from combustion of leaded fuel, batteries waste, insecticide and herbicides

Source[17]

2.4 Selected Metals

2.4.1 Lead (Pb)

Lead is a harmful environmental pollutant that has high toxic effects on many body organs. Even though Pb can be absorbed from the skin, it is mostly absorbed from respiratory and digestive systems. Pb exposure can induce neurological, respiratory, urinary, and cardiovascular disorders due to immune modulation, oxidative, and inflammatory mechanisms. Exposure to Pb can produce alteration in physiological functions of the body and is associated with many diseases[18-20]. The sources of lead varied in different countries based on the trend of using lead products. It is not limited to the processing of gold ore and recycling of used lead products. It is found that there has been decrease in blood lead levels in the population of the countries in which unleaded gasoline is in usage[21]. Lead is a non-biodegradable metal that is available in nature and found in relatively low amounts. Atmospheric lead levels are increasing continuously because of the human activities including manufacturing, mining, and fossil fuel burning. Lead is toxic to the human body when exposed to amounts greater than the optimum. Children are at higher risk of lead poisoning; when they come into contact with dust laden with environmental lead, the severity of poisoning increases[21].

Toxicological of lead has shown inhibition of the activity of d-aminolaevulinic dehydratase (porphobilinogen synthase, one of the major enzymes involved in the biosynthesis of heme) and developmental problems such as impaired cognitive function, behavioral disorder, stunted growth, and impaired hearing, lead blood level as low as 5 µg/l[23,24]. Lead also interferes with calcium metabolism, both directly also with vitamin D metabolism; it concentrated largely in bones in animals and humans and interferes with the normal maturation of erythroid elements in the bone marrow[25].These effects have been observed in children at blood lead levels ranging from 12 to 120 µg/l. Exposure to lead is especially dangerous for children under six years of age, as it disturbs development, growth and differentiation of nerve cells, and it causes damage of bone tissue. In 1980s, the National Health and Nutrition Examination Survey (NHANES) shows that 88% of children aged 1–5 years had an estimated blood lead levels (BLLs) ≥ 10µg/dl. Lead is toxic to both the central and peripheral nervous systems, inducing sub encephalopathy neurological and behavioural effects. Other effects include intelligence quotient deficits of about four points in children due to prenatal/postnatal exposure to lead (blood lead level ranging from 11 to 33µg/l), headache, irritability, constipation, weight loss, fatigue, hypertension, miscarriages, stillbirths, and renal tumors[26].

2.4.2 **Mercury** (Hg)

Mercury is an extremely hazardous heavy metal that may be found in biosphere. Due to human activities, it has also become a widespread contaminant and is increasing in the atmosphere. Mercury converts to the highly toxic methyl mercury when in contact with aquatic sediments[27]. The health effects of mercury are diverse and depend on the form of mercury encountered and the severity and length of exposure. The general population may be exposed to three forms of mercury. Mercury is found in air, water, and soil and exists in three forms: elemental or metallic mercury (Hg0), inorganic mercury (Hg^{+},Hg^{2+}), and organic mercury (commonly methyl or ethyl mercury)[27]. Elemental mercury is liquid at room temperature and can be readily evaporated to produce vapour. Mercury vapour is more hazardous than the liquid form; inhaling large amounts of Hg vapour can be fatal[28]. Organic mercury compounds such as methyl mercury (Me-Hg) or ethyl mercury (Et-Hg) are more toxic than the inorganic compounds. The toxicity of mercury depends on its chemical composition. Both volcanoes and forest fires are natural sources of mercury in the atmosphere. The burning of fossil fuels in power plants is one of the major anthropogenic sources of mercury[31]. Because of easy transportation, it is considered a global pollutant[30]. Even exposure to small quantities, shows toxic effects on various physiological systems, such as nervous and digestive systems and organs like lungs and kidneys. Mercury has a significant influence on the human body. Reports have shown that mercury is largely ingested through the consumption of fish: marine, freshwater and starfish[32-34]. A study conducted in China revealed that mercury levels in children's blood vary depending on the region or the rate of fish consumption[35]. The level of organic mercury (e.g. methyl mercury) depends on the species of fish[36]. Bio accessibility of mercury in food differs between raw and cooked foods and can be reduced by drinking green or black tea and black coffee during a meal[37,38]. Mercury has been shown to cause neurotoxicity, nephrotoxicity, and hepatotoxicity in humans. Cardiovascular toxicity has also been discovered in recent research.

2.4.2.1 Application of Mercury

Mercury compounds have many applications[31]:

1) In mining for the extraction of gold and some industrial processes.
2) In lamp producing factories, for the production of fluorescent light bulbs.
3) Me-Hg and Et Hg have been used as fungicides to protect plants against infections.
4) Had been of medicinal uses in the past, but such drugs have been replaced by safer pharmaceutical medicines such as chlormerodrin, merbaphen, and mercurophylline (all diuretics) and phenylmercury nitrate (disinfectant).
5) Some skin lightening creams and some soap are mercury polluted. Mercury chloride ($HgCl_2$) is one of the active ingredients of skin brightening creams which are used to remove freckles and spots of the skin due to excessive accumulation of melanin.
6) Mercury-containing organic compound called thimerosal has been used as a preservative in multi dose vials of vaccines.

2.4.3 Cadmium

Cadmium can be in the atmosphere as a result of natural or manmade activities. Animals and humans can be exposed to it differently. Cadmium pollution of the aquatic environment occurs through absorption, industrial waste, and surface runoff into sediments soil and sediments. People can be poisoned by cadmium via ingesting food, breathing air, or drinking water rich in the metal. Cadmium does not have any attributes that are helpful for plant growth and metabolic processes[81]. Cadmium has been found to greatly increase the risk of cardiovascular disease by smoking. Li showed the effects of cadmium in tobacco as a cardiovascular disease factor[82]. Leafy vegetables, oilseeds, crops, organ meat, and nuts are known to contain high levels of cadmium[83]. Cadmium is a toxicant and carcinogenic metal.

In addition to its carcinogenic properties, cadmium induces kidney disease, bone disease, and cardiovascular disease. Cadmium is mainly accumulated in kidney and liver; secondly in thyroid, spleen and pancreas. Several cross-sectional and longitudinal studies from different populations have demonstrated that cadmium exposure is associated with CVD such as stroke and coronary heart disease[45,49-53]. In prospective studies, cadmium was linked to an increased risk of cardiovascular death in the general population of the United States[54,55]. Food contamination with cadmium can come from natural sources, as well as from sewage and fertilization that gets through groundwater and runoff from fields into water bodies, causing the presence of cadmium in fish and oysters. One third of the total Cd (II) amount in the human body is accumulated in the liver and in the kidney[55].

Development of dermatitis allergic due to chromium exposure has also been found in many studies[57,58]. The major exposure of cadmium by human beings is through contaminated food and water . Cigarette smoke is the way of exposure through the inhalation route. The toxicity of cadmium is due to accumulation in plants and animals for nearly 25–30 years. Another major source of cadmium in the environment is phosphate fertilizers and the waste incineration process. There is huge difference between the cadmium blood level in smokers and non-smokers of cigarettes[59]. Occupational exposures to cadmium are the workers at battery production, pigment industries, and electroplating. The presence of lead and cadmium in the human body can reach the brain and can cause Alzheimer's disease[60].

Microbial fermentation is one of the effective methods to remove cadmium from food[61]. Studies have shown that a vegetarian diet possesses higher levels of cadmium compared to a non-vegetarian diet[62]. Spungen revealed that the highest ratio of cadmium is in vegetables and plant products such as sunflower seeds, spinach and potatoes, which can exceed 100 µg/kg of cadmium[63]. Consumption of cadmium has a particularly negative effect on fertility.

2.4.4 Arsenic (As)

Arsenic is a metalloid but due to its toxic and carcinogenic exposures through atmospheric air, groundwater, and certain kind of foods[64]. It is notoriously known as the king of poisons and poison of kings[65]. The order of increasing toxicity of As compounds is defined as organic arsenicals < As0 < inorganic species (As^{5+} < As^{3+}) < arsine[66-68]. Arsenic is a known reproductive toxin in humans, and it causes abnormalities in experimental animals, particularly neural tube anomalies[69]. Inorganic arsenic impairs male reproduction by reduction in weights of the testes, the accessory sex organs, and the volume of sperm in the epididymis. In females, arsenic consumption is associated with an increased incidence of endometrial cancer[70]. Arsenic is used as a pigment in color cosmetics (eye shadows, lipsticks) and is also in skin care products, such as lotions. The use of arsenic in its inorganic form may have many side effects, such as fatigue, nausea, vomiting, skin diseases and cancer[71,72]. In a study conducted in 2017, arsenic was detected in 20 different types of cosmetics such as skin foundation, lip balm, skin whitening cream, and hair dyes. The highest concentration of arsenic was found in lip balm (19.55 ppm)[73,74]. Arsenic's damaging action depends on the bioavailability, chemical form (metalloid, inorganic or organic), and metabolism of the human body. Oxidative stress has a major role in arsenic-induced toxicity[75]. The most toxic oxidative states of Arsenic are the inorganic arsenite (III) and arsenate (V) states. Arsenide is considered to be a more toxic inorganic form compared to arsenate, and the most toxic form of arsenic is Arsine gas (AsH_3). Inhalation of over 10 ppm can be lethal[76]. Chronic exposure to elevated concentrations of arsenic has been associated with the prevalence of several cancers and increased risk of a number of noncancerous effects. It is suggested that the main source of carcinogenicity and toxicity of arsenic is due to its reduction to arsenite in the body.

2.4.5 Nickel (Ni)

It is worth mentioning that Ni (II) ions are important for some plant and bacterial enzymes, however, nickel pollution is increasing in the environment[77]**.** Nickel is a naturally abundant element and has extensive industrial uses. It is emitted from both natural and anthropogenic sources into the atmosphere[78]. It has many adverse effects on humans, and causes allergies, nasal and lung cancer, and kidney and cardiovascular diseases owing to the inhalation of contaminated air[79].

Some metal ions do not have physiological functions in humans but can be important for bacteria. One of them is nickel, the cofactor of urease and Ni-Fe hydrogenase enzymes[80]. Nonetheless, most metals that are toxic to animals are also hazardous to microorganisms. Even Ni (II) is toxic to bacteria at elevated concentrations.

2.5 Theoretical Review of Heavy Metals

Nickel and Arsenic are currently classified to be ''carcinogenic to humans'' by the International Agency for Research on Cancer (IARC) among 87 mainly organic carcinogens. Humans could be exposed to multiple metals simultaneously, and the interactions of these metals have effects on human health. A study found that the body's absorption of As, Cd, and aluminium (Al) may increase when Fe concentration in the body is low, and sufficient of Fe provides some protection against toxic metals[84].

Another study did a finding, by determined the accumulation of toxic trace metals Ni, Cd, Pb and As in human body systems in Nigeria using blood and urine of patients at the University of Maiduguri Teaching Hospital (UMTH), Borno state. The authors found that the concentrations of metals increased as the age increasing, being lowest in group 1–10 years and highest in age group 51–60 years. Furthermore, levels of the metals in blood and urine were above those in drinking water sources in Maiduguri metropolis, where the patients reside[85].

Similar study also investigated the levels of heavy metals in urine and blood samples of 60 children in Owerri metropolis, in Eastern Nigeria. The study found that Pb, Cd, Ni, Mn and Cr in both the urine and blood samples varied, in which the blood concentrations were higher than those of urine samples. Indeed, the authors noted that the maximum concentrations of the metals in blood were higher than the maximum values specified by the USA Academy of paediatric[86].

A study also assessed the levels of toxic heavy metals concentrations in blood and urine samples of a group of 100 hairdressers in Enugu, due to the regular use of cosmetics the hairdressers were believed to have been exposed to metals. Exposure to Pb was shown from a high mean blood Pb concentration of 17.47µg/dl. The study also reported mean blood Hg level of 25.06 ng/ml, which was above the expected normal range of 10–20ng/ml. Mean concentration of Ni (0.49 µg/dl), was found to be above the reliable value of 0.2 µg/dl. These Ni levels were noted to be possibly responsible for carcinogenic effects that negatively affect the quality of life of the subjects, as indicated by the rate of dizziness, nausea, vomiting, sleeplessness and headaches[87]. Children are at higher risk of lead poisoning; when they come in contact with dust heavy with environmental lead, the degree of poisoning increases.

Cadmium has been found to greatly increase the risk of cardiovascular disease by smoking. A study showed the effects of cadmium as a cardiovascular disease factor in tobacco. Leafy vegetables, oilseeds, crops, organ meat, and nuts have also been reported to contain high levels of cadmium[83].

Nickel is a naturally abundant element and has extensive industrial uses. It is emitted into the atmosphere both by natural and anthropogenic sources[87]. It has many adverse effects on humans, and causes allergies, nasal and lung cancer, and kidney and cardiovascular diseases owing to the inhalation of contaminated air. Nickel is a naturally abundant element and has extensive industrial uses.

Food crops are one of the most essential components of our nutrition, and therefore contain variety of both necessary and hazardous metals, depending on the properties of the growth medium used[88,89]. Human exposure to heavy metals from comes mostly through edible vegetables, which account for about 90% and the remaining 10% comes from skin contact and breathing of polluted dust[90-92]. Because of the growing demand for food in recent decades, food safety has become a major public health concern in terms of human health. This scenario serves to motivate researchers and scientists to do more studies on the health risks linked with the ingestion of heavy metals as in Figure 2.3, pesticides, and toxin-contaminated food products[93]. Our food chain is constantly being replenished with essential and non-essential materials as a result of the excessive use of agrochemicals, municipal wastewater, industrial effluents, and raw sewage for irrigation[93]. In accordance with the Agency for Toxic Substances and Disease Registry's toxicity classification system, heavy metals and metalloids such as arsenic, lead, and cadmium present in the environment are classed as 1, 2, and 7 on a scale from 1 to 7[95].

Environmental pollution caused by heavy metals in Figure 2.3 is persistent, covert, and long-term[96]. Because metals are no biodegradable and have a lengthy half-life, biological species are unable to decompose them, and they remain in their body parts and surroundings, posing health risks[97]. Bioaccumulation of heavy metals in vegetables poses a health hazard due to their potential to transfer from polluted land and water into the food chain[98,99]. Through rivers and streams, the metals are transported as either dissolved species in water or as an integral part of suspended sediments, (dissolved species in water have the greatest potential of causing the most deleterious effects). They may then be stored in river bed sediments or seep into the underground water thereby contaminating water from underground sources, particularly wells.

Soil properties are crucial in food production, and the pollution of heavy metal in this resource is critical as well as their subsequent absorption and bioaccumulation in food crops, poses substantial environmental and health concerns, especially in poor countries. Heavy metal concentrations are influenced by soil type, plant genotype, and their interactions[100]. In comparison mineral fertilizers contain increased concentrations of heavy metals more that organic manure as a consequence, the use of mineral fertilizers leads to increased levels of heavy metal pollution in soil[101].

The health risks associated with toxic metals are dependent on the concentrations of these metals in certain media and the length of exposure. Even at low quantities of hazardous metals, long-term and chronic exposure may cause health problems[102]. Heavy metal toxicity is one of the principal abiotic stressors on plants, and it is based on heavy metal physiochemical features[103].

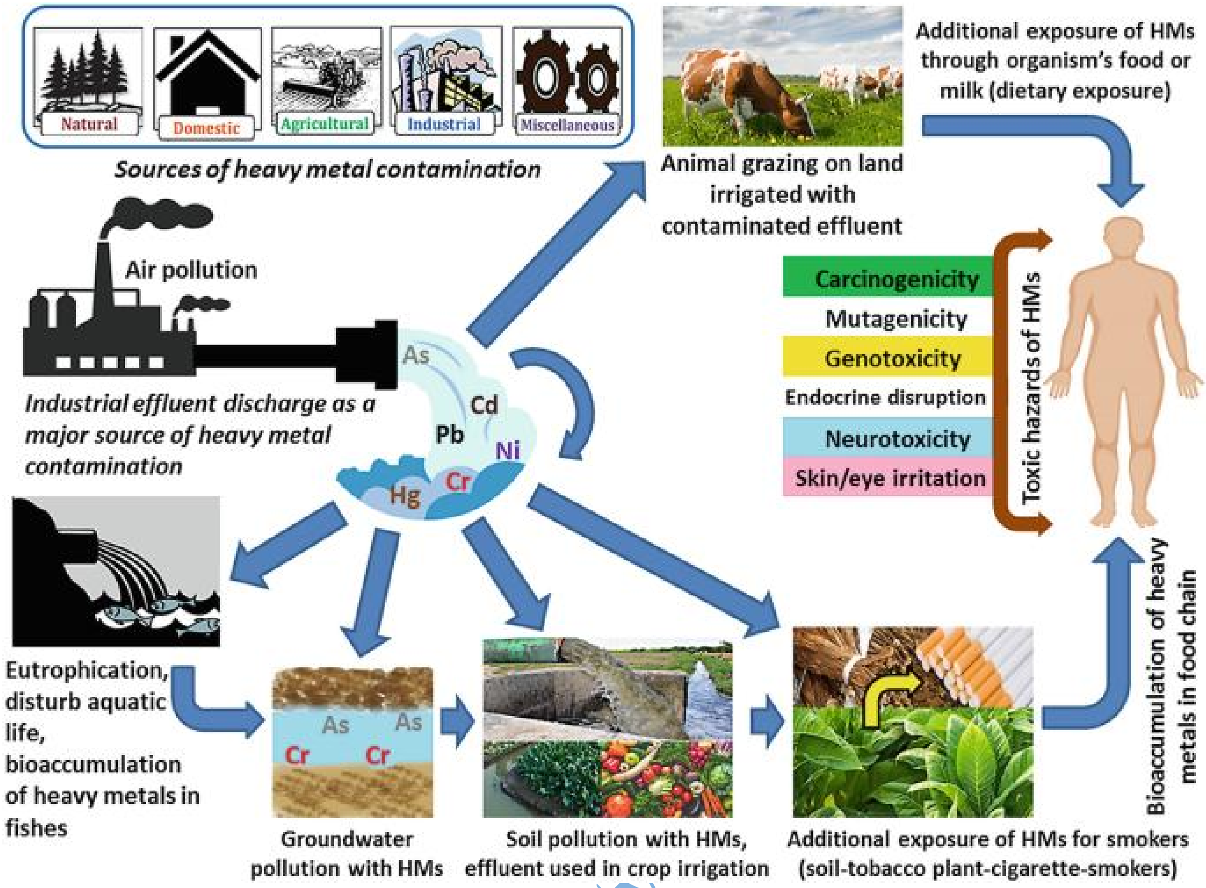

Figure 2.3: Pollution of Heavy Metals and its Toxic Effects

Source[103]

2.6 Empirical Studies

Nowadays the human is exposed to the highest levels of toxic and heavy metals coming from many sources, namely, the burning of coal, natural gas and petroleum, and incineration of waste materials worldwide[104]. Such metals represent a major cause of aging, diseases, and even genetic defects. Therefore, accurate and precise determination of these elements in the human fluids and tissues is extremely important[104-106]. Chronic adverse effects on human health may be as a result of prolonged intake of such toxic elements, some of which are powerful carcinogens. Based on their extreme toxicity, toxic and heavy metals must be detected at slit low levels in the human fluids and tissues[107-108].

The benefits of heavy metals are generally outweighed by their hazards Table2.2; for example lead poisoning causes intellectual abnormalities in children[109]. Mercury toxicity causes Minamata disease, while cadmium poisoning causes itai-itai disease. Heavy metals can also cause toxicity in certain organs of the human body Figure 2.4, such as nephrotoxicity, neurotoxicity, hepatotoxicity, skin toxicity, and cardiovascular toxicity, among other things[110-111]. A study conducted in China revealed that mercury levels in children's blood varies depending on the region and on the rate of fish consumption[112].

Regulation (EC) No 1223/2009 prohibits the use of cadmium and its compounds in the cosmetics[113]. The IARC (International Agency of Research on Cancer) classified cadmium and lead as group 2A of carcinogenic substances. Cosmetic products, especially lipsticks, can be dangerous to health, as average women inadvertently swallow as many as 4 pounds of lipstick during their lifetime[114]. Cadmium can also be found in rinse-off products. Long-term use of these products may lead to skin rashes, epithelium problems, and distortion of other organs[115]. Skin dermatitis can be caused also by nickel present in jewellery and cosmetics. Nickel usage in cosmetic products is prohibited by European Parliament, however, the available data show that it can be found in many types of colour cosmetics produced and used in various parts of the world[116-117]. Studies show that it is detected mainly in lipsticks and powders[118,119]. Generally, toxic metals present in cosmetics may act directly on the skin or indirectly by absorption through the skin into the blood, leading to bioaccumulation and toxic effects in various organs.

Recent researchers have reported that heavy metals exposure is directly associated with biomarkers of effects than measurement of external pollutants[120,121]. There are environmental (water, air, soil, dust), occupational, medicinal, and dietary sources of metal exposure. Biomarkers and heavy metals are equally better in providing an assessment of health risk before the onset of diseases[122]. Another study revealed that biomarkers can reveal exposure and early health effects of heavy metals. According to the reports of the International agency for research on cancer non-essential heavy metals (As, Cd, Cr (VI)) are major cancer-causing agents[123-124].

Table 2.2: Heavy Metals Sources and Health Effects in Human

Heavy Metals	Sources	Health Effects
Lead (Pb)	Batteries Coal combustion Paint industry	Serious effect on mental health (Alzheimers disease), Nervous system.
Arsenic (As)	Atmospheric deposition, mining, pesticides	Highly effects dermal region (Cancer) Brain and Cardiac problems
Mercury (Hg)	Coal combustion, Fish, Mining, Paint industry, Paper industry, Volcanic eruption	Sclerosis, Blindnes, Minamata Disease, Deafness, Gastric problems, Renal disorders
Cadmium (Cd)	Plastic Fertilizers pesticides	Osteo related problems Prostate, cancer, Lung diseases, Renal issues
Nickel (Ni)	Plant products, for example, legumes and soy products	Allergies, nasal and lung cancer, kidney and Cardiovascular diseases

Source[126]

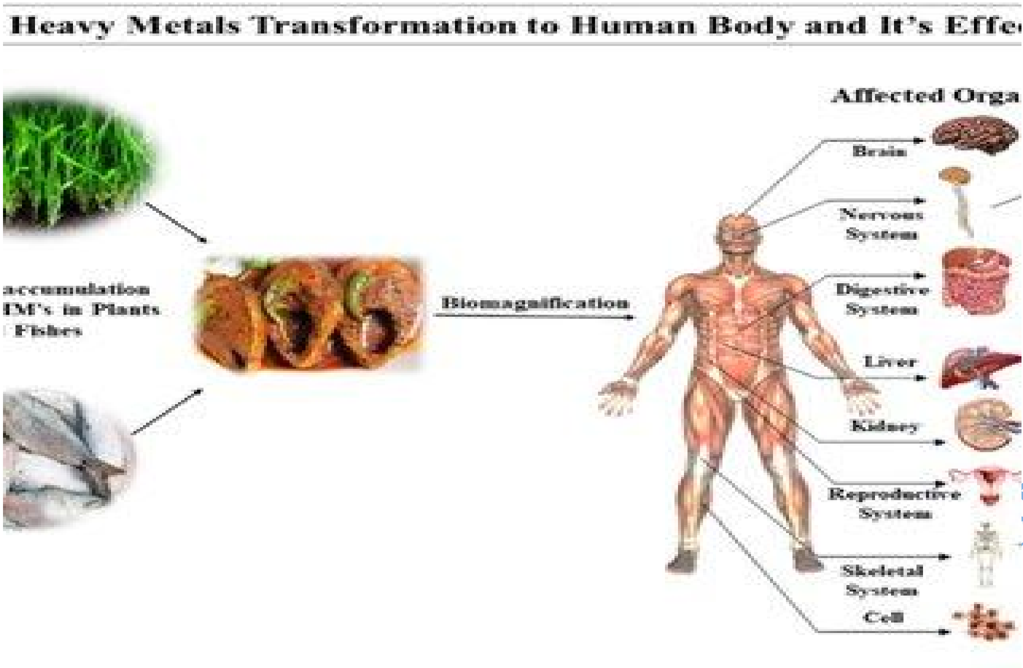

Figure 2.4: Heavy Metals Transformation to Human Body and it's Effect

Source[124]

2.7 Route of Exposure and Bioaccumulation of Heavy Metals in Humans

Humans get in contact with heavy metals by consuming contaminated food stuffs, sea animals, and drinking of water, through inhalation of polluted air as dust fumes and also through occupational exposure at workplace[125]. These heavy metals can be taken up through several routes Figure 2.5. Some heavy metals such as lead, cadmium, manganese, arsenic can enter the body through the gastrointestinal route; that is, through the mouth when eating food, fruits, vegetables or drinking water or other beverages. Others can enter the body by inhalation while others such as lead can be absorbed through the skin.

Elders are more sensitive to chemicals than younger adults, and elders may exhibit greater internal doses of toxicants for a given external exposure[126].

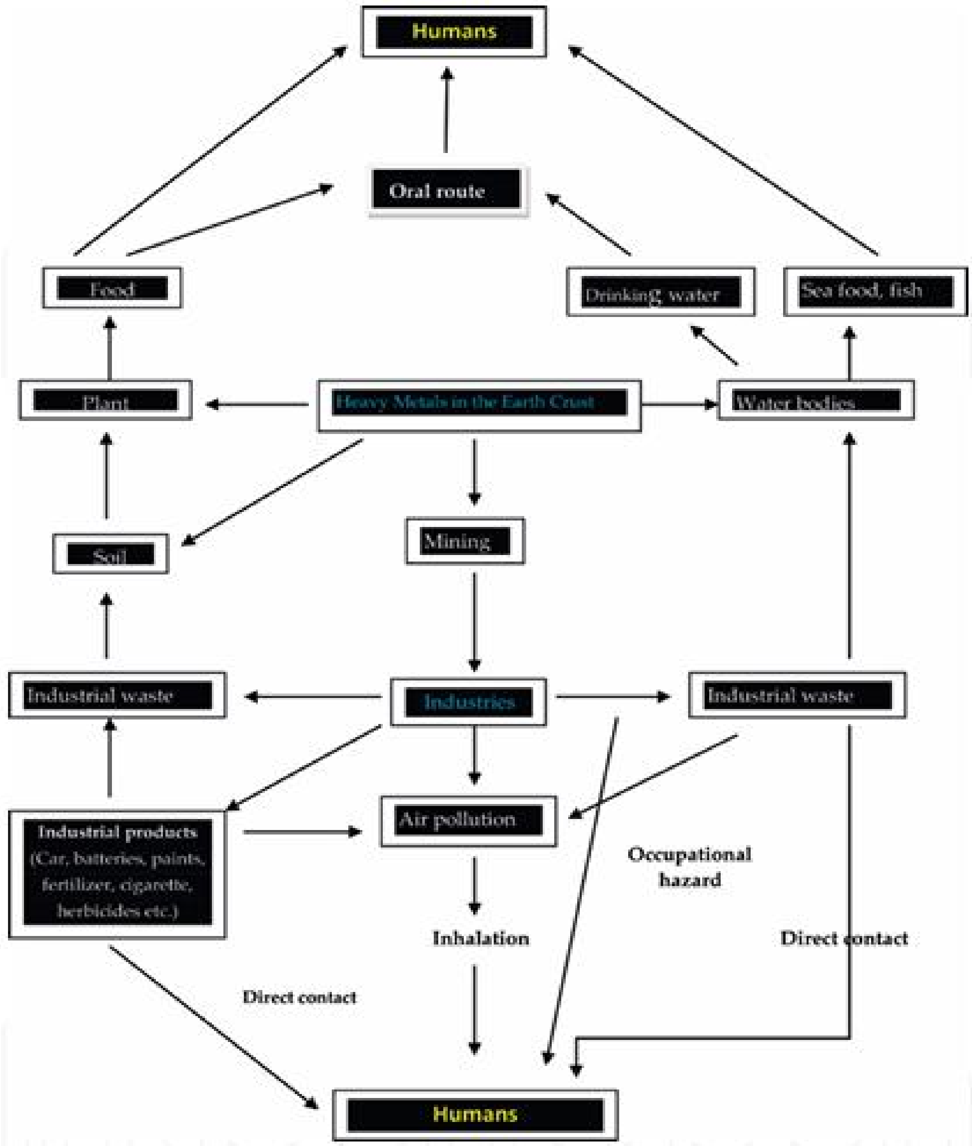

Figure 2.5: Mechanism of Heavy Metals in Humans

Source[126]

Heavy metals and metalloids are constantly flow into the ecosystems through wind mass blow and water current in rain seasons flowing into the lagoons, streams, lakes, rivers until its get to seas and oceans[127-130]. Heavy metals and metalloids have hazardous effects on soil and water–food such as (crops, vegetables, fruits, seeds, almonds, nuts, roots, bulbs, rhizomes, seafood, fish and animals) over their continuous cycling across the globe [131-136].

2.8 Health Effects of Heavy Metals

2.8.1 The Relationship of Heavy Metal with Some Illness

The biotoxic effects of heavy metals are refered to the harmful effects of heavy metals to the body when consumed above the bio-recommended limits. Although individual metals exhibit specific signs of their toxicity Table 2.2 , the following have been reported as general signs associated with cadmium, lead, arsenic, mercury, zinc, copper and alumi nium poisoning: gastrointestinal (GI) disorders, diarrhoea, stomatitis, tremor, hemoglobinuria causing a rust–red colour to stool, ataxia, paralysis, vomiting and convulsion, depression, and pneumonia when volatile vapours and fumes are inhaled[163]. The nature of effects could be toxic (acute, chronic or sub-chronic), neurotoxic, carcinogenic, mutagenic or teratogenic.

The finds shows that 1.56 billion people are likely to be down with hypertension by 2025[137]. The investigation according to these factors (such as age, smoking, alcohol consumption, and obesity) do not totally predict the extent of hypertension in the general population. Previous studies have reported the potential association between exposure to metals from the natural environment and pollution with hypertension[138,139]. In daily life, multiple metals coexist in almost all environmental media, such as soil, drinking water, ambient air, food, consumer products, and medications[140]. Recent epidemiological studies have evaluated associations of exposure to heavy metals with blood pressure (BP) and hypertension, but the results are equivocal. However, an inverse association between urinary Cd and BP was observed in a cross-sectional study among Canadian adults[141,142]. A meta-analysis with eight studies included suggested an increased correlation between arsenic (As) exposure and hypertension[143]. Meanwhile, significant associations between high level of urinary As and Cd with slight elevations in BP were found in one Spanish cohort study[144]. The 1999–2004 US National Health and Nutrition Examination Survey confirmed the association between As exposure and incident hypertension in American adults[145]. However, no link between As exposure and hypertension was observed in a cross- sectional study of China[146].

In China 114 million people are suffering from diabetic this accounts to one-third of the world diabetic population[147]. An increasing amount of evidence has shown the link between environmental compounds and type 2 diabetes[148]. Heavy metal pollution is currently an important environmental issue because heavy metal ions are difficult to degrade. The heavy metals arsenic (As), cadmium (Cd), copper (Cu), nickel (Ni), lead (Pb), and zinc (Zn) may be associated with diabetes development. For example, a cross-sectional study in France found that blood Cd concentrations were significantly and positively associated with HbA1c levels [149]. Glycated hemoglobin (HbA1c) is an indicator of long-term glucose metabolism. However, some studies did not find a relationship between heavy metal exposure and diabetes incidence or HbA1c levels[150,151].

A case-control study from Norway found that elevated blood nickel levels significantly increased the risk of diabetes development[152]. However, a study did not find significant differences in serum Ni levels between diabetic patients and healthy subjects in a case-control study, and no significant association was found between serum Ni and HbA1c levels[153]. Interestingly, a case-control study from Italy found significantly lower blood Ni levels in patients with types 1 and 2 diabetes than in the controls, and the study concluded that diabetes is associated with nickel deficiency[154]. Evidence from animal studies suggested that Ni can induce hyperglycemia in rats by increasing hepatic glycogenolysis and glucagon release, thereby decreasing peripheral glucose utilization or gluconeogenesis[155]. A study based on a Chinese occupational population also did not find any interaction among the effects of multiple metal mixtures on fasting blood glucose[156].

Cancer risk was the probability of an individual developing any cancer during the entire lifetime due to a specific exposure to a hazardous heavy metal or metalloid. Recently, certain heavy metals such as cadmium (Cd), mercury (Hg), lead (Pb), chromium (Cr), and arsenic (As) showed a close association to breast cancer[157]. Heavy metals are confirmed as human carcinogens; lead, cobalt, and iron are observed as potential carcinogens. Prostate cancer mortality was found to be strongly contributed to cadmium (Cd), followed by zinc (Zn) and chromium (Cr)[158]. Excess occupational and environmental exposure to metals is considered to be a major cause of metal-related cancer and also associated with increased cancer risk[159]. Occupational exposure to cadmium and nickel are linked to renal and prostate cancer. Lead is associated with glioma and stomach cancers while mercury exposures are associated with prostate and bladder cancers. Metalloestrogens such as cadmium, calcium, cobalt, copper, nickel, chromium, lead, mercury, and tin activate the estrogen receptor, and exposure to these metals may increase the risk of developing breast cancer[160,161,162]. Obviously, there is a strong correlation between cancer rate and metal exposure, lung cancer is associated with the occupational exposure to metals including cadmium, chromium, nickel, copper, cobalt, lead, and mercury.

Recently, the effect of heavy metals exposure on cardiometabolic health has received extensive attention from researchers, and compelling evidence has confirmed its association and Metabolic Syndrome[164]. Among these heavy metals, cadmium is a kind of widespread environmental contaminant with a release of 2.2×104 tonnes globally due to steadily increasing industrial activities, and cadmium has been recognized as a metabolic disruptor[165]. Another research suggested cadmium contributed negatively to the environmental risk for the development of MetS among 15 heavy metals in a prospective cohort[166]. Cadmium has been categorized as hyperglycemia metal through upregulation of gluconeogenesis and pancreatic islet dysfunction[167].

Endnotes

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Chapter Three
Methodology

3.1 Research Design

This research involved the determination of some heavy metals as an environmental pollutant and their interaction with some diseases. Patients with various diagnoses were selected such as hypertension, diabetics, cancers, liver diseases and other infections. All selected patients were informed of the objective of the study and their consent were obtained. This was carried out in three phase, the first phase was the time of sample collection and questionnaire response. The second phase was the period of digestion of the blood sample while the third phase was laboratory bench work and instrumental analysis.

3.2 Study Site

The study area was University College Hospital, Ibadan, Oyo state, Nigeria. The hospital is situated 190 meters northwest. The facility is spatially located at 7 40143^0 North, 3 90462^0 East and Elevation 223 meters (732 feet) as shown in Figure 3.1.

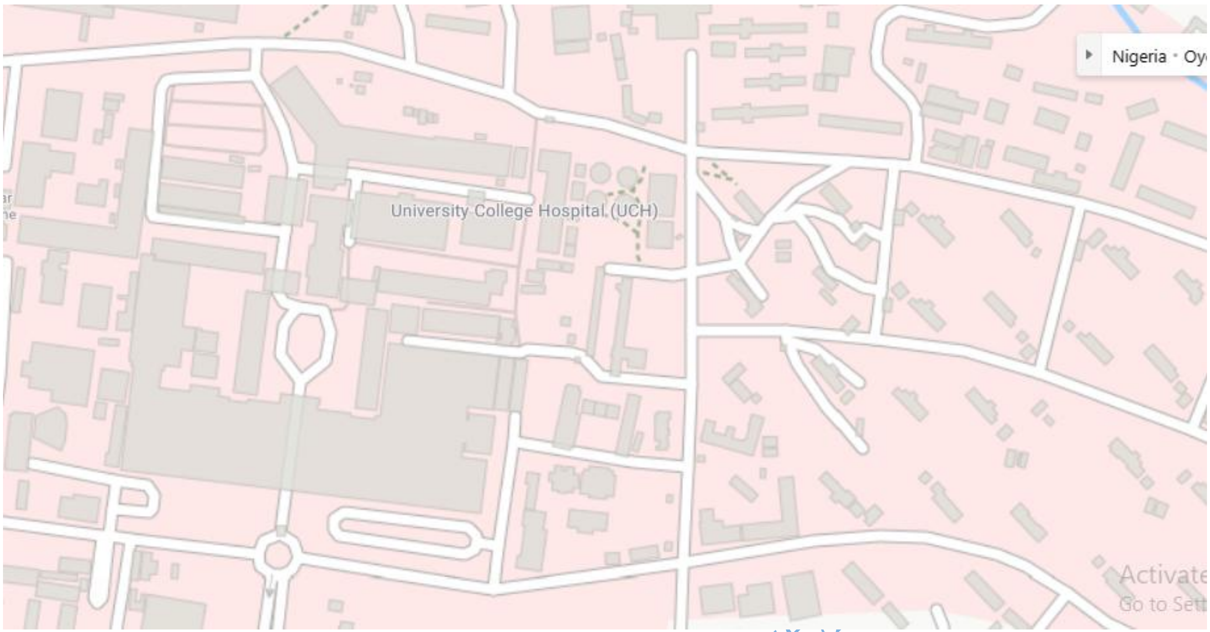

Figure 3.1 Map of UCH showing the Phlebotomy Units of the Hospital Complex

Source: Author's Field work, 2023

3.3 Questionnaire Administration

A structured questionnaire was used to collect the socio-demographic data survey number, name, age, sex, diagnosis, ethnicity, level of education and their work place. The questionnaire also included their knowledge and exposure to heavy metals.

3.4 Blood Sample Collection

The blood samples were collected from selected people in the morning before noon. Blood samples were collected by venous puncture using pyrogen-free sterile disposal syringes in ethylene diamine tetra acetic acid (EDTA) in the presence of a trained Phlebotomist[1].

After identify and re-assuring the patient, the tourniquet were applied to the upper arm (ante cubital area) or back of the hand due to the volume of blood needed. The tourniquet were applied to constrict the flow of blood in the arm and makes the veins more prominent. The venipuncture site was cleansed with methylated spirit (70% alcohol), venipuncture was performed by evacuated tube system or Needle and syringe. The EDTA tubes were filled, the tourniquet was removed. All the sharps were disposed accordingly. The EDTA tube was inverted 8 times to prevent clotting and platelets clumping[2]. This mixing step is important because some metals (e.g. Pb) are known to be associated mostly with the red blood cells in the specimen and a uniform distribution of this cellular material must be produced to reflect the average metal concentration of all fractions of the larger specimen[7]. If steps are not taken to prevent this process from occurring, blood will immediately begin to form clots once leaving the body and entering the tube. These clots will prevent the uniform distribution of cellular material in the blood specimen, even after rigorous mixing making a representative sub-sample of the larger specimen unattainable. Each specimen tube was attached with an identification label and were stored at 4^0C for subsequent analysis.

3.4.1 Sample Preparation/Specimen Storage and Handling throughout Testing

Samples in which left at room temperature all through evaluation for confirmation analyses to be made. Stringent precautions have been taken to avoid outside infection by way of manner of the metals to be determined[8]. Specimens may be saved short time period at refrigerated temperatures, but need to be saved long term (>4weeks) at ≤ -20 °C. The technique used has been tested to provide valid consequences for different Pb, Cd, Hg, and Mn even 48 hrs after sample coaching[3].

3.5 Determination of Metals Concentration

3.5.1 Chemicals and Reagent Used

All chemicals used were of Analar grade and of highest purity. Reagents used include concentrated nitric acid (HNO_3), perchloric acid ($HClO_4$) and sulphuric acid (H_2SO_4), deionized water.Sigma Aldrich Stock standard solutions 1000 µg/ml of Arsenic, Cadmium, Mercury, Lead and Nickel for AAS

3.5.2 Digestion of Whole Blood

2ml of the whole blood sample was measured into the digestion tube, 10ml of tri acid mixture (conc Nitric acid (HNO_3) + Sulphuric acid (H_2SO_4)+ Perchloric acid($HClO_4$) in ratio 3:1:1 (v\v\v) was added to the blood in the digestion tube(a pressure resistance bottle). The tubes were placed into the Q-block wireless digester and were digested for an hour at 110^{o}C[4]. The temperature was increased to 250^{o}C with continuous heating for another 1 hour and cool to room temperature. The samples were digested until clear solutions were obtained and evaporated to near dryness[10]. These were transferred to 10ml volumetric flask after filtered with whatman filter paper and made-up with deionized water, these were later analysed.

3.5.3 Preparation of Working Standard

From 1000 ppm to prepare 100 ppm

$C_1 V_1 = C_2 V_2$ Where C_1 = Initial concentration (1000ppm)

V_1 = Unknown (x)

C_2 = Final concentration (100ppm)

V_2 =Final volume (100mls)

$$V_1 = \frac{C_2 V_2}{C_1}$$

$$V_1 = \frac{100 \times 100}{1000} = 10\text{mls}$$

So from 1000ppm Standard 10mls was taking and makeup to 100mls with distilled water in a volumetric flask

3.5.4 Analysis of Mercury, Nickel, Lead, Cadmium, Arsenic

The ashes from the digester were washed into 100ml volumetric flask with deionized water[6]. Heavy metals such as Hg, Ni, Pb, Cd, and As were analyzed by flame atomic absorption spectrometry (FAAS) using Buck Scientific Model 200 series AAS equipped with a Hollow Cathode lamp and each metals has its own lamp[9]. This diluent was aspirated into the Buck 211VGP Atomic Absorption Spectrophotometer (AAS) through the suction tube(Table 3.0). Each of the trace mineral elements was read at their respective wavelengths with their respective hollow cathode lamps using appropriate fuel and oxidant combination[5].

Table 3.0 Buck 211VGP Atomic Absorption Spectrophotometer (AAS) Working Condition

Element	Wavelength	Slit width nm	Working Range	Sensitivity (µg/ml),	Lamp Current	Flame Type
Arsenic	193.7	0.7	1-100	45.0	300.0	MHS
Cadmium	228.8	0.5	0.5=5	0.03	15.0	Air-C_2H_2
Mercury	253.7	0.7	1-200	4.2	150.0	MHS
Nickel	352.4	0,5	6-30	0.2	25.0	Air-C_2H_2
Lead	283.3	0.5	4-40	0.2	440.0	Air-C_2H_2

Source: Author's Field work, 2023

3.5.5 Quality Control/Quality Assurance

All quality assurance/quality control protocol was observed throughout the experiment. Safety was generally handled carefully using appropriate sample containers and preservation method to avoid contamination of samples. All glass wares for metal analysis were previously soaked in 14% HNO_3 for 24 hours. All the reagents used were of analytical grade and reagent blank and standard were run concurrently along with the tests.

3.6 Data Analysis

3.6.1 Statistical Tools for Analysis of Results

The descriptive statistics were used for raw datas, one-way Analysis of Variance (ANOVA) and Pearson Product Moment Correlation which is a parametric statistical tools used to test significant difference in mean levels of variables.

3.7 Ethical Approval

Ethical clearance from ethical committee of Oyo state ministry of health and UI\UCH research ethical committee were obtained.

Endnotes

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Chapter Four

Results and Discussion of Findings

4.1 Questionnaire Data Analysis

Data collected from the questionnaire was analysed using Statistical Package for Social Sciences (SPSS) 23.0 Version.

Table 4.1 below showed that the participants' age ranged from 3 to 82 years, and mean age was 45.45 ± 20.68 years. Majority (37.5%) were in the age group of 40-59 years. A little above half (53.8%) of the respondents were males, while 46.2% were females. Over three-quarter (77.5%) were Yoruba, and this could be attributed to the fact that the study setting is predominantly Yoruba. Over half (56.2%) had tertiary education as their highest educational qualifications, followed by secondary education (27.5%) and primary education (11.3%) respectively. Concerning the respondents' occupation, 37.5% were civil servants, 20.0% were traders, and 15.0% were self employed and unemployed/student respectively.

Table 4.2 below showed that majority (66.3%) of the participants have heard about heavy metals before; while 33.7% have not heard about heavy metals. Almost half (48.8%) acknowledged that they live in an area with high concentration of heavy metal. Also, 48.8% of the participants affirmed that they work in an area with high concentration of heavy metal. In addition to this, 38.8% claimed that they used products with high concentration of heavy metal.

Table 4.1: Socio-demographic Characteristics

Participants' Socio-demographic characteristics (n=80)	Frequency	Percent (%)
Age (years)		
<20	14	17.5
20-39	13	16.3
40-59	30	37.5
≥60	23	28.8
Mean (±SD)	45.45 ± 20.68 years	
Range	3 to 82 years	
Gender		
Male	43	53.8
Female	37	46.2
Ethnicity		
Yoruba	62	77.5
Ibo	9	11.2
Others	8	10.0
Non response	1	1.3
Level of Education		
Primary	9	11.3
Secondary	22	27.5
Tertiary	45	56.2

Non response	4	5.0
Occupation		
Civil servant	30	37.5
Trading/business	16	20.0
Self employed	12	15.0
Farmer	3	3.8
Retired	7	8.7
Unemployed/student	12	15.0
Total	**80**	**100.0**

Source: Author's Field work, 2023

Table 4.2: Knowledge and Exposure to Heavy Metal

Participant's Knowledge of Heavy Metal (n=80)	Yes		No	
Have you heard about heavy metals before?	53	66.3	27	33.7
Do you live in an area with high concentration of heavy metal?	39	48.8	41	51.2
Do you work in an area with high concentration of heavy metal?	39	48.8	41	51.2
Do you use products with high concentration of heavy metal?	31	38.8	49	61.2

Source: Author's Field work, 2023

The data analyses according to the knowledge of exposure to heavy metals was conducted in which the subjects picked either "Yes or No" in response to the questions asked. Majority of people who were involved in the study shows that they have heard about metals before. Some leave and even work in areas that are polluted with it shown in Table 4.2.

4.2 Results of Heavy Metal Analysis

The concentrations of Hg, As, Ni, Cd and Pb analysed in the blood samples of various diseased individuals and control are presented in Table 4.3. Metals concentrations varied in all these diseases and this was shown in Figure 4.1 below.

Table 4.3: Mean Concentrations of Heavy metals in Blood Samples Analysed

Heavy metals	Hg	As	Ni	Cd	Pb
Diabetes	0.95	2.40	14.89	15.23	6.02
Kidney Disease	1.21	2.07	18.17	9.95	6.78
Hypertension/Heart Disease	1.17	2.44	13.86	14.49	7.24
Hypertension/Diabetes	1.27	1.43	11.16	16.70	8.36
Cancers	0.99	2.67	14.93	21.34	8.27
Liver Disease	1.34	2.90	14.48	22.99	8.73
Other Diseases	1.17	2.22	16.58	14.01	7.67
Routine/ Control	1.14	1.75	12.92	13.31	6.51

Source: Author's Field work, 2023

The distribution pattern for the studied metals (Hg, As, Ni, Cd and Pd) from table 4.3 showed that the maximum concentrations of Hg (1.34ng\dl) and As (2.90µg\dl) were found in the Liver diseases, the maximum concentrations of Ni (18.17µg\dl) were found in Kidney diseases while that of Cd (22.99µg\dl) and Pb (8.73µg\dl) highest concentration was also found in Liver diseases . The level of control \ routine in Ni and Cd were even higher to the one in subjects with hypertension with diabetes.

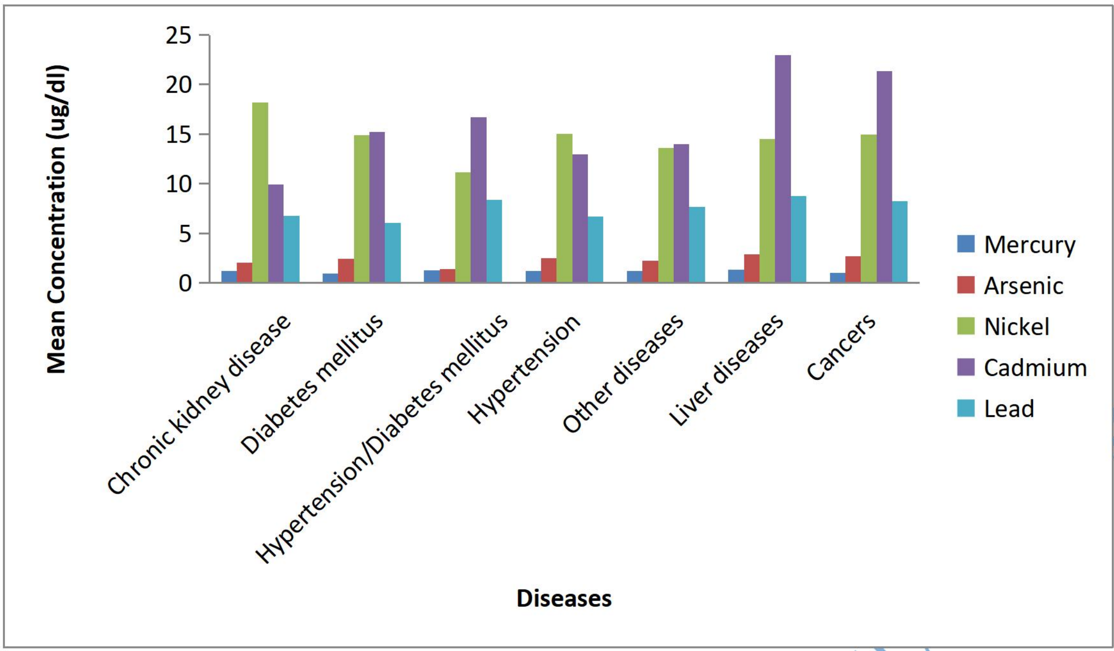

Figure 4. 1: A graph showing the mean concentration (ug/dl) of heavy metals in various diseases.

Source: Author's Field work, 2023

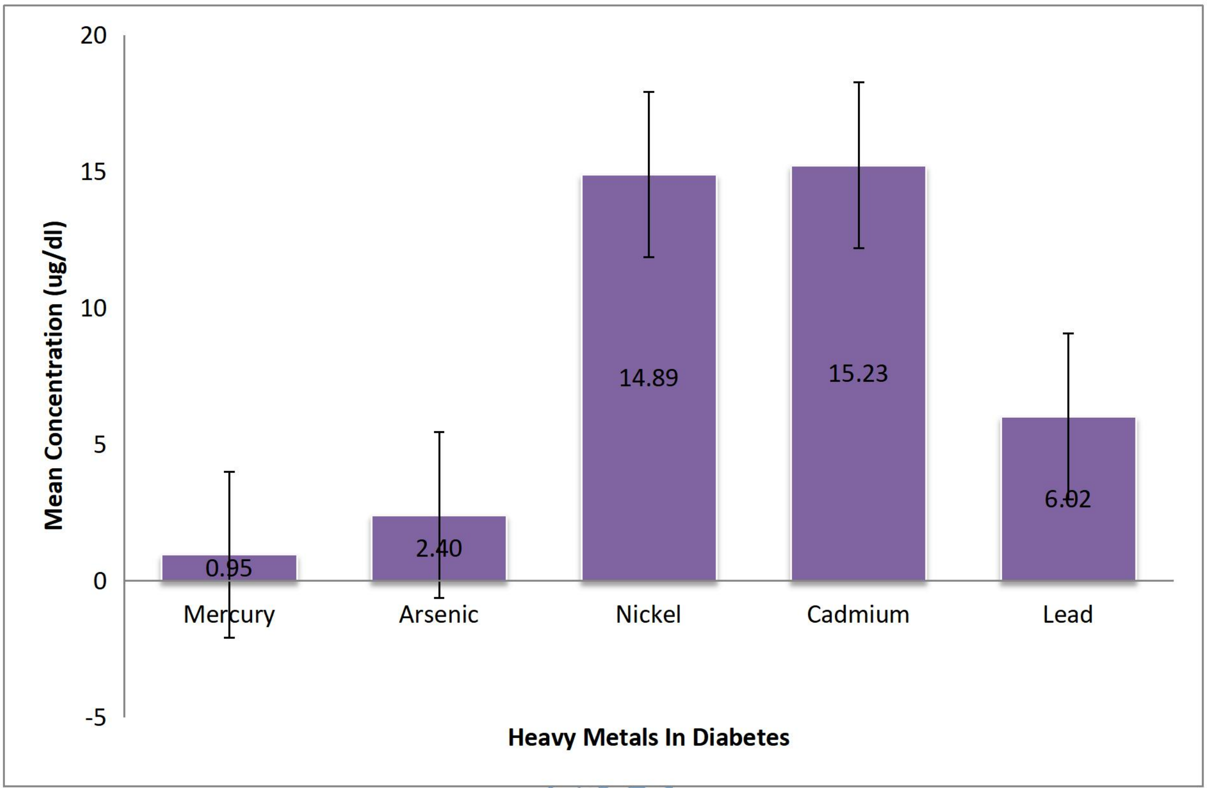

Figure 4.2: A graph with error bars showing the mean concentration (ug/dl) of heavy metals in Diabetes

Source: Author's Field work, 2023

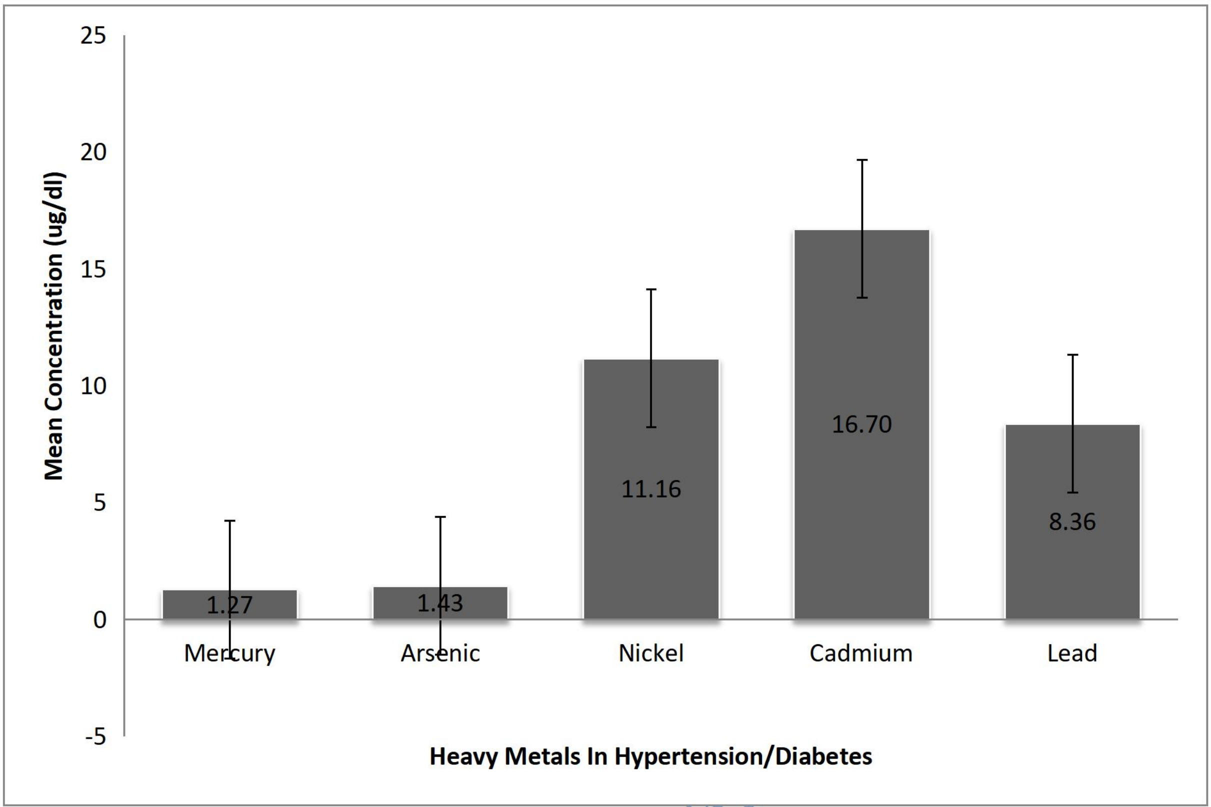

Figure 4.3: A graph with error bars showing the mean concentration (ug/dl) of heavy metals in Hypertension/Diabetes

Source: Author's Field work, 2023

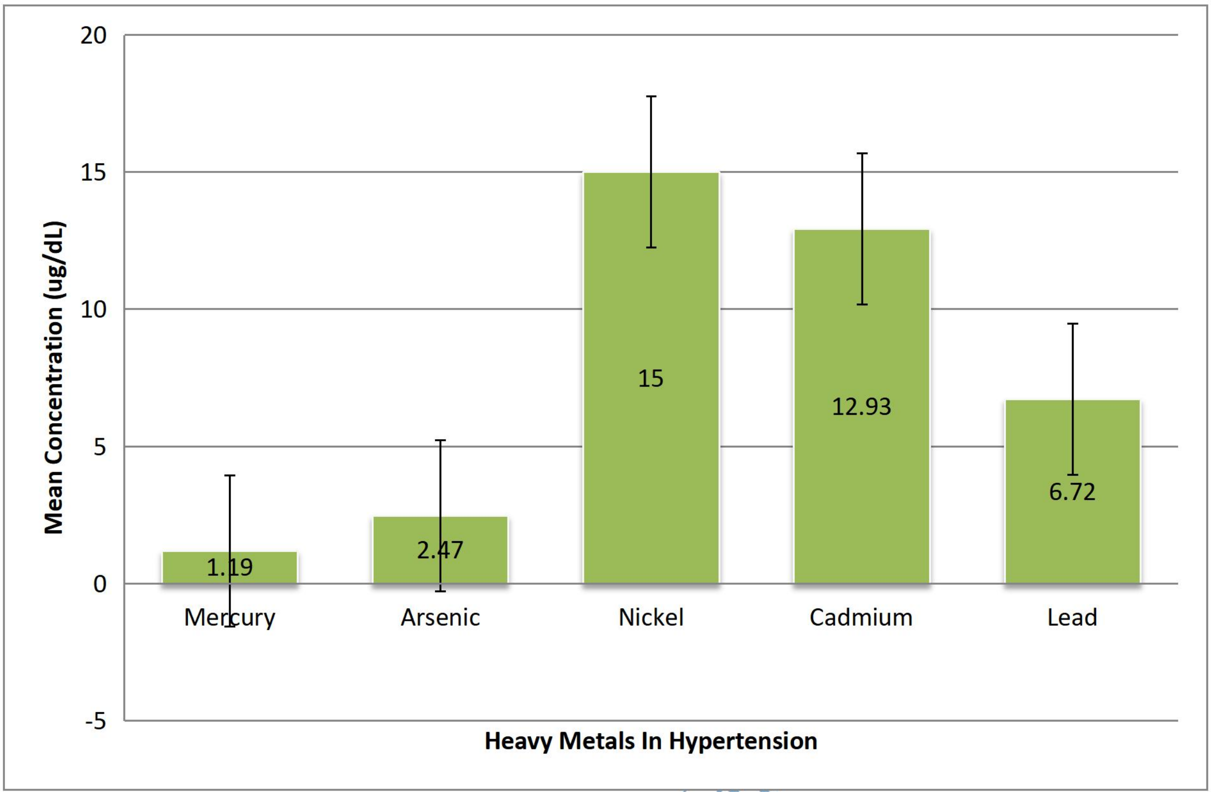

Figure 4.4: A graph with error bars showing the mean concentration (ug/dL) of heavy metals in Hypertension

Source: Author's Field work, 2023

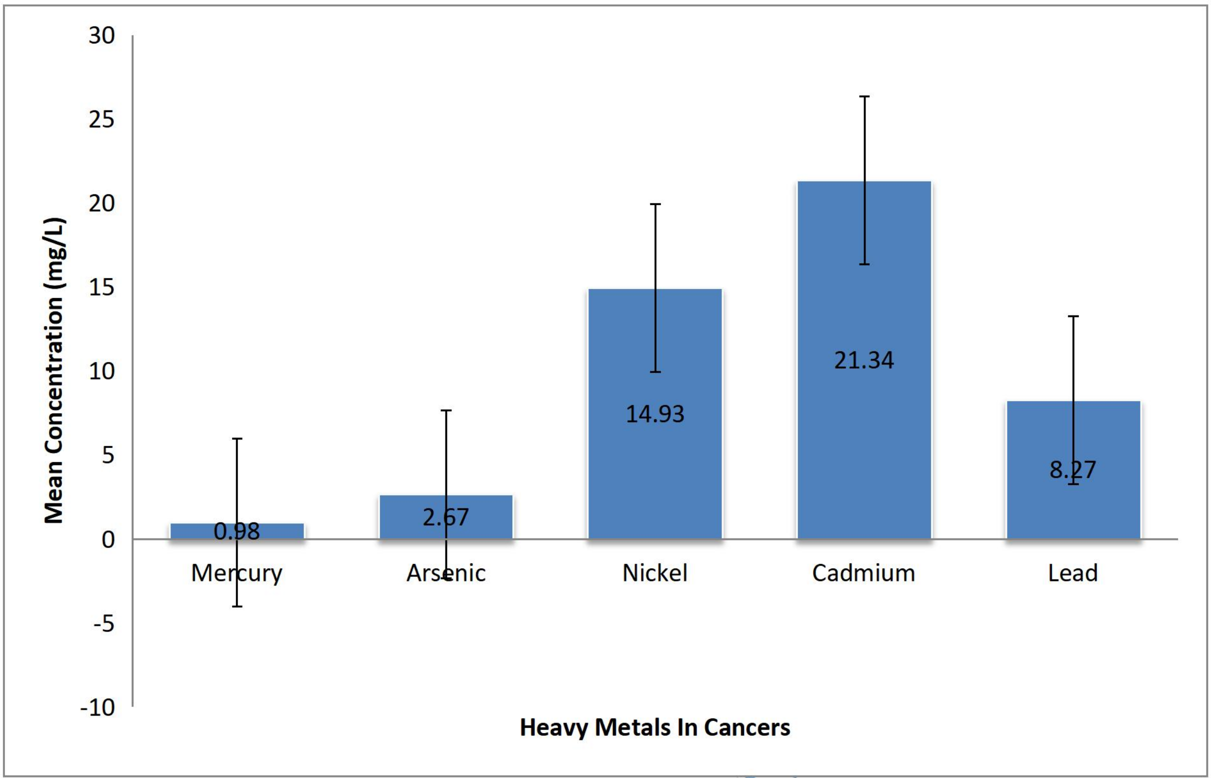

Figure 4.5: A graph with error bars showing the mean concentration (ug/l) of heavy metals in Cancers.

Source: Author's Field work, 2023

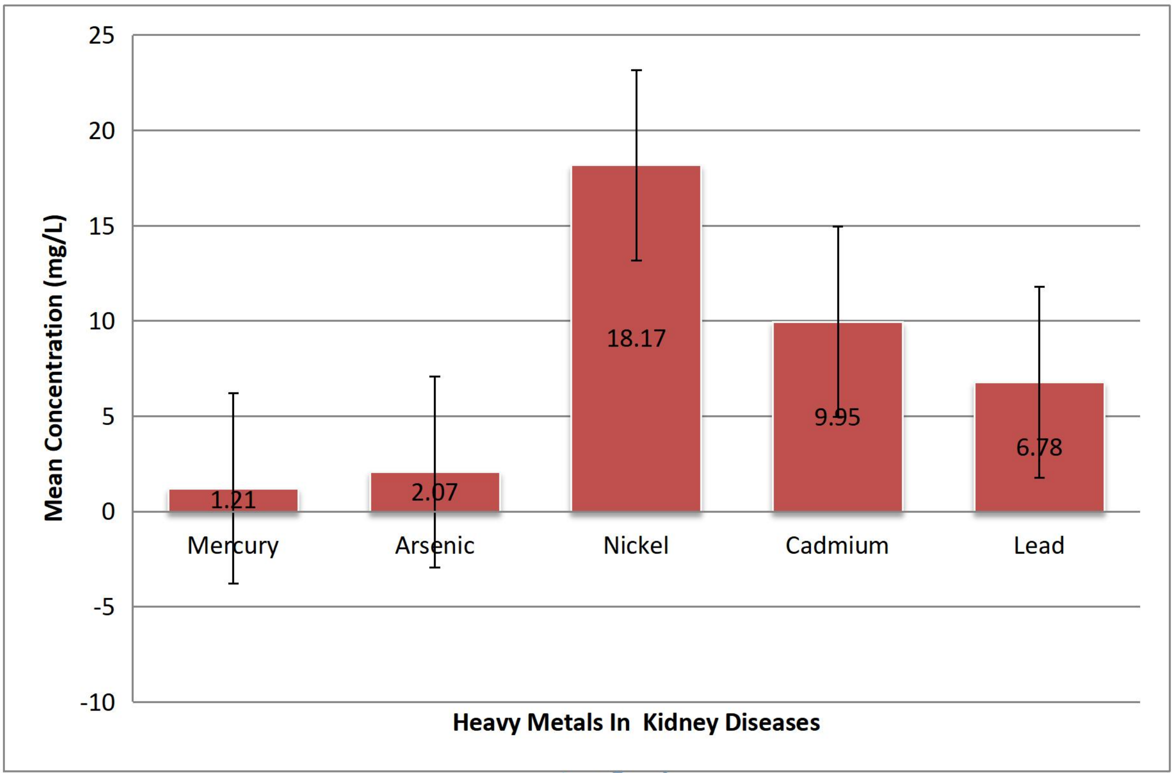

Figure 4.6: A graph with error bars showing the mean concentration (ug/l) of heavy metals in Kidney Diseases,

Source: Author's Field work, 2023

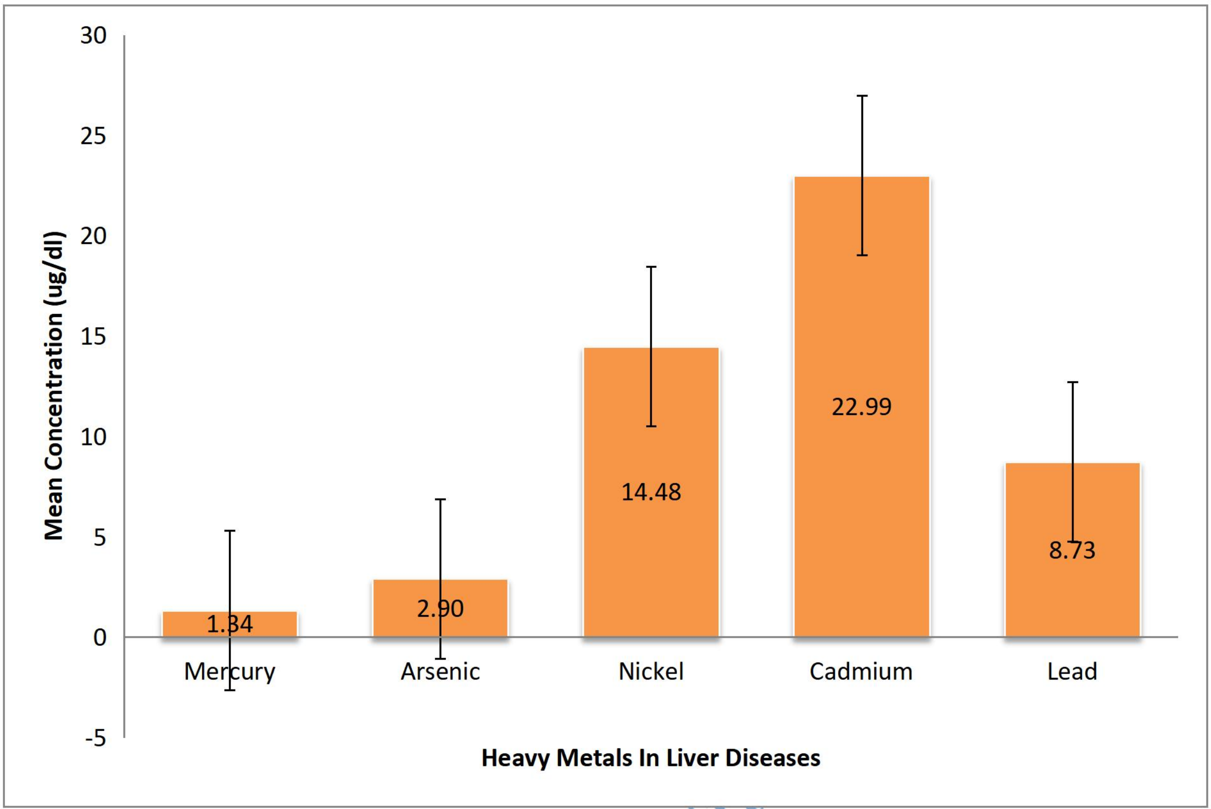

Figure 4.7: A graph with error bars showing the mean concentration (ug/dL) of heavy metals in Liver diseases

Source: Author's Field work, 2023.

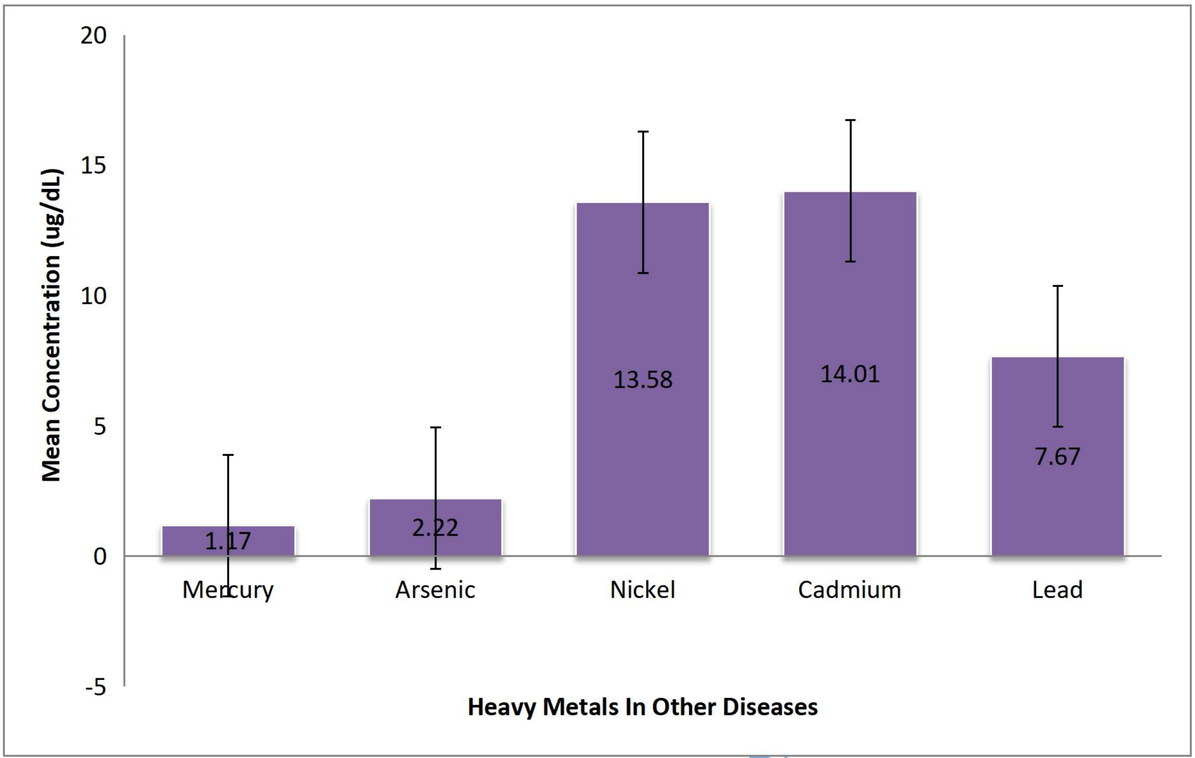

Figure 4.8: A graph with error bars showing the mean concentration (ug/dl) of heavy metals in other diseases

Source: Author's Field work, 2023

Table 4.4: Summary of mean concentration (ug/dl) of heavy metals (Hg, As, Ni, Cd and Pb) in diseases in the General Populations

Heavy metals (ug/dl)	No of subjects	Mean±SD	Median	Minimum	Maximum
Mercury (Hg)	80	1.15 ± 0.50	1.08	0.23	2.16
Arsenic (As)	80	2.31 ± 0.87	2.18	0.81	4.25
Nickel (Ni)	80	15.00 ± 7.34	14.1	4.0	30.2
Cadmium (Cd)	80	16.03 ± 7.29	15.62	5.78	36.09
Lead (Pb)	80	7.33 ± 2.59	7.28	2.84	13.99

Source: Author's Field work, 2023

The mean concentration of data render a representation of an order of heavy metals concentration in blood were Cd (16.03± 7.29) > Ni(15.0 ± 7.34) > Pb (7.33 ± 2.59) > As(2.31 ± 0.87) > Hg (1.15 ± 0.50) respectively. The data showed in Table 4.4 that Cd got extreme concentration in the blood while Hg was minimally accumulated.

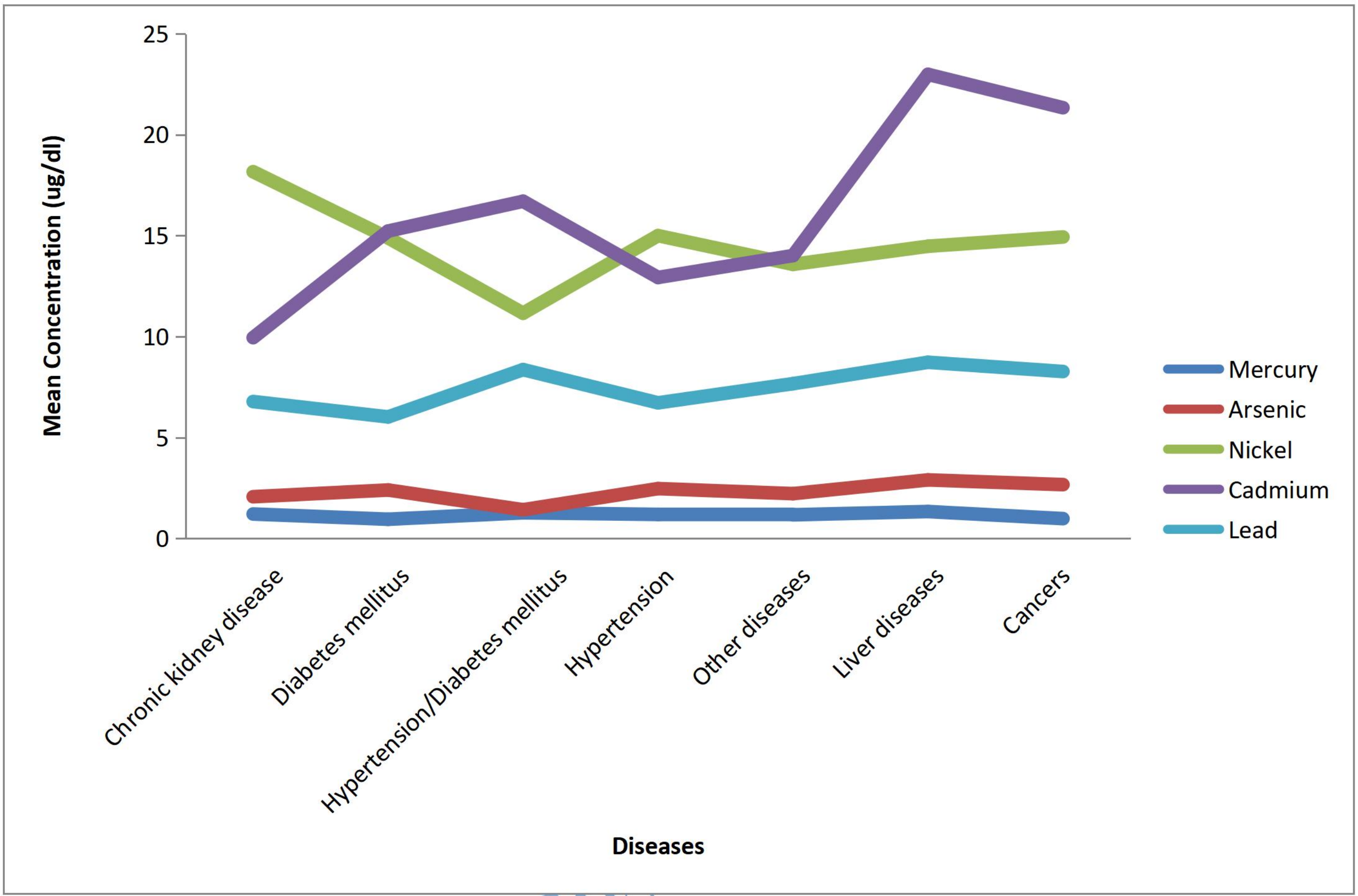

Figure 4.9: Straight line graphs that combine the mean concentration of all disease conditions

Source: Author's Field work, 2023

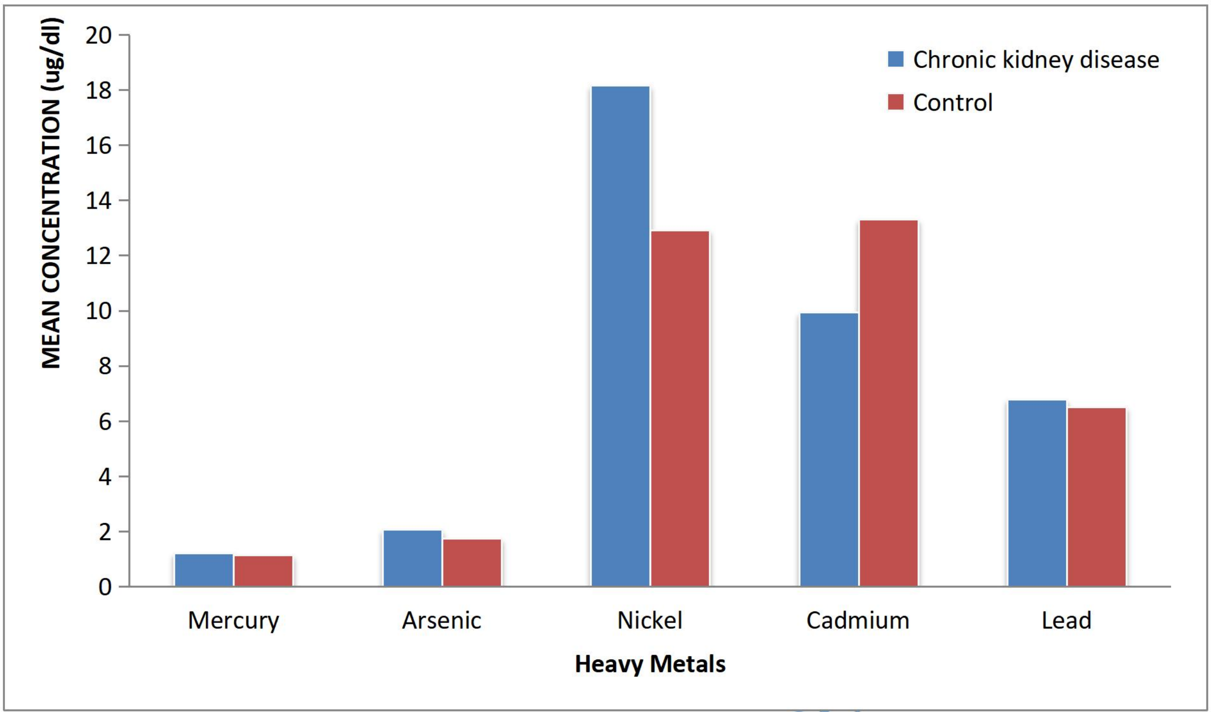

Figure 4.10: A graph showing the comparison of mean concentration (ug/dl) of heavy metals in chronic kidney disease and Controls

Source: Author's Field work, 2023

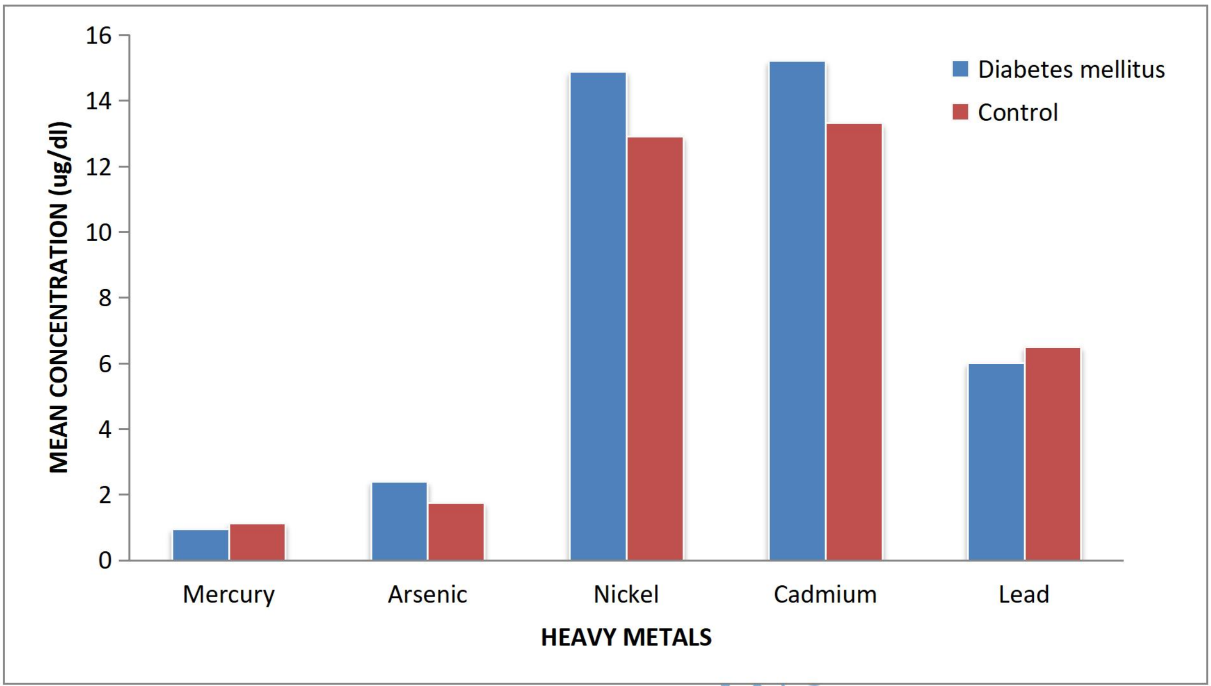

Figure 4.11: A graph showing the comparison of mean concentration (ug/dl) of heavy metals in Diabetes

Source: Author's Field work, 2023

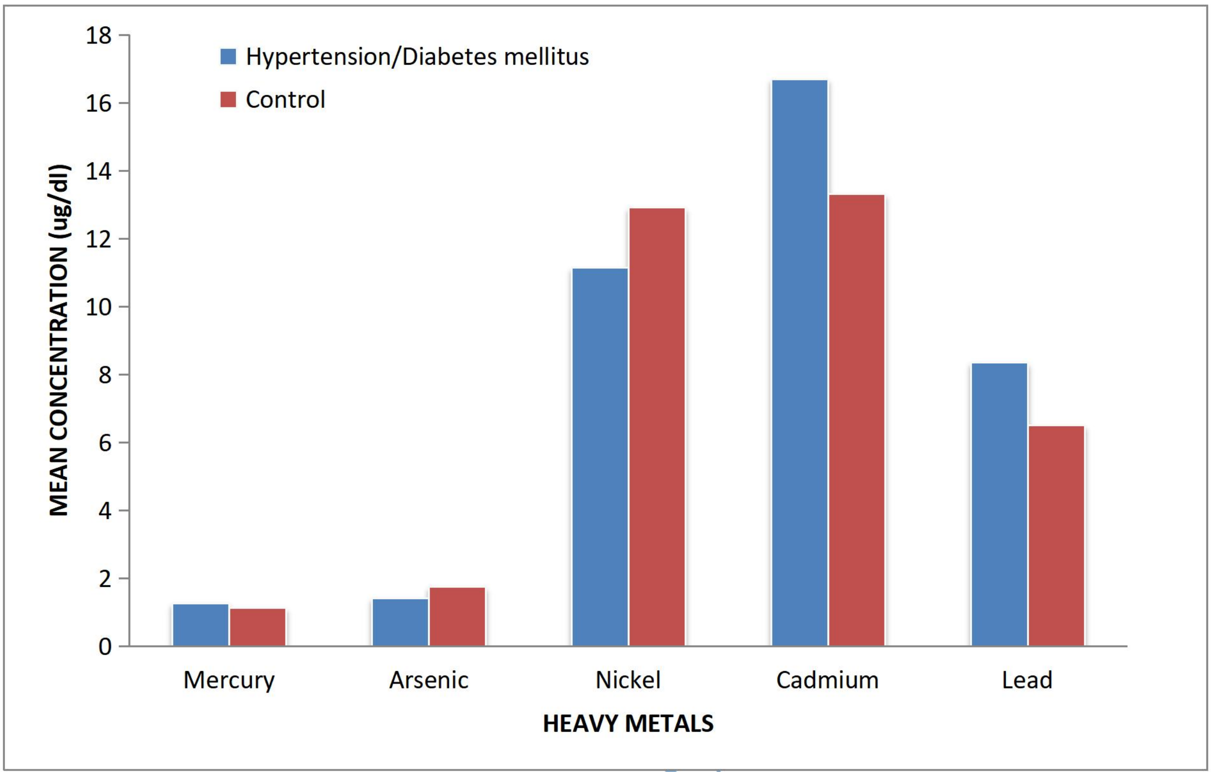

Figure 4.12: A graph showing the comparison of mean concentration (ug/dl) of heavy metals in Hypertension/Diabetes Mellitus and Controls

Source: Author's Field work, 2023

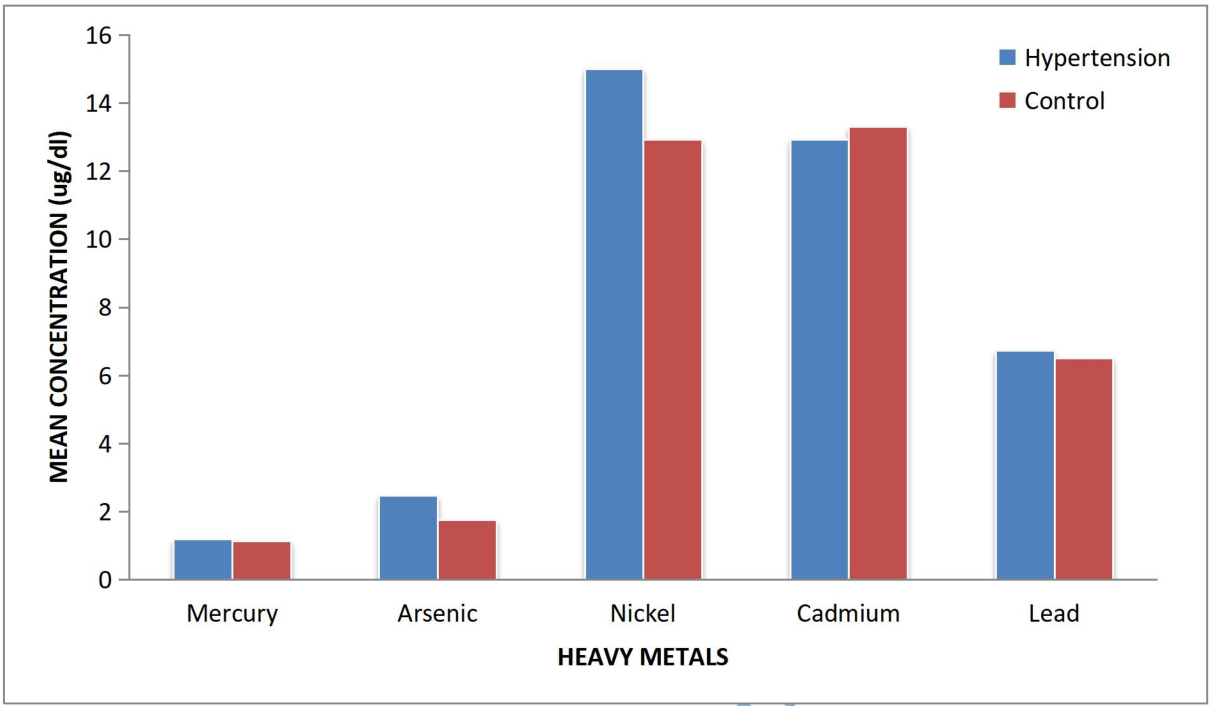

Figure 4.13: A graph showing the comparison of mean concentration (ug/dl) of heavy metals in Hypertension and Controls

Source: Author's Field work, 2023

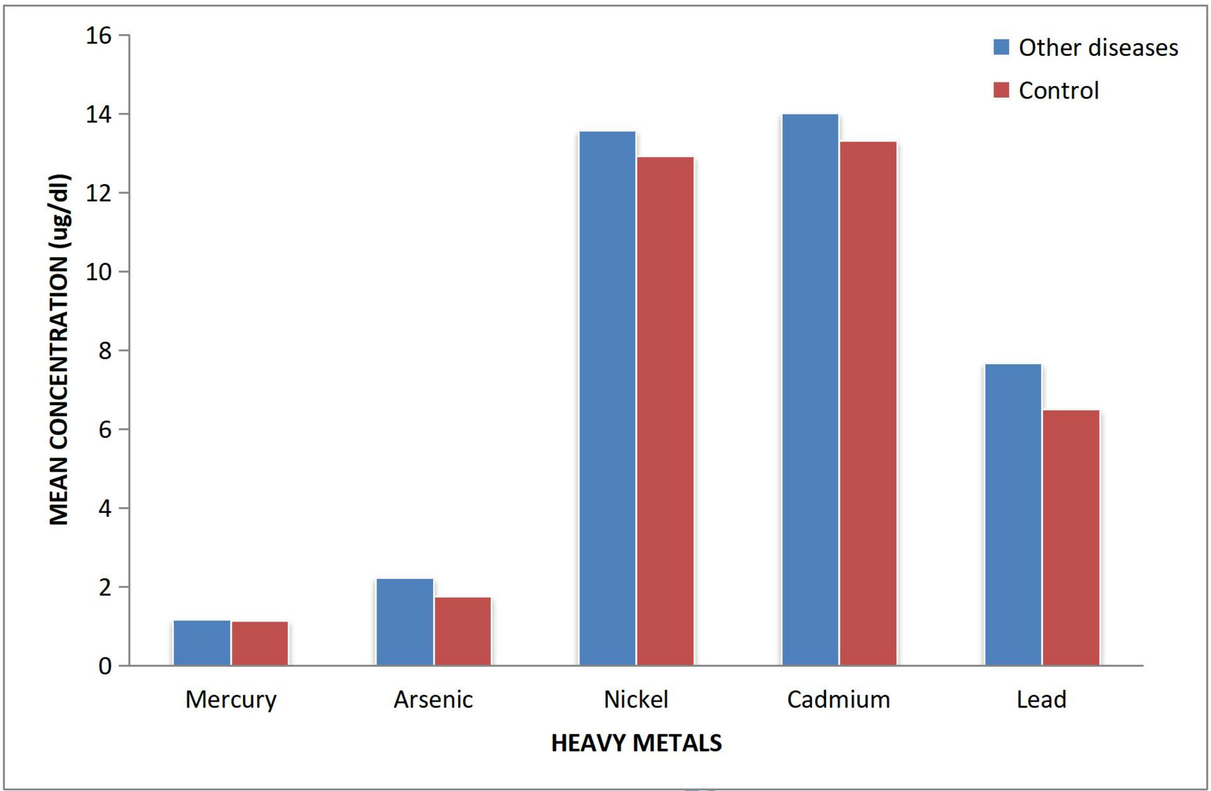

Figure 4.14: A graph showing the comparison of mean concentration (ug/dl) of heavy metals in other diseases and Controls.

Source: Author's Field work, 2023

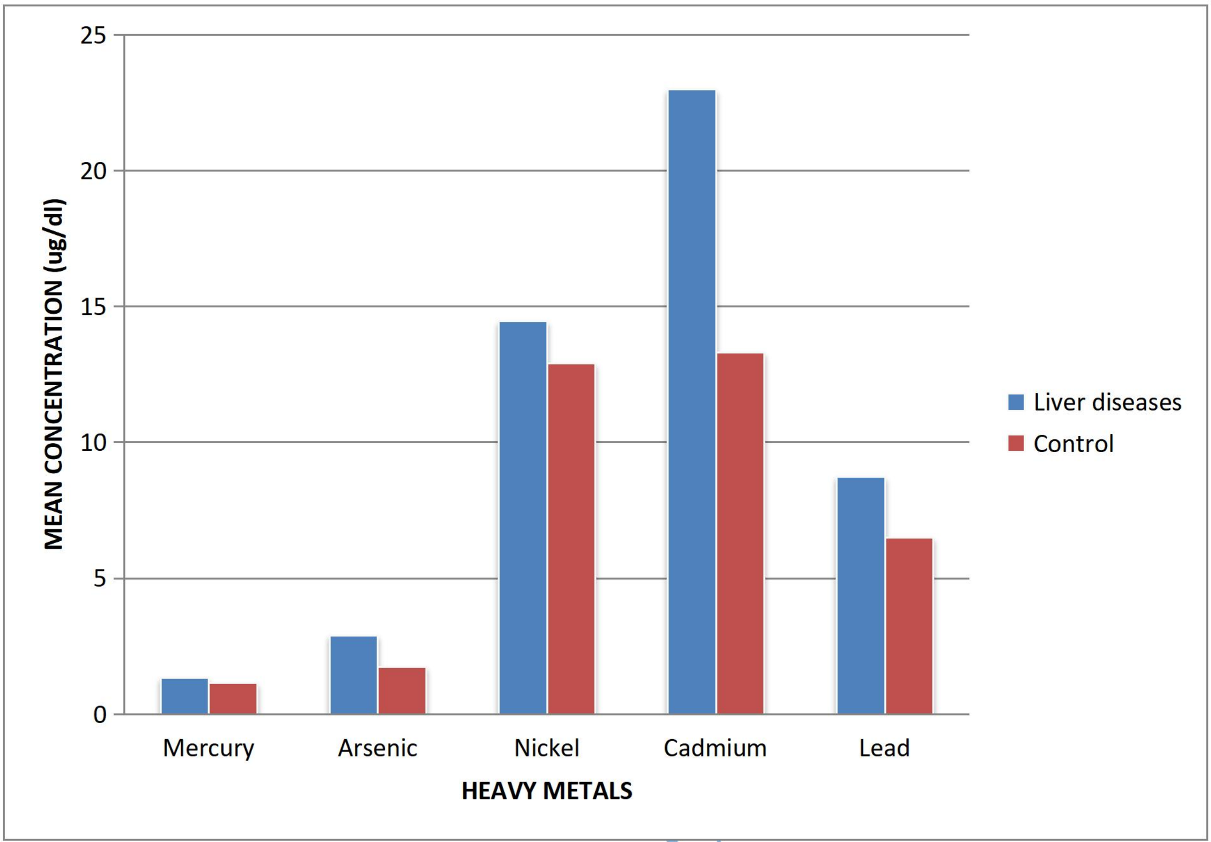

Figure 4.15: A graph showing the comparison of mean concentration (ug/dl) of heavy metals in Liver diseases and Controls

Source: Author's Field work, 2023

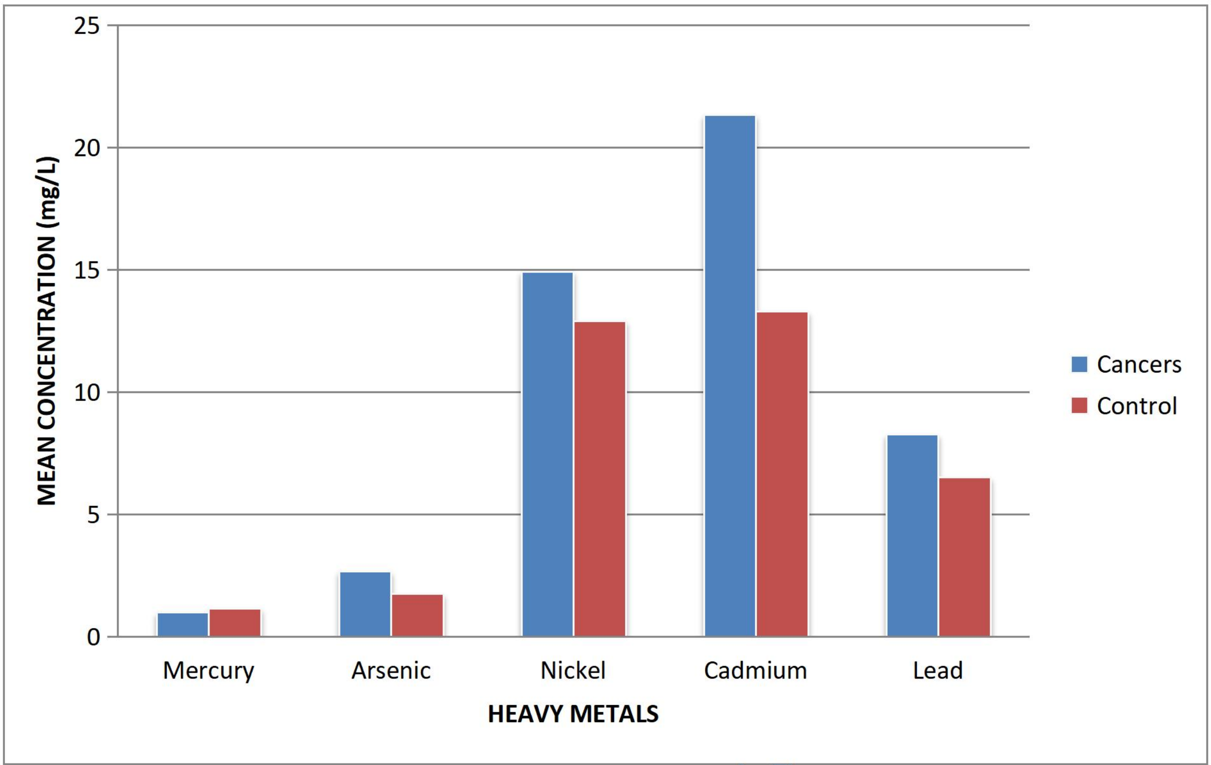

Figure 4.16: A graph showing the comparison of mean concentration (ug/dl) of heavy metals in Cancer diseases

Source: Author's Field work, 2023

Table 4:10: Mean Concentrations of Hg As, Ni, Cd, and Pb, in Blood Samples of Different Diseases Population Characteristics.

Diseases	Hg (g\dl)	As (µg\dl)	Ni (µg\dl)	Cd (µg\dl)	Pb (µg\dl)
Limit	**10 -20ng\dl**	**3.12µg\dl**	**5.0µg\dl**	**5.0µg\dl**	**2-10µg\dl**
Liver	13.3	2.90	14.48	22.98	8.72
Kidney	12.1	2.06	18.16	9.94	6.78
Diabetes	9.5	2.40	14.89	15.22	6.02
Hypertension	11.9	2.47	15.0	12.93	6.72
Hypertension\ diabetes	12.7	1.42	11.16	16.70	8.36
Cancers	12.1	2.06	18.16	9.94	6.78
Others	11.7	2.22	13.58	14.01	7.66

Source: Author's Field work, 2023

Table 4.11 Comparing the Study with WHO Reference Value

Heavy metals	Study results	WHO reference value
Mercury(Hg)	11.5ng\dl	10 ng\dl
Arsenic (As)	2.31µg\dl	15µg\dl
Nickel (Ni)	15µg\dl	3 µg\dl
Cadmium (Cd)	16.03µg\dl	6 µg\dl
Lead(Pb)	7.3 µg\dl	2 µg\dl

Source: Author's Field work, 2023

From the above results the concentration of some were higher than the WHO recommended level, this show that most of the diseases are being affected by the heavy metals.

4.3 Discussion of Findings

This study aimed to identify the metals associated with various diseases. It was first evaluated the association of As, Cd, Ni, Pb, and Hg with HTN, Diabetes, Cancers , Liver diseases, Kidney diseases, Infertility, HTN\diabetes and other diseases such as thyroids , eye defect , asthma. The study results show our findings as follows: Pearson Correlation coefficient (r) between Absorbance and concentration of Hg, As, Ni, Cd, and Pb, where very strong and it is statistically significant. A p- value of less than 0.05 was considered to indicate a statistically significant. As(r=0.92, p=0.01), Cd(r=0.97, p=0.00),Ni (r=0.91, p=0.01) Pb(r=0.91, p=0.01) and Hg (r=0.95, p=0.00).

The results from figure 4.1 showed the heavy metals (Hg, As, Ni, Cd and Ni) in various diseases – kidney diseases, diabetis, hypertension, hypertension with diabetis, liver, cancers and other diseases such as asthma , infertility,thyrodism, skin diseases, eye defects etc.

The prevalence of these diseases in the general population of persons selected for this study shows the associations of exposure to heavy metals with them. There is a positive association among the selected heavy metals exposure and the risk of having these diseases.

Most of these people were exposed to multiple metals simultaneously, and the effects may be due to consumption of food such as rice, grains, seafood, drugs and herbal medicines that contain accumulated heavy metals which maybe from the natural environment and pollution.

Some of these metals have target on some certain diseases such has Cd on liver and cancers diseases, Ni on kidney diseases which also have high variations among the remaining diseases. The chronic low-dose Lead exposure exerts subtle effect on all the diseases.

A case-manipulate have a look at from Norway located that elevated blood nickel tiers substantially improved the risk of diabetes development[1]. However, Yara et al. Did not locate massive differences in serum Ni ranges between diabetic patients and wholesome persons in a case-manage study[2]. Another to look at from Italy observed notably decrease in blood Ni values in patients with types 1 and 2 diabetes than within the controls [3]. From this study the levels of Nickel and Cadmium were significantly higher ranges from Ni: 4.3- 27.0µg\dl while Cd: 6.25 – 26.72µg\dl.

From this study according to Figure 4.2 maximum of the humans identified with diabetes have extra exposure to Ni, Cd and Pb with suggested concentration of 14.89 µg\dl, 15.23 µg\dl and 6.02µg\dl. Comparing the above effects with the ones diagnosed of HTN and diabetes in Figure 4.3 the Pb and Cd increase even as the Ni decreased Ni 11.16 µg\dl, Cd 16.70 µg\dl, Pb 8.36 µg\dl. The As in Figure 4.3 is lower to the one in Figure. 4.2 this shows that people with diabetes only were more exposed to As than those that have combined diagnosis of hypertension and diabetes.

Nour et al. found a negative association between serum cadmium and the prevalence of diabetes and obesity in Lebanon population[24]. It was reported blood cadmium levels were positively associated with Type 2 Diabetes Mellitus and fasting glucose levels in the general population from Norway[1]

Figure 4.4 indicates people recognized with HTN have high level of As stage compared to people with Diabetes or Diabetes with hypertension. The Figure 4.2 and 4.3 shows that people diagnosed with diabetes alone and those with hypertension alone have raised As compared to those with hypertension and diabetes together.

A prospective study conducted in the US reported a positive association between low-to-moderate level of urinary cadmium (Cd) and hypertension in the general population. However, an inverse association between urinary Cd and BP was observed in a cross-sectional study among Canadian adults[25]. A meta-analysis with eight studies included suggested an increased correlation between arsenic (As) exposure and hypertension.

Meanwhile, significant associations between high level of urinary As and Cd with slight elevations in BP were found in one Spanish cohort study[26]. However, no link between As exposure and hypertension was observed in a cross- sectional study of China[35].The Ni level was significantly higher among the people diagnosed with diabetes and hypertension.

The people diagnosed with cancers in Figure 4.5 and those with liver disease in Figure 4.7 have many things in common the level of Cd, Ni and Pb where very near and notably higher. Also the As level very close, this shows that people suffering by those diseases have the identical matters in common place in terms of heavy metals exposure.

Those identified with kidney diseases from Figure 4.6 has a distinct maximum level of Ni compared to diseases. In other sicknesses extended level of Ni, Cd and Pb were clearly distinct.

Figure 4.8 study shows that the level of all selected metals in all other diseases dermatitis, asthma, infertility, thyroiditis, depression and so on and so forth where higher

In Ireland Thompson et al. study toxic effects of cadmium on reproductive system and embryo of males from fetal to adulthood periods causing an adverse effects on the growth of the gonads[28] . Orisakwe reported in Nigeria that lead and cadmium are associated with human mental health[29]. Also Bouchard et al., affirm that smoking enhance the blood lead level, causes rise in depression among young Americans[30].

The association of blood Lead level dominant and asthma shows that African Americans had a higher mean BLL when compared with Caucasians, 5.5 µg/dL (SD = 4.3, median = 4.0 µg/dL) versus 3.2 µg/dL (SD = 2.5, median = 3.0 µg/dL), respectively, $p < 0.01$. The overall mean BLL for the entire sample was 4.7 µg/dL (SD = 4.0, median = 4.0 µg/dL). Whereas from this study the value of Pb is 7.67µg\dl in other diseases in which Asthma is part of them.

This shows that the blood lead value is higher in this locality. An Egyptian study found children with a BLL ≥ 10µg/dL had a higher frequency of eosinophilia, total IgE, and increased asthma severity[34].

The instantly line graph Figure 4.9 genuinely display that a few diseases or analysis has a few metals that are peculiar to them from the arrangement that was displayed on the graph.

The study indicates that the mean concentration of Ni and Cd overlapped each other in Figure 4.9 for humans with HTN and coronary heart illnesses even as people who have HTN with Diabetes the mean awareness was very distinct and Pb concentration were appreciably high.

From this study according to Figure 4.11 to 4.13 the individual with HTN and Diabetes the Ni degree became decrease than the controls while people with DM alone the Ni level was better than the control, there is a tremendous correlation among Ni and Diabetes. From Figure 4.11 and 4.12 Ni shows a clear correlation in Fig 4.11 the Ni was higher than the control while in Fig 4.12 the Ni was lower to the control. Fig 4.13 shows a similar patten like that of Fig 4.11, those with HTN and coronary heart sicknesses and diabetes. From Fig 4.14 these show the concentration of the selected heavy metals are where higher than the control also those in Fig 4.15 and Fig 4.16. In all those metals were higher than the controls in most cases condition.

Insuffience of Fe can lead to greater absorption and toxicity of Cd and Pb[4,5]. Cd tiers in adults have been determined to be negatively related to being overweight[6]. Overweight/overweight girls have been discovered to have an excessive prevalence of Ni hypersensitivity and a low-Ni weight loss plan could assist loss weight[7].

Toxic metals-precipitated oxidative strain directly damage pancreatic islet β-cells: toxic metals (As, Cd, Hg, Pb) have the capacity to induce oxidative stress via the accelerated manufacturing of reactive oxygen species (ROS) along with superoxide radicals, hydrogen peroxide and nitric oxide which might be tremendously reactive[8,9].

Pb ranges in comparison with control have been appreciably better. The blood Cd level was extensively higher in prostate cancer patients compared with controls. The blood Hg stage was now not significantly lower (p=zero.190) in prostate cancer sufferers compared with the controls. The prostate cancer may additionally increase the degrees of those heavy metals[10-12].

Liver cells are frequently exposed to chemical compounds and this result in liver dysfunction, cell harm, and organ failure[13-16]. Likewise in Fig 4.9 of this study the straight line additionally suggest the equal highest level of Cd in human beings with liver related diseases.

Viral hepatitis related to chronic hepatitis B virus or hepatitis C virus infection has been reported to be the leading cause of liver cirrhosis and hepatocellular carcinoma. With a decrease in the prevalence of viral hepatitis, fatty liver disease (including alcoholic liver disease and non-alcoholic fatty liver disease (NAFLD)) has emerged as an important cause of chronic liver disease. In USA non-alcoholic steatohepatitis is now the second leading cause of liver transplantation while Asia shows prevalence of fatty liver disease over the past decade. Prevalence of NAFLD was also reported in China 20%, Hong Kong 27%, and 15–45% in SouthAsia, South-EastAsia,Korea, JapanandTaiwan[33]. Werder et.al. also shows that liver diseases was positively associated with Lead and Cadmium.

Leads cardiovascular consequences have been related to expanded blood strain (BP) and within the widespread populace a nice association of lead publicity with coronary artery disorder CAD and stroke mortality, and peripheral arterial ailment had been identified[17,18]. A study discovered that mean level of serum Lead tended to be higher in CAD patients[19].

This study shows that the mean concentration of Ni and Cd overlapped each other in Fig4.9 for people with HTN and heart diseases while those that have HTN with DM the mean

concentration was very distinct and Pb concentration was significantly high. From Fig 4.12 the As and Ni control were higher than the subjects in while in others the subjects where greater (Fig 4.10, 4.11, 4.13 and 4.14). Also in Fig 4.13 the Cd level is greater than the subject but in others diseases the mean concentration were higher than the control.

In addition to the ones culture threat elements, suggestions from several studies have it that heavy metals which incorporates such as cadmium (Cd), lead (Pb), arsenic (As), mercury (Hg), uranium, and chromium (Cr) gather inside the kidneys or even at low level can result in kidney sicknesses and proteinuria[20,21].

When comparing the imply concentration of heavy metals in all diseases in this study with the threshold restriction of USEPA and WHO according to table 4.10 underneath this found out that the blood stage of Hg, As, and Pb were within the limit levels of WHO for heavy metals in blood whilst Ni and Cd in high ranges in all the sicknesses.

Although blood arsenic levels vary, the Florida Poison Control Centre considers <7.0µg\dl as normal Control. The body rapidly excretes arsenic. Blood tests are only useful for measuring exposure to arsenic within three to four hours of exposure[22]. According to America Centres for Disease Control and Prevention, the reference value for lead is 5µg/dl [23] .

The differences in the values of parameters determined in this study when take a look at it might be adduced to the reality that the patients are from different environments and occupati

Endnotes

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Conclusion

5.1 Summary of Findings

From this study, the mean concentration of the five metals were Hg-11.5ng\dl, As-2.31µg\dl, Ni-15.00µg\dl., Cd-16.03µg\dl and Pb-7.33µg\dl. The results discovered that maximum of these diseased individuals had high concentration of Ni and Cd in their blood due to the high degree of environmental pollution. All these toxic substances made their way to human, from water, and food stuff through leaching and runoff, medicinal drugs, cosmetics and also by way of anthropogenic activities. Some of these factors contribute to the concentration greater than the levels of the international tolerance values, particularly Ni and Cd. The findings of this study also discovered that the concentration of those metals are numerous in all of the illnesses kingdom.

Liver diseases - The values of all metals were very significant, the value of Cd was extremely high followed by Ni and Pb. The level of Hg and As were also raised.

Kidney diseases - The highest exposure of metal in people diagnosed with kidney disease was Ni followed by Cd and Pb. The Hg and As were within the standard range.Orisakwe et al and Alasia et al with some other studies show Lead exposure is one of the risk factor in kidney diseases. Hypertension –Ni and Cd shows a very high significant values followed by Pb with a slight increase in As and Hg. Wu et al, report a study that shows a significant report of some metals exposure associated with hypertension in which Ni is one of them.

Hypertension with diabetes –The people with combined diagnosis shows a very high significant Cd level with Ni and Pb followed with lower level of As compared to its concentration in those with hypertension only. Lv et al, shows a relationship with multiple heavy metals and diabetes. Schwartz et al, also shows a strong relationship of Cd with diabetes.

Cancers diseases- In various cancer diseases the level of Cd was very prominent with Ni and Pb follow. The value of As although was low but on the higher side while the Hg value was very low in people diagnosed with different types of cancers. Martin et al, also confirmed this in it study. In other diseases different from all these ones the concentration of this metals were very distinct in the sense that the levels of Ni and Cd were closely related to each other followed by Pb. The Arsenic was on the higher side of normal while Hg was low. Although the lowest concentration of all these metals in man are serious health risk. Jurasovic et al, Cebi et al, Asonye and Bello they all mentioned relationships of these metal to other diseases that affects man.

5.2 Conclusion

All those heavy metals have been toxic causing extreme damaging fitness results in organs, even at a totally tiny amount. They have deleterious outcomes in humans, inflicting acute and chronic toxicities.

These Ni and Cd stages have been referred to be likely liable for carcinogenic outcomes, and additionally impaired the satisfactory of existence of the subjects.

5.3 Recommendations

Based on the findings from this work following recommendations were made

i) There must be an expanded attention and enlargement of know-how concerning the impact of heavy metals on human health.

ii) Follow-up observe have to be performed on fitness risks of all styles of humans.

iii) The presence of toxic metals wished in addition studies to assess their lengthy-time period cumulative hazard on humans and additionally for early detection of signs of toxicity.

iv) There need to be a map out sports to monitor the anthropogenic activities of human in the surroundings to assure protection.

v) The research and regulatory bodies must provide specific publicity records to Scientists, physicians, and health officials to help save from diseases because of a few environmental chemical compounds.

5.4 Contribution to Knowledge

From this study, these are the findings that are keys which are contributed to expertise:

Health is wealth on the point of access into any medical institution or medical care the level of heavy metals have to be decided. The popularity and inclusion of heavy metals within the control of patient should be remembered to be crucial.

In most of the diseased recognized in UCH their beginning can be traced to the exposure of heavy metals which shows that our surroundings is particularly polluted.

The assessment from this study shows that the level of nickel and cadmium were exceptionally high and also the lead concentration. The level of mercury and arsenic were not overwhelming.

5.5 Suggested Areas for Further Research

1) Due to excessive level of pollution in UCH and it's environ there may be need for air and effluent analysis for heavy metals.

2) Further research with exclusive sex subjects (ladies and men) in a different way with specific age brackets.

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Appendix I

Calibration Report

Concentration (ppm)	Absorbance
0.00	0.000
1.00	0.018
2.00	0.024
3.00	0.029
4.00	0.035
5.00	0.038

Appendix II

Absorbance Readings of Different Extracts For Hg

Sample	Absorbance	Concentration (Ppm)
BLK	0.002	0.277
1	0.005	0.568
2	0.003	0.341
3	0.008	0.909
4	0.004	0.455
5	0.009	1.023
6	0.005	0.568
7	0.015	1.705
8	0.019	2.159
9	0.011	1.250
10	0.008	0.909
11	0.006	0.682
12	0.015	1.705
13	0.010	1.136
14	0.004	0.455
15	0.013	1.477
16	0.009	1.023
17	0.011	1.250
18	0.007	0.795
19	0.005	0.568
20	0.017	1.932
21	0.009	1.023

22	0.012	1.364
23	0.006	0.682
24	0.009	1.023
25	0.016	1.818
26	0.011	1.250
27	0.009	1.023
28	0.013	1.477
29	0.008	0.909
30	0.018	2.045
31	0.012	1.364
32	0.006	0.682
33	0.015	1.705
34	0.009	1.023
35	0.011	1.250
36	0.017	1.932
37	0.010	1.136
38	0.007	0.795
39	0.014	1.591
40	0.019	2.159
41	0.011	1.264
42	0.012	1.379
43	0.030	3.448
44	0.009	1.034
45	0.027	3.103
46	0.015	1.724
47	0.012	1.379

48	0.034	3.908
49	0.022	2,529
50	0.021	2.414
51	0.017	1,954
52	0.036	4.138
53	0.019	2.184
54	0.025	2.874
55	0.013	1.494
56	0.016	1.839
57	0.010	1.149
58	0.024	2.759
59	0.023	2.644
60	0.014	1.609
61	0.032	3.678
62	0.031	3.563
63	0.018	2.069
64	0.020	2.299
65	0.016	1.839
66	0.028	3.218
67	0.013	1.494
68	0.023	2.644
69	0.019	2.184
70	0.015	1.724
71	0.021	2.414
72	0.026	2.989
73	0.012	1.379

74	0.016	1.874
75	0.025	2.874
76	0.017	1.954
77	0.027	3.103
78	0.031	3.563
79	0.019	2.184
80	0.025	2.874

Appendix III

As Working Standard Solutions Concentration and Absorbance

Concentration(ppm)	Absorbance
0.00	0.000
1.00	0.021
2.00	0.025
3.00	0.029
4.00	0.033
5.00	0.038

Sample	Absorbance	Concentration (ppm)
Blank	0.005	0.575
1	0.017	1.954
2	0.009	1.034
3	0.023	2.644
4	0.019	2.184
5	0.014	1.609
6	0.027	3.103
7	0.021	2.414
8	0.015	1.724
9	0.029	3.333
10	0.012	1.379
11	0.016	1.839
12	0.025	2.874
13	0.022	2.529
14	0.013	1.494

15	0.028	3.218
16	0.010	1.149
17	0.015	1.724
18	0.009	1.034
19	0.016	1.839
20	0.032	3.678
21	0.012	1.379
22	0.024	2.759
23	0.011	1.264
24	0.007	0.805
25	0.030	3.448
26	0.017	1.954
27	0.022	2.529
28	0.035	4.023
29	0.013	1.494
30	0.037	4.253
31	0.019	2.184
32	0.010	1.149
33	0.031	3.563
34	0.015	1.724
35	0.020	2.299
36	0.028	3.218
37	0.012	1.379
38	0.016	1.839
39	0.025	2.874
40	0.034	3.908

41	0.011	1.264
42	0.012	1.379
43	0.030	3.448
44	0.009	1.034
45	0.027	3.103
46	0.015	1.724
47	0.012	1.379
48	0.034	3.908
49	0.022	2,529
50	0.021	2.414
51	0.017	1,954
52	0.036	4.138
53	0.019	2.184
54	0.025	2.874
55	0.013	1.494
56	0.016	1.839
57	0.010	1.149
58	0.024	2.759
59	0.023	2.644
60	0.014	1.609
61	0.032	3.678
62	0.031	3.563
63	0.018	2.069
64	0.020	2.299
65	0.016	1.839
66	0.028	3.218

67	0.013	1.494
68	0.023	2.644
69	0.019	2.184
70	0.015	1.724
71	0.021	2.414
72	0.026	2.989
73	0.012	1.379
74	0.016	1.874
75	0.025	2.874
76	0.017	1.954
77	0.027	3.103
78	0.031	3.563
79	0.019	2.184
80	0.025	2.874

Appendix IV

Caliberation Report

Ni Working Standard Solutions Concentration and Absorbance

Concentration(ppm)	Absorbance
0.00	0.000
10	0.026
20	0.029
30	0.035
40	0.038
50	0.044

Sample	Absorbance	Concentration (Ppm)
BLK	0.030	3.0
1	0.070	7.0
2	0.040	4.0
3	0.121	12.1
4	0.093	9.3
5	0.117	11.7
6	0.114	11.4
7	0.062	6.2
8	0.273	27.3
9	0.141	14.1
10	0.082	8.2
11	0.080	8.0
12	0.213	21.3
13	0.110	11.0
14	0.061	6.1
15	0.231	23.1
16	0.162	16.2
17	0.124	12.4
18	0.081	8.1
19	0.103	10.3
20	0.262	26.2
21	0.104	10.4
22	0.143	14.3
23	0.092	9.2
24	0.090	9.0
25	0.183	18.3
26	0.221	22.1
27	0.162	16.2

28	0.073	7.3
29	0.182	18.2
30	0.200	20.0
31	0.061	6.1
32	0.141	14.1
33	0.302	30.2
34	0.275	27.5
35	0.193	19.3
36	0.241	24.1
37	0.084	8.4
38	0.123	12.3
39	0.174	17.4
40	0.233	23.3
41	0.089	8.9
42	0.076.	7.6
43	0.137	13.7
44	0.245	24.5
45	0.043	4.3
46	0.097	9.7
47	0.043	4.3
48	0.174	17.4
49	0.085	8.5
50	0.044	4.4
51	0.122	12.2
52	0.243	24.3
53	0.173	17.3
54	0.060	6.0
55	0.075	7.5
56	0.231	23.1
57	0.300	30.0
58	0.142	14.2
59	0.187	18.7
60	0.203	20.3
61	0.082	8.2
62	0.154	15.4
63	0.063	6.3
64	0.201	20.1
65	0.116	11.6
66	0.270	27.0
67	0.261	26.1
68	0.052	5.2
69	0.103	10.3
70	0.212	21.2
71	0.281	28.1
72	0.170	17.0
73	0.202	20.2
74	0.091	9.1
75	0.225	22.5
76	0.143	14.3
77	0.100	10.0

78	0.217	21.7
79	0.179	17.9
80	0.294	29.4

Appendix V

Calibration Report for Cadmium (Cd)

Concentratio(ppm)	Absorbance
0.00	0.000
0.50	0.012
1.00	0.018
1.50	0.027
2.00	0.036
3.00	0.042
4.00	0.049
5.00	0.056

Sample	Absorbance	Concentration (ppm)
Blank	0.000	0.000
1	0.080	6.250
2	0.161	12.578
3	0.092	7.188
4	0.240	18.750
5	0.182	14.219
6	0.200	15.625
7	0.102	7.969
8	0.083	6.484
9	0.314	24.531
10	0.223	17.422
11	0.112	8.750
12	0.300	23.438

13	0.240	18.750
14	0.261	20.391
15	0.143	11.172
16	0.074	5.781
17	0.183	14.297
18	0.254	19.844
19	0.091	7.109
20	0.200	15.625
21	0.112	8.750
22	0.400	31.250
23	0.321	25.078
24	0.273	21.328
25	0.211	16.484
26	0.172	13.438
27	0.113	8.828
28	0.292	22.813
29	0.134	10.469
30	0.101	7.891
31	0.200	15.625
32	0.162	12.656
33	0.181	14.141
34	0.263	20.547
35	0.311	24.297
36	0.273	21.328
37	0.142	11.094
38	0.462	36.094

39	0.123	9.609
40	0.231	18.047
41	0.111	8.672
42	0.094	7.344
43	0.152	11.875
44	0.203	15.859
45	0.310	24.219
46	0.083	6.484
47	0.212	16.563
48	0.084	6.563
49	0.142	11.094
50	0.261	20.391
51	0.223	17.422
52	0.090	7.031
53	0.252	19.688
54	0.174	13.594
55	0.220	17.188
56	0.364	28.438
57	0.133	10.391
58	0.201	15.703
59	0.443	34.609
60	0.100	7.813
61	0.292	22.813
62	0.154	12.031
63	0.172	13.438
64	0.234	18.281

65	0.142	11.094
66	0.342	26.719
67	0.270	21.094
68	0.193	15.078
69	0.143	11.172
70	0.241	18.828
71	0.082	6.406
71	0.120	9.375
73	0.252	19.688
74	0.402	31.406
75	0.130	10.156
76	0.244	19.063
77	0.324	25.313
78	0.190	14.844
79	0.420	32.813
80	0.213	16.641

Appendix VI

Caliberation Report Metal: Lead (Pb)

CONCENTRATION (ppm)	ABSORBANCE
0.00	0.000
4.00	0.358
8.00	0.412
12.00	0.514
16.00	0.612
20.00	0.732
30.00	0.868
40.00	0.942

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Sample	Absorbance	Concentration (ppm)
BLK	0.000	0.000
1	0.321	8.005
2	0.174	4.339
3	0.263	6.559
4	0.411	10.249
5	0.202	5.037
6	0.361	9.002
7	0.364	9.077
8	0.292	7.282
9	0.314	7.830
10	0.250	6.234
11	0.114	2.843
12	0.221	5.511

13	0.173	4.314
14	0.512	12.768
15	0.425	10.599
16	0.369	9.202
17	0.274	6.833
18	0.402	10.025
19	0.212	5.287
20	0.183	4.564
21	0.324	8.080
22	0.273	6.808
23	0.162	4.040
24	0.344	8.579
25	0.183	4.564
26	0.244	6.085
27	0.241	6.010
28	0.561	13.990
29	0.311	7.756
30	0.292	7.282
31	0.174	4.339
32	0.353	8.803
33	0.213	5.312
34	0.264	6.584
35	0.303	7.556
36	0.452	11.272

37	0.261	6.509

38	0.196	4.888
39	0.332	8.279
40	0.413	10.299

Appendix V11

Concentration of Subjects with Diabetes

Hg	As	Ni	Cd	Pb
0.568	1.954	7.0	6.25	8.005
1.25	3.333	14.1	24.531	7.83
0.909	1.379	8.2	17.422	6.234
0.682	1.839	8.0	8.75	2.843
1.25	1.954	22.1	13.438	6.085
0.795	3.448	13.7	11.875	3.092
0.909	1.379	4.3	16.563	6.384
1.136	4.138	24.3	7.031	5.212
0.795	3.218	27.0	26.719	7.506
1.25	1.379	20.2	19.688	7.032

Appendix VIII

Concentration of Subjects with Hypertension \ Heart diseases

Hg	As	Ni	Cd	Pb
1.705	2.414	6.2	7.969	9.077
1.477	3.218	23.1	11.172	10.599
1.818	3.448	18.3	16.484	4.564
0.909	1.494	18.2	10.469	7.756
1.477	1.379	7.6	7.344	5.96
0.795	3.908	17.4	6.563	8.254
1.591	3.563	15.4	12.031	4.214
1.136	1.494	26.1	21.094	3.392
0.341	2.529	8.5	11.094	9.352
0.682	1.264	9.2	25.078	4.04
0.909	2.644	12.1	7.188	6.559
0.455	2.184	9.3	18.75	10.249
1.705	2.874	21.3	23.438	5.511
0.682	1.264	9.2	25.078	4.04
1.818	2.874	6.0	13.594	7.98

Appendix IX
Concentration of Subjects with Hypertension \Diabetes mellitus

Hg	As	Ni	Cd	Pb
1.023	1.379	10.4	8.75	8.08
1.023	0.805	9.0	21.328	8.579
1.705	1.034	24.5	15.859	8.329
1.591	2.414	4.4	20.391	4.04
1.023	1.494	7.5	17.188	12.793

Appendix X

Concentration of Subjects with Liver disease

Hg	As	Ni	Cd	Pb
2.159	3.908	23.3	18.047	10.299
0.568	2.184	17.3	19.688	10.274
2.045	3.678	8.2	22.813	10.748
0.568	1.839	9.1	31.406	3.591

Appendix XI

Concentration of Subjects with Kidney disease (KD)

Hg	As	Ni	Cd	Pb
1.364	1.609	20.3	7.813	7.307
1.364	2.184	6.1	15.625	4.339
0.909	2.414	28.1	6.406	8.703

Appendix XII

Concentration of Subjects with Cancers

Hg	As	Ni	Cd	Pb
0.341	1.034	4.0	12.578	4.339
0.455	1.494	6.1	20.391	12.768
1.932	3.678	26.2	15.625	4.564
1.932	3.218	24.1	21.328	11.272
0.227	3.103	4.3	24.219	11.496
0.909	2.644	18.7	34.609	3.516
1.023	3.563	21.7	14.844	10.075
1.477	2.184	17.9	32.813	7.406
0.568	3.103	11.4	15.625	9.002

Appendix XIII

Concentration of Subjects with Other diseases

Hg	As	Ni	Cd	Pb
2.159	1.724	27.3	6.484	7.282
1.136	2.529	11.0	18.75	4.314
1.023	1.149	16.2	5.781	9.202
1.25	1.724	12.4	14.297	6.833
0.795	1.034	8.1	19.844	10.025
0.568	1.839	10.3	7.109	5.287
1.023	2.529	16.2	8.828	6.01
1.477	4.023	7.3	22.813	13.99
2.045	4.253	20.0	7.891	7.282
1.136	1.379	8.4	11.094	6.509
0.795	1.839	12.3	36.094	4.888
1.591	2.874	17.4	9.609	8.279
0.682	1.149	14.1	12.656	8.803
0.795	2.989	17.0	9.375	10.973
1.705	3.563	30.2	14.141	5.312
0.682	1.149	30.0	10.391	7.83
0.341	2.759	14.2	15.703	6.608
0.909	2.874	22.5	10.156	8.055
1.591	3.103	10.0	25.313	13.766

Appendix XIV

Concentration of Subjects with Inflections

Hg	As	Ni	Cd	Pb
1.25	2.299	19.3	24.297	7.556
0.568	1.839	11.6	11.094	6.209
1.477	2.644	5.2	15.078	7.855
1.364	2.184	10.3	11.172	6.758

Appendix XV

Concentration of Subjects with Infertility

Hg	As	Ni	Cd	Pb
1.364	2.759	14.3	31.25	6.808
0.455	1.839	23.1	28.438	2.968
1.705	1.954	14.3	19.063	5.387

Appendix XVI

Concentration of Subjects with Routine

Hg	As	Ni	Cd	Pb
1.023	1.724	27.5	20.547	6.584
0.455	1,264	8.9	8.672	6.883
1.25	1.724	9.7	6.484	9.8
1.932	1.954	12.2	17.422	3.641
1.023	2.069	6.3	13.438	5.636

Appendix XVII

Instruments used for the Analysis

Appendix XVIII

Calibration Curve on Mercury

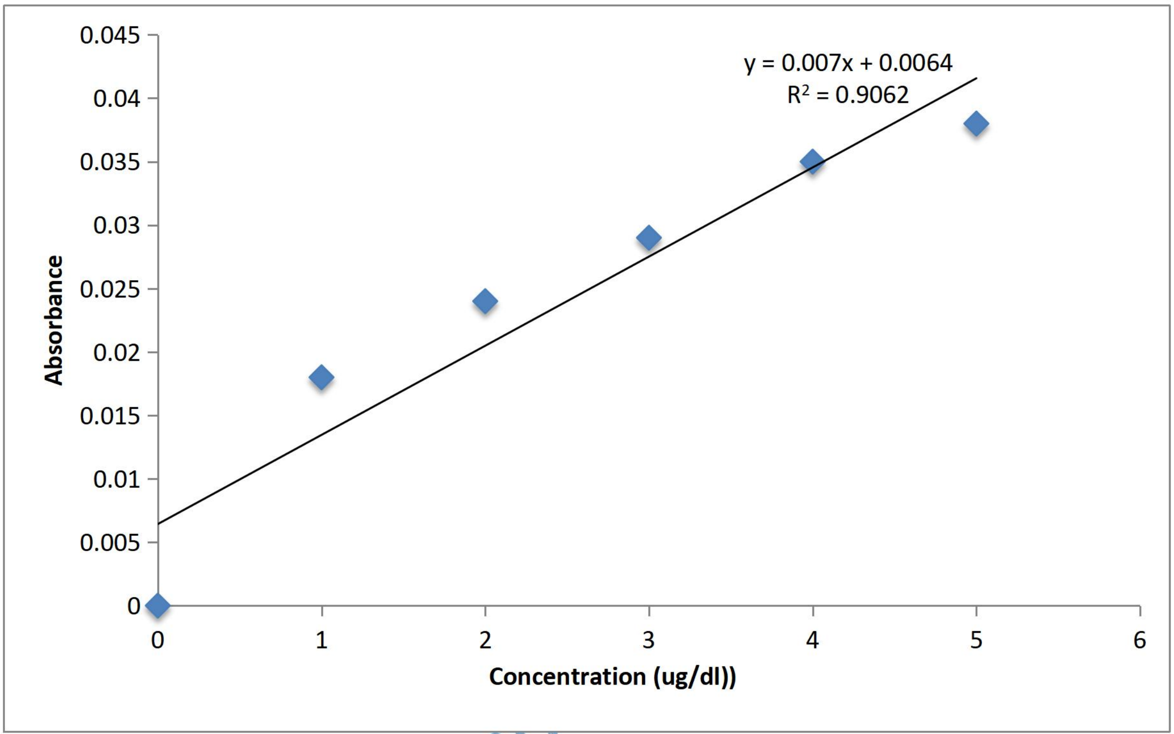

Figure 3: Calibration curve for Mercury (Hg)

Figure 3 above showed that in every unit of absorbance, there is a corresponding increase in concentration by 0.007.

Table 3: Pearson Correlation coefficient (r) between Absorbance and concentration of Mercury (Hg)

Variables	Mean	Std Deviation	r	p-value	Remark
Concentration (ug/dl)	2.50	1.87	0.952	0.003*	Significant
Absorbance	0.024	0.013			

*p<0.05 (i.e. Significant).

This means that there is a very strong correlation between Absorbance and concentration, and it is statistically significant (r=0.952, p=0.003).

Appendix XXV

Calibration Curve on Arsenic

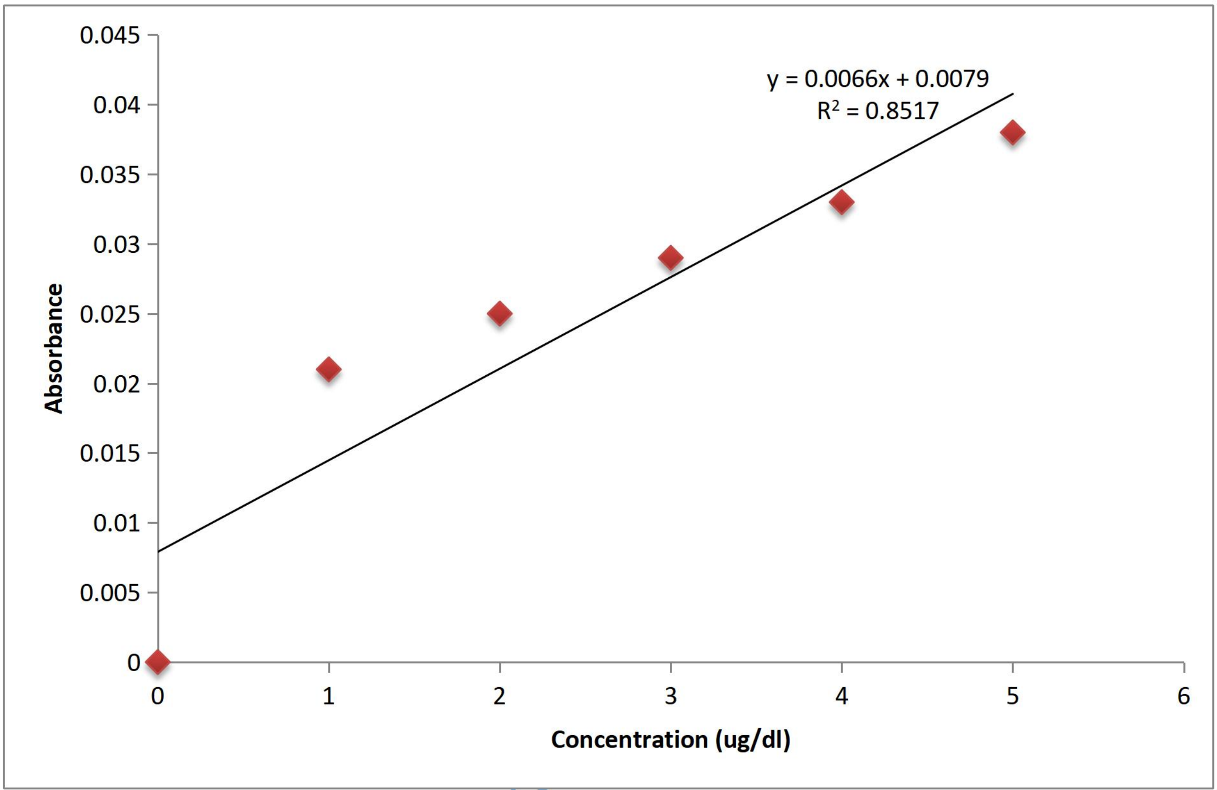

Figure4. : Calibration curve for As

Figure4 above showed that in every unit of absorbance, there is a corresponding increase in concentration by 0.006.

Table 4: Pearson Correlation coefficient (r) between Absorbance and concentration of Arsenic (As)

Variables	Mean	Std Deviation	r	p-value	Remark
Concentration (mg/L)	2.50	1.871	0.923	0.009*	Significant
Absorbance	0.0243	0.013			

*p<0.05 (i.e. Significant).

This means that there is a very strong correlation between Absorbance and concentration, and it is statistically significant (r=0.923, p=0.009).

Appendix XVIII

Calibration Curve on Nickel

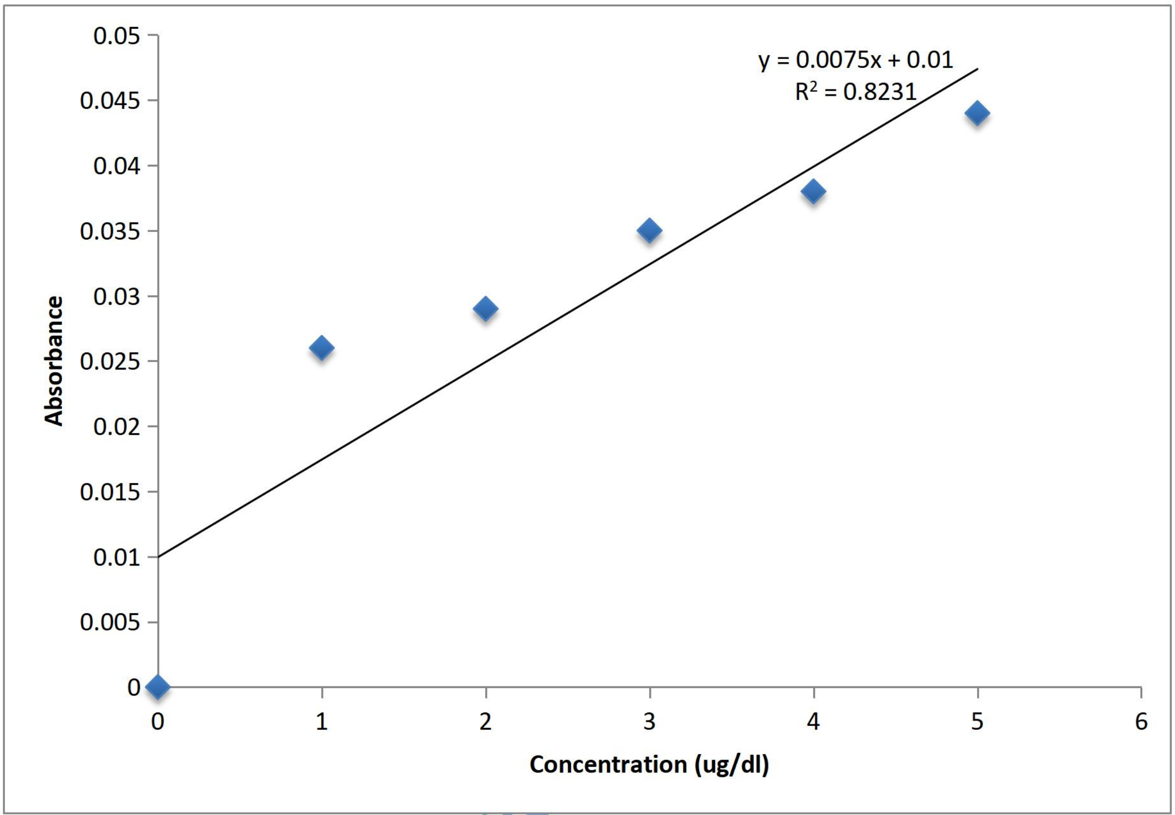

Figure 5: Calibration curve for Nickel (Ni)

Figure 5 above showed that in every unit of absorbance, there is a corresponding increase in concentration by 0.007.

Table 5: Pearson Correlation coefficient (r) between Absorbance and concentration of Nickel (Ni)

Variables	Mean	Std Deviation	r	p-value	Remark
Concentration (ug/dl)	2.50	1.871	0.907	0.013*	Significant
Absorbance	0.0287	0.015			

*p<0.05 (i.e. Significant).

This means that there is a very strong correlation between Absorbance and concentration, and it is statistically significant (r=0.907, p=0.013).

Appendix XVIII

Calibration Curve on Cadmium

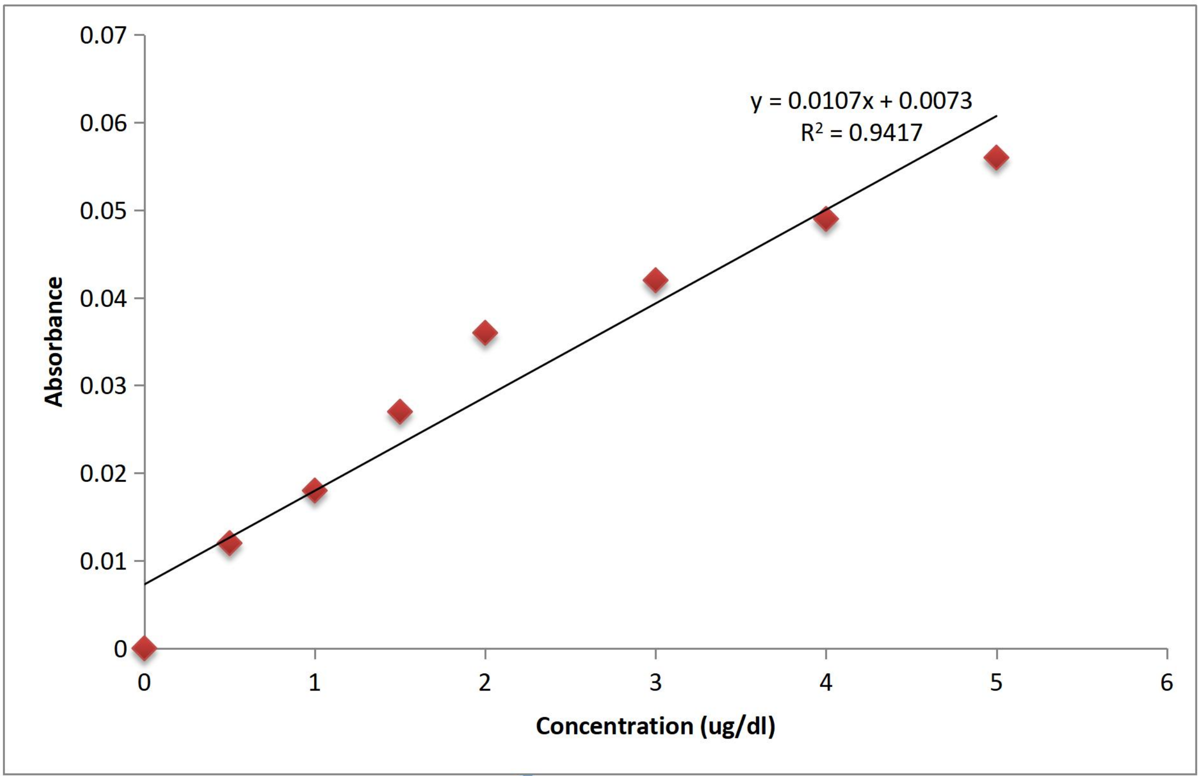

Figure 6: Calibration curve for Cadmium (Cd)

Figure 6 above showed that in every unit of absorbance, there is a corresponding increase in concentration by 0.010.

Table 6: Pearson Correlation coefficient (r) between Absorbance and concentration of Cadmium (Cd)

Variables	Mean	Std Deviation	r	p-value	Remark
Concentration (ug/dl)	2.125	1.747	0.970	0.000*	Significant
Absorbance	0.030	0.019			

*p<0.05 (i.e. Significant).

This means that there is a very strong correlation between Absorbance and concentration, and it is statistically significant (r=0.970, p=0.000).

Appendix XVIII

Calibration Curve on Lead

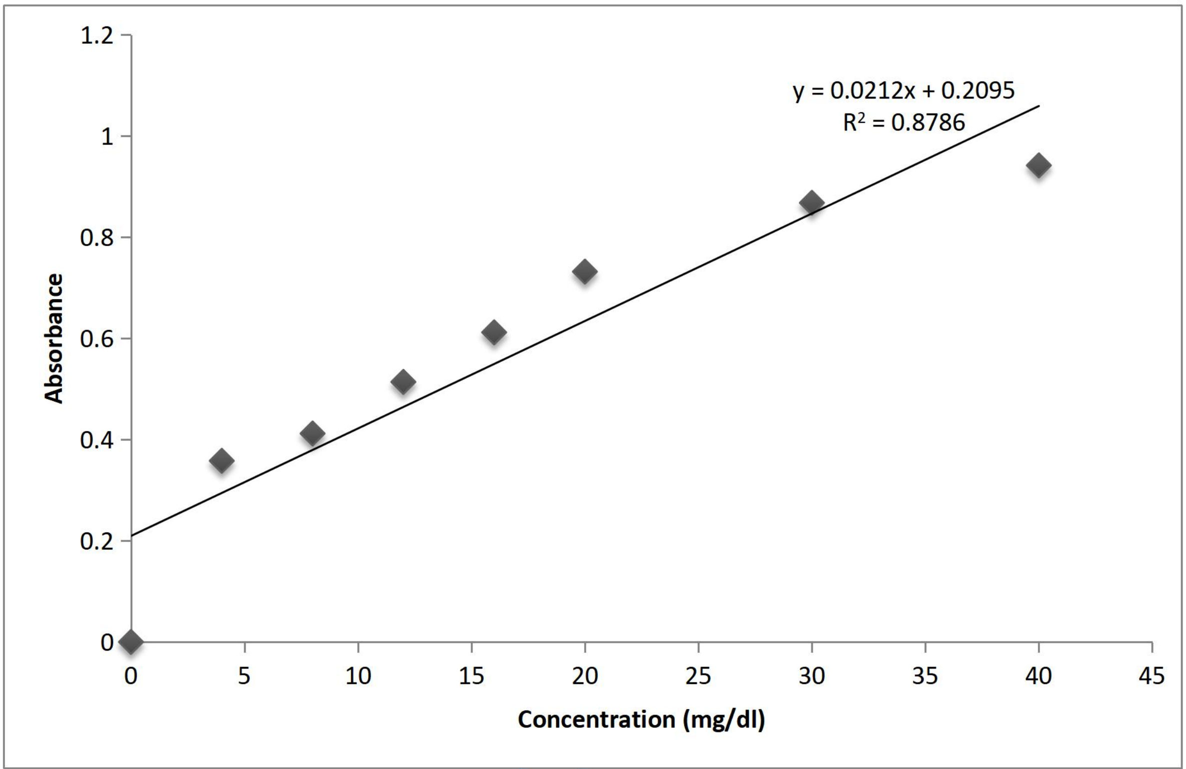

Figure 7: Calibration curve for Lead (Pb)

Figure 7 above showed that in every unit of absorbance, there is a corresponding increase in concentration by 0.021.

Table 7: Pearson Correlation coefficient (r) between Absorbance and concentration of Lead (Pb)

Variables	Mean	Std Deviation	r	p-value	Remark
Concentration (ug/dl)	16.250	13.456	0.937	0.001*	Significant
Absorbance	0.554	0.305			

*p<0.05 (i.e. Significant).

This means that there is a very strong correlation between Absorbance and concentration, and it is statistically significant (r=0.937, p=0.001).

Appendix XIX

Straight Line Graph Shown the Means Concentrations of. Heavy Metals

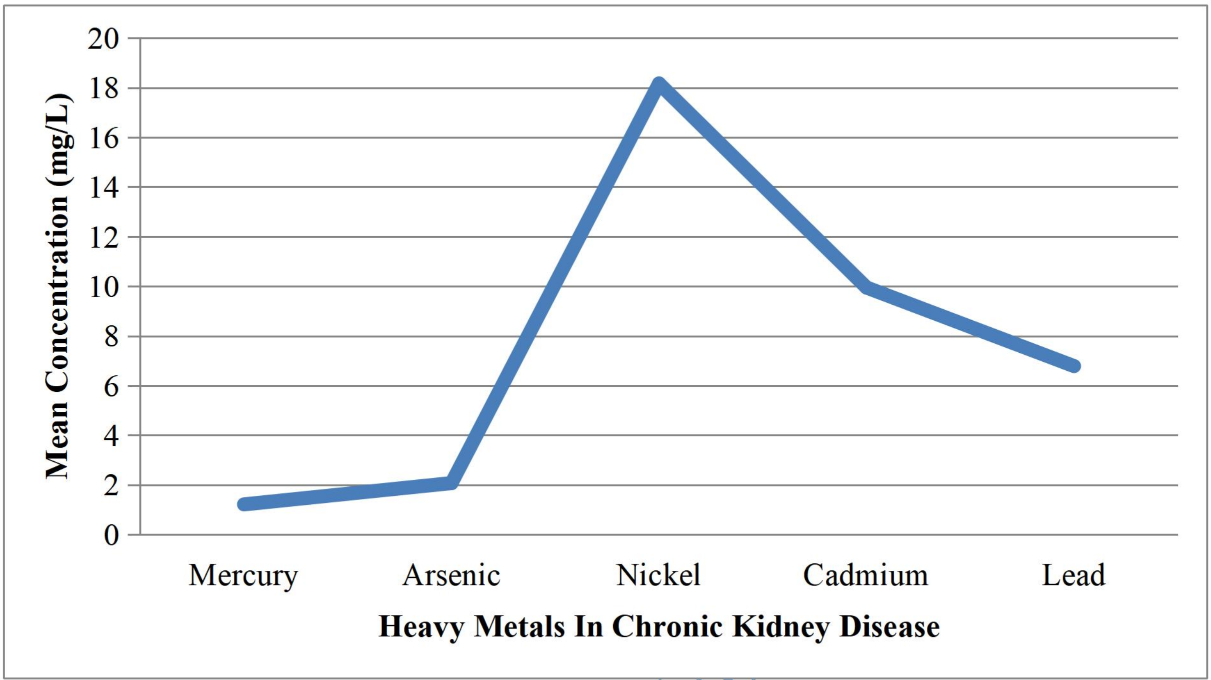

Figure 15: Straight line graph showing the mean concentration of heavy metals in chronic kidney disease

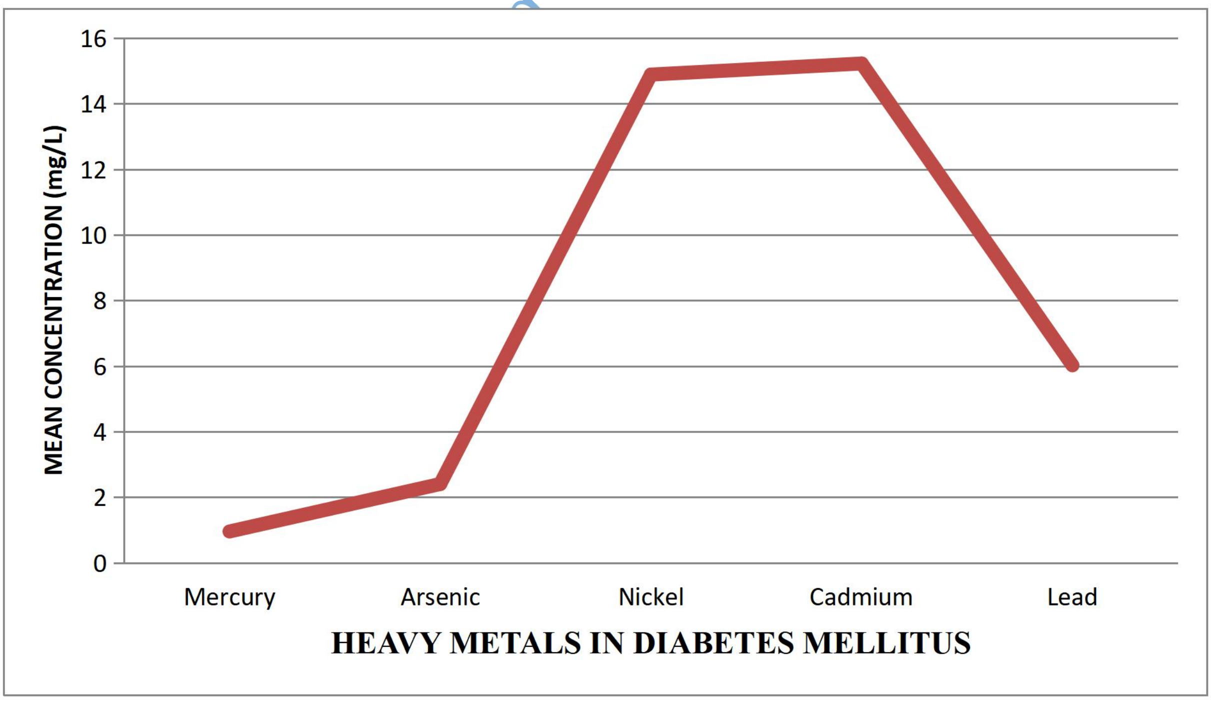

Figure 16: Straight line graph showing the mean concentration of heavy metals in diabetes mellitus

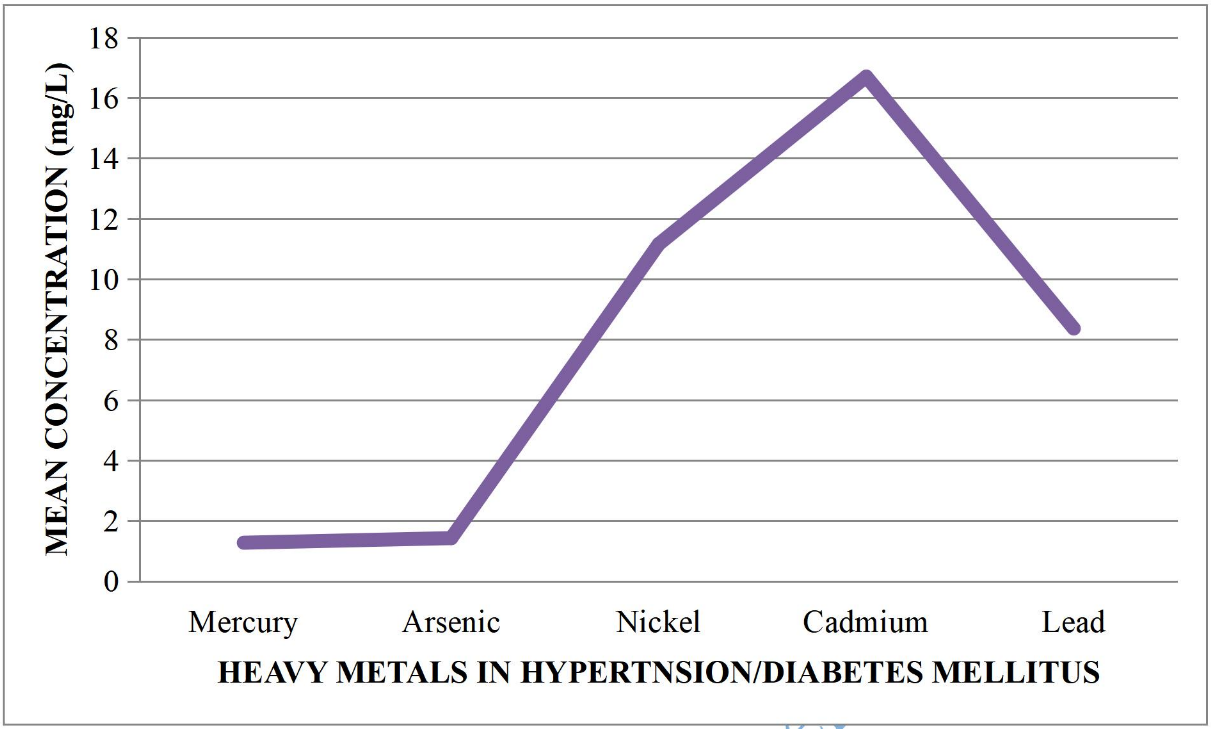

Figure 17: Straight line graph showing the mean concentration of heavy metals in Hypertension/diabetes mellitus

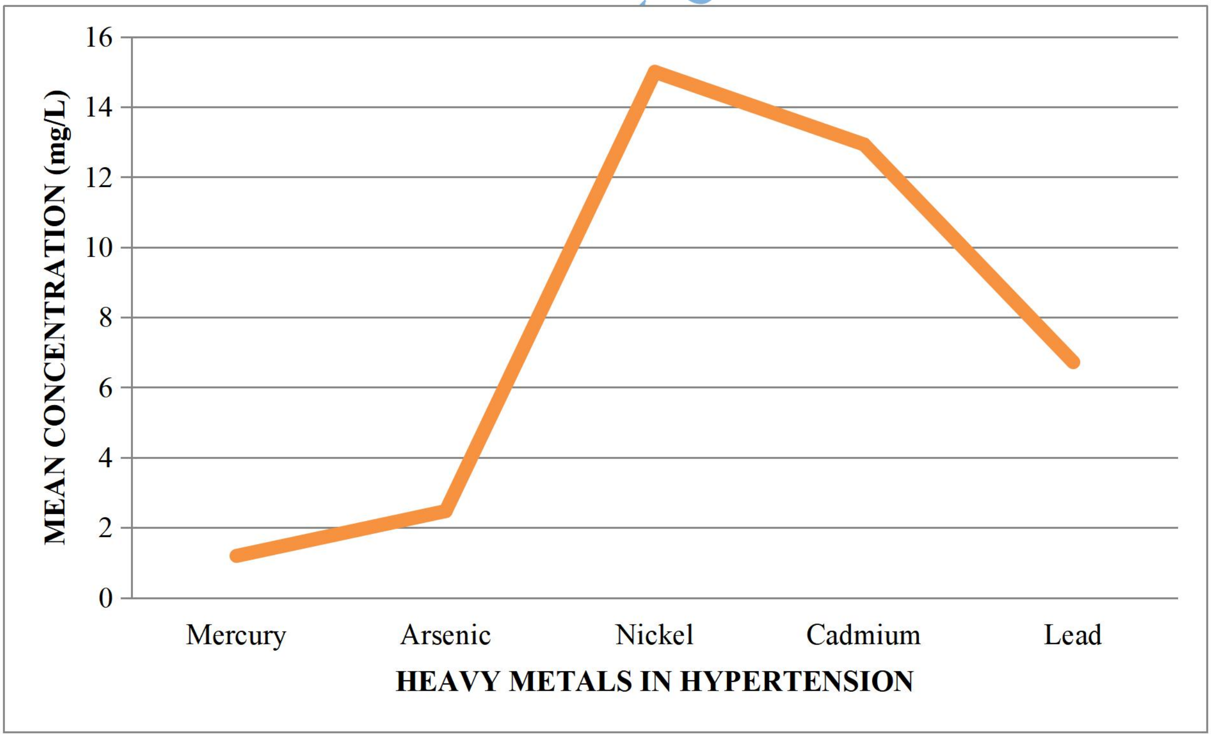

Figure 18: Straight line graph showing the mean concentration of heavy metals in Hypertension

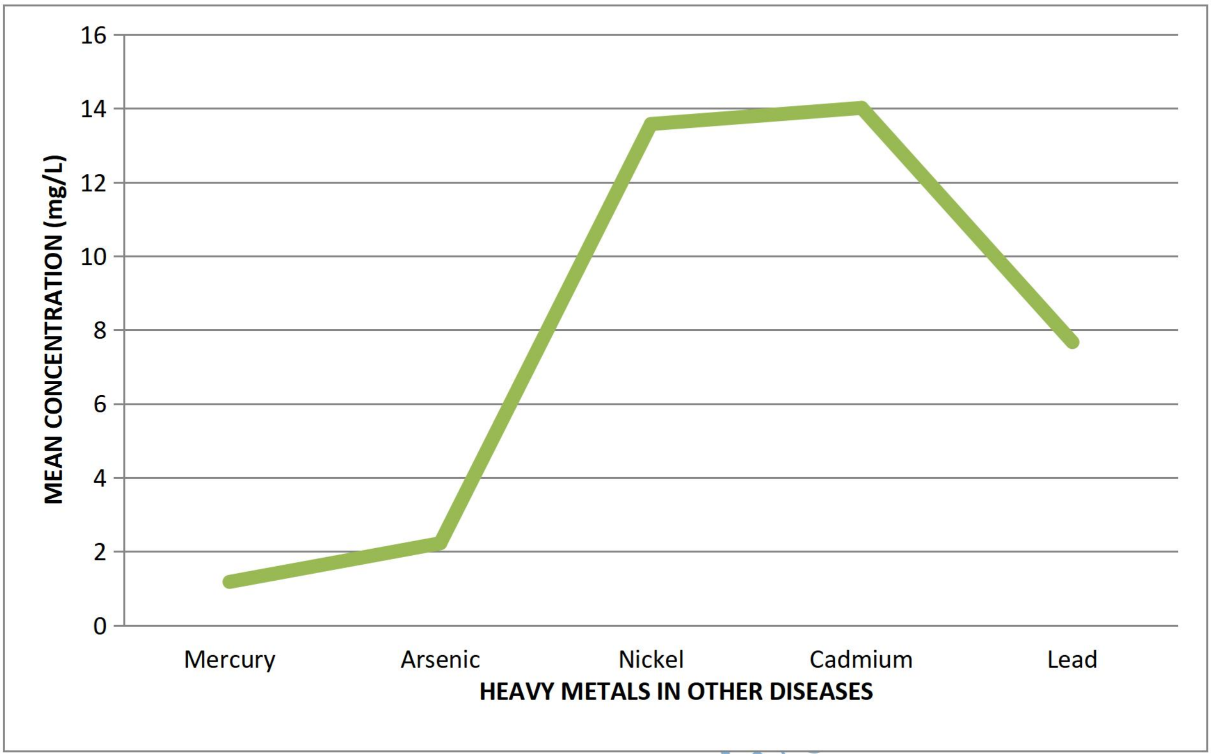

Figure 19: Straight line graph showing the mean concentration of heavy metals in other diseases

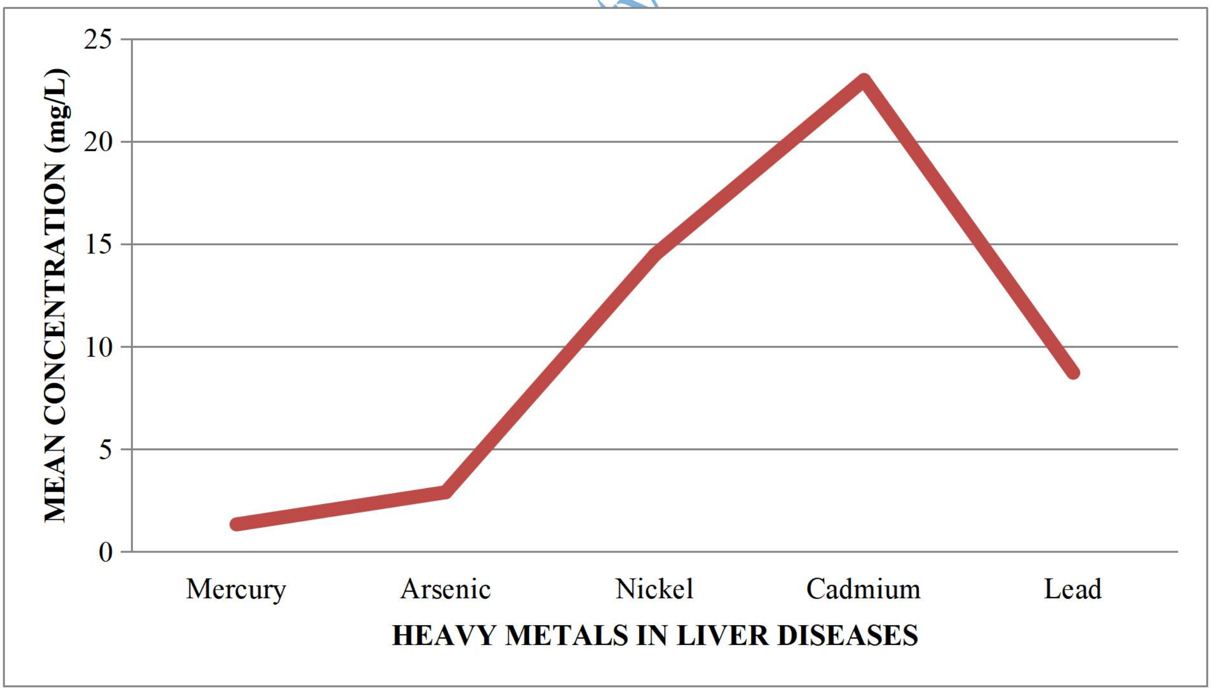

Figure 20: Straight line graph showing the mean concentration of heavy metals in liver diseases

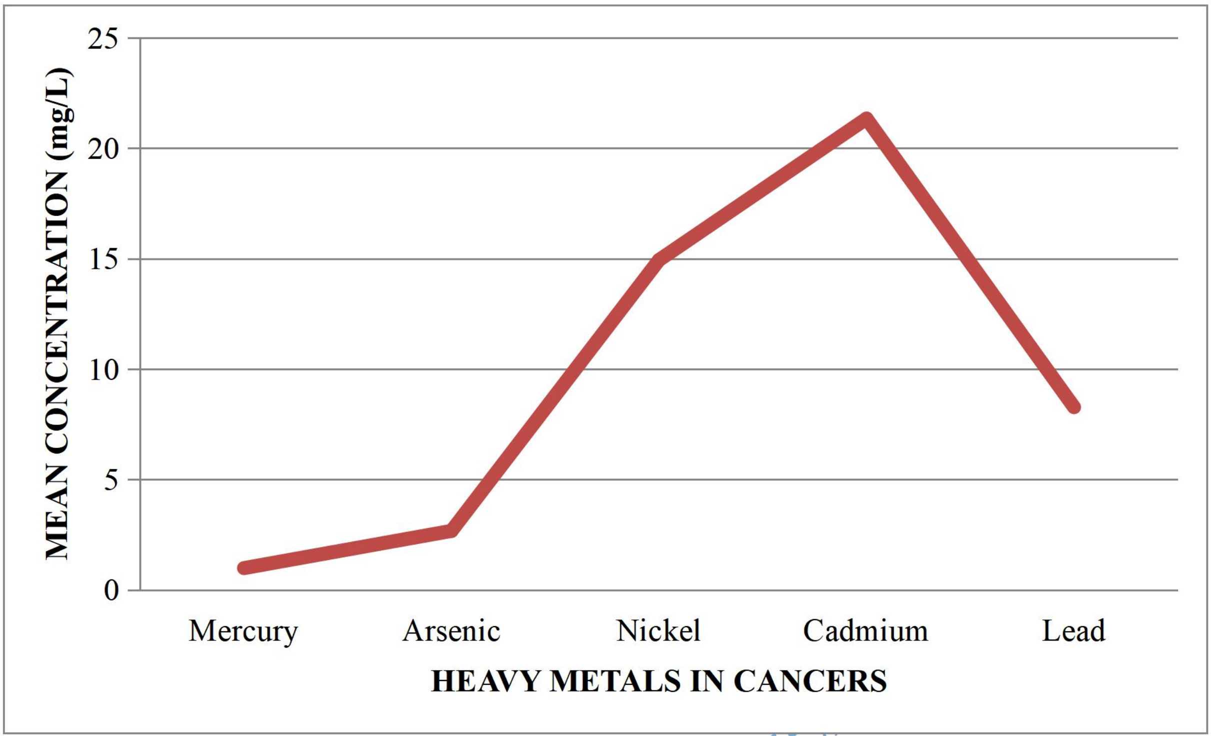

Figure 21: Straight line graph showing the mean concentration of heavy metals in cancers

Bio Data

A . Personal Data:

1, Full Name:	Adedunni Oluwabimpe Adegoke
2. Contact Address:	Bukola Moses Drive, Temidayo lane 1 Ajadi Ologuneru, Ibadan, Oyo State.
3. Email Address:	oluwabimpeadegoke@gmail.com
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5. Date of Birth:	13th of August 1969
6. Place of Birth:	Ile- Ife
7. Nationality:	Nigerian
8. State of Origin:	Oyo
9. Local Government Area:	Ibadan North
10. Religion:	Christianity
11. Next of Kin:	Mr Andrew Olusola Adegoke
12. Next of Kin's Contact Address:	Bukola Moses Drive Temidayo Lane 1, Ajadi Ologuneru, Ibadan
13. Next of Kin's Phone Number:	08055373564

B. Education Background:

Educational Institution Attended with Dates and Qualification:

School Attended	Dates	Qualifications
• Salvation Army Primary School	1975-1980	Primary School Certificate
• Renascent High School	1981- 1986	West Africa School Certificate
• School of Medical Laboratory	1988-1991	Medical Laboratory Technician Certificate
• University of Ibadan	1993-2000	Final Diploma Chemistry\ Biochemistry
• Lead City University, Ibadan.	2021-2023	MSc in view

C. Working Experience with Date:

• Akande Laboratory, Ibadan	1991
• Ayodele Hospital, Ibadan	1992
• Acelab Diagnostic Center, Ibadan	1993-2010
• Blossom Biomedical Laboratory	2010-2012
• University College Hospital.	2012- till date.

D. Awards and Fellowships In view

E. Membership of Academic/ Professional Bodies Medical Lab.Council of Nigeria

Nigeria Institute of Science Lab.Tech

F. Publication Pharmacokinetic Study of Elimination Of Cassava Cyanide in Albino Wistar Rats.

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Signature **Date**

The University Compliance Certification

This is to certify that, this Thesis written by **Adedunni Oluwabimpe, ADEGOKE with Matric No. LCU/PG/002460** in the Department of Biological Science, Faculty of Natural and Applied Sciences, Lead City University, Ibadan is in full compliance with the approved University format and style.

____________________________ __________________

Signature **Date**