

**LEVELS OF HEAVY METALS IN THE BLOOD OF
ELECTRONIC TECHNICIANS IN PORT HARCOURT
METROPOLIS, RIVERS STATE.**

BY

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CERTIFICATION

This is to certify that this work on "Levels of heavy metals in the Blood of Electronic Technicians in Port Harcourt Metropolis, Rivers State", was carried out by Ekine Dumoteinm Stephen Opuda, (Reg. No. 20104774408) in partial fulfillment for the award of Master's Degree in Public Health (Environmental Health and Safety Option) in the department of Public Health, Federal University of Technology, Owerri.

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DEDICATION

I dedicate this work to the ALMIGHTY FATHER for His love and guidance throughout my life and period of schooling and generally to humanity at large

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ABSTRACT

Different types of heavy metals used in the production and repairs of electronics, can be found in the blood of those handling these electronics. This study was done to determine the levels of heavy metals in the blood of electronic technicians in Port Harcourt metropolis. The study was aimed at determining specifically the levels of lead (Pb), Mercury (Hg) and Arsenic (As) in the blood of electronic technicians. The study design was experimental as the metals are introduced into the body through their occupation and the population of electronic technician sampled was 40 using the modified Cochran formula, Purposive sampling method was used and 40 volunteers allowed their venous blood to be collected and, analyzed using Atomic Absorption spectrophotometry method of analysis. The results revealed that there was statistical significant difference in the mean concentration of these metals [$F(2, 117) = 8.243, P = 0.000$] and the levels of the metals in the blood was 0.64218 mg/L for lead with the highest concentration, 0.134505 mg/L for mercury with the least and 0.399275 mg/L for Arsenic . It also showed increased bio-accumulation levels for the various metals studied. It shows that there is an accumulation of metals in the blood of technicians and also that the PPE's used were only nose masks and aprons indicating inhalation and dermal contacts as the commonest exposure route. Proper enlightenment is needed to reduce bio-accumulation of metals in these technicians, Also there should be measures by government on use of PPE's.

Keywords; Heavy metals, Bio-accumulation, Occupational safety, exposure, Environmental pollution, Toxicity.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND TO THE STUDY

Heavy metals are naturally occurring elements that have a high atomic weight and a density at least 5 times greater than that of water. (Paul, Clement , Anita and Dwayne, 2014) also, their multiple industrial, domestic, agricultural, medical and technological applications have led to their wide distribution in the environment. There is a rising concern over their potential effects on human health and the environment, Their toxicity depends on several factors including the dose, route of exposure, and chemical components, as well as the age, gender, genetics, and nutritional status of exposed individuals.(Paul, *et al.*, 2014)

Human beings are exposed to a high level of toxic and heavy metals coming from many sources, which may include the burning of coal, through natural gas and petroleum exploitation, also through incineration of waste materials worldwide.(Lemos and De Carvalho, 2010).

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. In this context, many analytical approaches have been reported for the determination of heavy and toxic metals in biological samples. (Yahaya, Shehu, and Dabai, 2013). However, the determination of the toxic heavy metals, minor minerals, and even major elements in the human body is a critical issue in the field of forensic and toxicological clinical chemistry. The major minerals which are present in high levels such as Na, K, Mg, and Ca are crucial for the metabolic activity of the human body. (Yahaya, *et al.*, 2013). It was also stated by Paul *et al.*, (2014) that because of their high degree of toxicity, arsenic, cadmium, chromium, lead, and mercury rank among the priority metals that are of public health significance. These metallic elements are considered systemic toxicants that are known to induce multiple organ damage, even at lower levels of exposure.

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. Although the human body needs certain minerals to maintain a healthy

condition, too much of one mineral may become toxic.(Yahaya *et al.*, 2013)

Moreover, toxic and heavy metals are highly dangerous even in trace levels and may cause chronic acute poisoning. In fact, these metals are harmful and have no known function in the human body. The toxicity of these metals can result in many illnesses, namely, reduced or damaged mental and central nervous function, lower energy levels, and damage to blood composition, lungs, kidneys, liver, and other vital organs.Yahaya *et al.*, (2013) posited that the long-term exposure to such elements may result in slowly progressing physical, muscular, and neurological degenerative processes that mimic Alzheimer's disease, Parkinson's disease, muscular dystrophy, and multiple sclerosis. Among these elements, cadmium and lead are carcinogenic and the most toxic metals and the cardiovascular effects of such two metals in humans come from their association with increased blood pressure.(Yahaya *et al.*, 2013)

Heavy metals have no function in the body and can be highly toxic. They occur near the bottom of the periodic table, and are non degradable Paul *et al.*, (2014)

The toxic or heavy metals enter the human body through many sources, namely, the houses paint, fish, dental amalgam, farming, mining and smoking including second hand smoke. Smoking is an important source

of exposure to nickel, cadmium, lead, and other toxic metals. Once inhaled through smoking, toxic metals have a long biological life span. Chronic adverse effects on human health may therefore, in later years result from prolonged intake of such toxic elements, some of which are powerful carcinogens - (Lemos and De Carvalho, 2010). Based on their extreme toxicity, toxic and heavy metals must be detected at very low levels in the human fluids and tissues. In this context, blood and hair are the most suitable human biological samples generally used in such metal analysis. The blood samples have been used to assess the heavy metals levels in human body for several years . Due to the partitioning of the toxic and heavy metals in their hair, recently hair samples have been used as good index in such studies.(Lemos and De Carvalho, 2010)

Atomic absorption spectrometer (AAS) has been used in the detection of some minerals and toxic heavy metal in biological samples. Anodic stripping voltammetry has been applied in the determination of heavy metals (Cd, Cu, and Pb) in blood.

1.2. STATEMENT OF PROBLEM

It is a well-known fact that Electronic products are a complex mixture of several hundred components, which contain heavy metals. These dangerous substances can cause serious pollution in the environment and put workers especially those who have direct contact with them at risk of exposure when the products are produced, diagnosed, repaired and maintained. Saikat et al., (2022) posited that heavy metals are well-known environmental pollutants, and have ability to accumulate in the human body via bioaccumulation. The pollution with toxic heavy metals is a major environmental concern that has great consequences for public health both locally and on a global scale. Electronic technicians are involved in the repair and maintenance of these household or industrial electronics. The exposure levels of these technicians increases and the metals are inhaled, ingested or also taken through dermal contacts which can lead to various conditions if they bio-accumulate in the bloodstream of individuals involved in this occupation. Their exposure rate is as a result of them not taking into consideration the safety measures that are required while handling these products. Hence, the need to determine the blood levels of heavy metals commonly found in electronics within the electronic technicians, and compare with reference values of these metals.

1.3. OBJECTIVES OF THE STUDY

1.3.1 GENERAL OBJECTIVE

The main objective of this work is to determine the levels of heavy metals (Lead (Pb)), Mercury (Hg) and Arsenic (Ar)) in the blood of electronic technicians found in Rivers State.

1.3.2 SPECIFIC OBJECTIVE

- (i) To determine the levels of Lead, Mercury and Arsenic in electronic technicians.
- (ii) To determine which blood heavy metal has the highest and least concentration in the blood .
- (iii) To compare the values of these metals obtained from exposed individuals with reference values.
- (iv) To determine the commonest method of exposure from the type of PPE used.
- (v) To determine the relationship between years of exposure to the levels of heavy metals in blood of electronic technicians.

1.4. SIGNIFICANCE OF THE STUDY

It is important to assess the presence and levels of heavy metals particularly Lead, Arsenic and Mercury because they are the main causes of excessive free radical activity which can cause damage to the healthy state of the body including depleting the body's immune system. This study will be able to inform us about the occupational exposure rate of heavy metals on the electronic technicians in port Harcourt metropolis. Also it will be able to state and ascertain certain conditions that may be associated with these metals if they bio-accumulate in the body. The study can enable us begin to proffer possible preventive measures against the conditions of excessive levels of these metals as a result of high exposure rates and contacts to these metals. It will also help the government, particularly the ministries of Health and Environment in putting up laws and regulations on how to minimize the chances of getting these metals into the body system thereby reducing future increase in ailments associated with bioaccumulation of heavy metals.

1.5. SCOPE OF THE STUDY

The scope of this work is limited to Electronic Technicians in Port Harcourt metropolis taking into consideration the area that is densely populated like Illabuchi area that has over 90 percent of them and is delimited to only males as the profession is predominated by only them.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

2.1.1: Concept Of Heavy Metal

The term heavy metal refers to any metallic chemical element that has a relatively high density and is toxic or poisonous at low concentrations. Examples of heavy metals include mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), Thallium (TI), and Lead (Pb). Heavy metals are natural components of the Earth's crust. They cannot be degraded or destroyed. To a small extent, they enter our bodies via food, drinking water, and air. As trace elements, some heavy metals (e.g. copper, selenium, zinc) are essential to maintain the metabolism of the human body. However, at higher concentrations, they can lead to poisoning. Heavy metal poisoning could result, for instance, from drinking-water contamination (e.g. lead pipes), high ambient air concentrations near emission sources, or intake via the food chain. (Alina, Azrina, & Mohd, 2012).

Heavy metal, is also defined as a naturally occurring element having a high atomic weight and high density which is five times greater than that of water (Abate, Hussien, Laing, & Mengistu, 2013). Among all the pollutants, heavy metals have received paramount attention from

environmental chemists due to their toxic nature. Heavy metals are usually present in trace amounts in natural waters but many of them are toxic even at deficient concentrations. Metals such as arsenic, lead, cadmium, nickel, mercury, chromium, cobalt, zinc, and selenium are highly toxic even in minor quantities. An increasing quantity of heavy metals in our resources is currently an area of greater concern, especially since a large number of industries are discharging their metal-containing effluents into fresh water without any adequate treatment (Ghani, 2011). Heavy metals become toxic when they are not metabolized by the body and accumulate in the soft tissues. They may enter the human body through food, water, air, or absorption through the skin when they come in contact with humans in agriculture, manufacturing, pharmaceutical, industrial, or residential settings. Industrial exposure accounts for a common route of exposure for adults. Ingestion is the most common route of exposure in children. Natural and human activities are contaminating the environment and its resources, they are discharging more than what the environment can handle (Chen, Chen, and Dong, 2012)

Heavy metals are dangerous because they tend to bioaccumulate. Bioaccumulation means an increase in the concentration of a chemical in a biological organism over time, compared to the chemical's

concentration in the environment. Compounds accumulate in living things when they are taken up and stored faster than they are broken down (metabolized) or excreted. Heavy metals can enter a water supply through industrial and consumer waste, or even from acidic rain breaking down soils and releasing heavy metals into streams, lakes, rivers, and groundwater.

2.1.2: SOURCES OF HEAVY METALS

Heavy metals can emanate from both natural and anthropogenic processes and end up in different environmental compartments (soil, water, air, and their interface)

Natural processes

Many studies have documented different natural sources of heavy metals. Under different and certain environmental conditions, natural emissions of heavy metals occur. Such emissions include volcanic eruptions, sea-salt sprays, forest fires, rock weathering, biogenic sources, and wind-borne soil particles. Natural weathering processes can lead to the release of metals from their endemic spheres to different environment compartments. Heavy metals can be found in the form of hydroxides, oxides, sulfides, sulfates, phosphates, silicates, and organic compounds. The most common heavy metals are lead (Pb), nickel (Ni), chromium (Cr), cadmium (Cd), arsenic (As), mercury (Hg), zinc (Zn),

and copper (Cu). Although the aforementioned heavy metals can be found in traces, they still cause serious health problems for humans and other mammals (Baranoff, 2015).

Anthropogenic processes

Industries, agriculture, wastewater, mining and metallurgical processes, and runoffs also lead to the release of pollutants to different environmental compartments. Anthropogenic processes of heavy metals have been noted to go beyond the natural fluxes for some metals. Metals naturally emitted in wind-blown dust are mostly from industrial areas. Some important anthropogenic sources that significantly contribute to the heavy metal contamination in the environment include automobile exhaust which releases lead; smelting which releases arsenic, copper, and zinc; insecticides which release arsenic and burning of fossil fuels which release nickel, vanadium, mercury, selenium and tin. Human activities have been found to contribute more to environmental pollution due to the everyday manufacturing of goods to meet the demands of the large population (Baranoff, 2015).

Examples of these are lead, which is found in paint in old homes as well as many other sources, arsenic, which can be found in well water and wood products; and mercury, which can build up in fish that we eat. At

very high levels, most heavy metals can cause health problems. (Ashraf,2012)

Heavy metals are toxic to human health; the most common heavy metals to be discussed are lead, mercury, and arsenic. The Methods of exposure are Ingestion, Inhalation, and dermal contact. (Ashraf 2012). The extent to which one is exposed and the dosage determines the level of heavy metal poisoning. For example, swallowing a leaded toy can cause a large amount of lead exposure at once. This can cause acute exposure which can lead to serious health effects or death.

The table below shows the sources of exposure of these metals to electronic technicians

(Igharo, Anetor , Osibanjo, Osadolor and Dike, 2014) reported that People may be exposed to small amounts of heavy metals through ingestion of food, and water, inhalation of air, and skin contact of commercial electronic products. People can also be exposed in their workplace, as several industries use or produce these metals. Each metal is different in where it is found and how it behaves in our bodies. Exposure alone does not mean that it is causing any disease or harm. Acute heavy metal poisoning usually occurs when people are exposed to large amounts of metals at a time. For example, swallowing a leaded toy can cause a large amount of lead exposure all at once. This generally does not occur from

exposures that you are aware of. Acute exposures are dangerous and can quickly cause serious health effects or death.

Lead - is a chemical element with the symbol Pb (from the Latin plumbum) and atomic number 82. It is a heavy metal that is denser than most common materials. Lead is soft and malleable, and also has a relatively low melting point. When freshly cut, lead is silvery with a hint of blue; it tarnishes to a dull gray color when exposed to air. Lead has the highest atomic number of any stable element and three of its isotopes are endpoints of major nuclear decay chains of heavier elements. (<https://en.wikipedia.org/wiki/Lead>). lead has two main uses in electronic products. Metallic lead is used in electrical solder primarily on printed circuit boards. Workers using lead in high-temperature processes such as lead smelters can be significantly exposed to inorganic lead fumes and lead-bearing dust. Lead is highly toxic to humans. It has no known chemical or nutritional function (ATSDR 2000, Goyer 1996). The toxic effects of lead are the same irrespective of whether it is ingested or inhaled. It causes damage to the kidney, the nervous system, the blood system, and the reproductive system (Canfield *et al*, 2003 Goyer, 1993).

Mercury - is a chemical element with the symbol Hg and atomic number 80. It is commonly known as quicksilver and was formerly named hydrargyrum (/haɪˈdrɑːrdʒərəm/ hy-DRAR-jər-əm). A heavy, silvery d-

block element, mercury is the only metallic element that is liquid at standard conditions for temperature and pressure; the only other element that is liquid under these conditions is the halogen bromine, though metals such as cesium, gallium, and rubidium melt just above room temperature. (<https://en.wikipedia.org/wiki/mercury>)

It is used in lightening devices, switches relays of computers. Mercury and its compounds are highly toxic and have no biochemical or nutritional value. Inhalation of high levels causes effects ranging from damage to the central nervous system among adults and fetuses, also there are reported cases in children (Manhaffey *et al*, 2004 and Unep 2002). There is also an increased risk in the rate of cardiovascular and heart diseases (Virtanen *et al*, 2005).

Arsenic - is a chemical element with the symbol As and atomic number 33. Arsenic occurs in many minerals, usually in combination with sulfur and metals, but also as a pure elemental crystal. Arsenic is a metalloid. It has various allotropes, but only the gray form, which has a metallic appearance, is important to industry(<https://en.wikipedia.org/wiki/arsenic>). Exposure to arsine gas is also an environmental health hazard of concern in numerous occupational circumstances. Manhaffey *et al*, (2004) confirmed that the primary use of arsenic is in alloys of lead (for example, in car batteries

and ammunition). Arsenic is a common n-type dopant in semiconductor electronic devices. It is also a component of the III-V compound semiconductor gallium arsenide. Arsenic and its compounds, especially trioxide, are used in the production of pesticides, treated wood products, herbicides, and insecticides. These applications are declining with the increasing recognition of the toxicity of arsenic and its compounds(Manhaffeyet *al*, 2004 Unep 2002)

EFFECTS OF THE HEAVY METALS ON THE ENVIRONMENT.

EFFECTS OF LEAD ON THE ENVIRONMENT

In humans, exposure to lead can result in a wide range of biological effects depending on the level and duration of exposure. Various effects occur over a broad range of doses, with the developing fetus and infant being more sensitive than the adult. High levels of exposure may result in toxic biochemical effects in humans which in turn cause problems in the synthesis of hemoglobin, effects on the kidneys, gastrointestinal tract, joints, and reproductive system, and acute or chronic damage to the nervous system. Lead poisoning, which is so severe as to cause evident illness, is now very rare indeed. At intermediate concentrations, however, there is persuasive evidence that lead can have small, subtle, subclinical effects, particularly on neuropsychological developments in children. Some studies suggest that there may be a loss of up to 2 IQ

points for a rise in blood lead levels from 10 to 20 μ g/dl in young children (Ghani, 2011).

The average daily lead intake for adults in the UK is estimated at 1.6 μ g from air, 20 μ g from drinking water, and 28 μ g from food. Although most people receive the bulk of their lead intake from food, in specific populations other sources may be more important, such as water in areas with lead piping and plumbosolvent water, air near the point of source emissions, soil, dust, paint flakes in old houses or contaminated land. Lead in the air contributes to lead levels in food through the deposition of dust and rain containing the metal, on crops and the soil. For the majority of people in the UK, however, dietary lead exposure is well below the provisional tolerable weekly intake recommended by the UN Food and Agriculture Organisation and the World Health Organisation. Lead in the environment arises from both natural and anthropogenic sources. Exposure can occur through drinking water, food, air, soil, and dust from old paint containing lead. In the general non-smoking, adult population the major exposure pathway is from food and water. Food, air, water, and dust/soil are the major potential exposure pathways for infants and young children. For infants up to 4 or 5 months of age, air, milk formulae, and water are the significant sources. Lead is among the most recycled non-ferrous metals and its secondary production has

therefore grown steadily despite declining lead prices. Its physical and chemical properties are applied in the manufacturing, construction, and chemical industries. It is easily shaped and is malleable and ductile. There are eight broad categories of use: batteries, petrol additives (no longer allowed in the EU), rolled and extruded products, alloys, pigments and compounds, cable sheathing, and shot and ammunition.

EFFECTS OF MERCURY ON THE ENVIRONMENT

Mercury is a toxic substance that has no known function in human biochemistry or physiology and does not occur naturally in living organisms. Inorganic mercury poisoning is associated with tremors, gingivitis, and/or minor psychological changes, together with spontaneous abortion and congenital malformation.

Monomethylmercury causes damage to the brain and the central nervous system, while fetal and postnatal exposure has given rise to abortion, congenital malformation, and development changes in young children.

Mercury is a global pollutant with complex and unusual chemical and physical properties. The major natural source of mercury is the degassing of the Earth's crust, emissions from volcanoes, and evaporation from natural bodies of water. Worldwide mining of the metal leads to indirect discharges into the atmosphere. The usage of mercury is widespread in industrial processes and various products (e.g.

batteries, lamps, and thermometers). It is also widely used in dentistry as an amalgam for fillings and by the pharmaceutical industry. Concern over mercury in the environment arises from the extremely toxic forms in which mercury can occur. Mercury is mostly present in the atmosphere in a relatively unreactive form as a gaseous element. The long atmospheric lifetime (of the order of 1 year) of its gaseous form means the emission, transport, and deposition of mercury is a global issue. Natural biological processes can cause methylated forms of mercury to form which bioaccumulate over a million-fold and concentrate in living organisms, especially fish. These forms of mercury: monomethylmercury and dimethylmercury are highly toxic, causing neurotoxicological disorders. The main pathway for mercury to humans is through the food chain and not by inhalation.

The main sources of mercury emissions in the UK are the manufacture of chlorine in mercury cells, non-ferrous metal production, coal combustion, and crematoria. UK emissions of mercury are uncertain and it is estimated that the range is from 13 to 36 tonnes per year (DERA). Emissions are estimated to have declined by around ¾'s between 1970-1998 (NAEI), mainly due to improved controls on mercury cells and their replacement, and the fall in coal use. Whilst there has been a decline in the level of European emissions of mercury, emissions from

outside of Europe have started to increase – increasing the level of ambient concentrations in the continent.

Arsenic: Acute effects

The immediate symptoms of acute arsenic poisoning include vomiting, abdominal pain, and diarrhoea. These are followed by numbness and tingling of the extremities, muscle cramping, and death, in extreme cases.

Long-term effects

The first symptoms of long-term exposure to high levels of inorganic arsenic (for example, through drinking water and food) are usually observed in the skin and include pigmentation changes, skin lesions, and hard patches on the palms and soles of the feet (hyperkeratosis). These occur after a minimum exposure of approximately five years and may be a precursor to skin cancer.

In addition to skin cancer, long-term exposure to arsenic may also cause cancers of the bladder and lungs. The International Agency for Research on Cancer (IARC) has classified arsenic and arsenic compounds as carcinogenic to humans and has also stated that arsenic in drinking water is carcinogenic to humans.

In vitro studies have shown arsenic to alter the expression of p53 protein which also led to decreased expression of p21, one downstream target. Arsenic compounds have been shown in an in vitro cell line study to promote genotoxicity in humans and mice leucocytes. Also, a methylated form of arsenic was shown to inhibit DNA repair processes and generate ROS in the liver and spleen as metabolic products. Arsenic can bind DNA-binding proteins and disrupt the DNA repair processes thereby increasing the risk of carcinogenesis. For example, the tumor suppressor gene-coded DNA was suppressed when arsenic was bound to methyl-transferase. Also, cancers of the liver, skin, prostate, and Kupffer cell were associated with Arsenic poisoning. Heavy metals, for example, lead, mercury, arsenic, and cadmium have caused significant worry as identified with human medical issues throughout the years.

Worries over such episodes have sprung various examinations concerning the digestion and harmful impacts of these four components. Throughout the years, doctors became expanding acquainted with the manifestations of mental harm emerging in occupation uncovered laborers and in singular instances of harming.

There have been measures to assign heavy metals dependent on nuclear number, harmfulness, and different elements; in any case, the use of the term is focused on certain metallic components that have sway on

people, conditions, fauna, and vegetation. As far as intricate heavy metals incorporate thallium, copper, silver, zinc, nickel, manganese, chromium, selenium, cadmium, mercury, lead, and arsenic bars the Lanthanides and Actinides. A portion of the components assume a crucial job in metabolic capacities; nonetheless, they can deliver antagonistic impacts whenever ingested at adequately high focuses.

Heavy metals are generally ingested through sullied nourishment, water, or the inward breath of tobacco smoke (ATSDR, 2003). Significant wellsprings of dietary cadmium are fish, grains verdant vegetables, potatoes, and other root vegetables. It is relevant to express that heavy metal refining, manures refining (ATSDR, 2003, Bhattacharya et al, 2000; Jarup et al, 1998; Liu et al, 2000).

2.2: Lead, Mercury and Arsenic

According to Alina, Azrina, & Mohd (2012), the **term heavy metal** refers to “any metallic chemical element that has a relatively high density and is toxic or poisonous at low concentrations” Examples of heavy metals include mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), thallium (Tl), and lead (Pb). Heavy metals are natural components of the Earth's crust. They cannot be degraded or destroyed. To a small extent, they enter our bodies via food, drinking water, and air. As trace elements, some heavy metals

(e.g. copper, selenium, zinc) are essential to maintain the metabolism of the human body. However, at higher concentrations, they can lead to poisoning. Heavy metal poisoning could result, for instance, from drinking-water contamination (e.g. lead pipes), high ambient air concentrations near emission sources, or intake via the food chain. Heavy metals enter into the environment by natural and anthropogenic means. Such sources include natural weathering of the earth's crust, mining, soil erosion, industrial discharge, urban runoff, sewage effluents, pest or disease control agents applied to plants, air pollution fallout, and several others (Morais, 2012). Although some individuals are primarily exposed to these contaminants in the workplace, for most people the main route of exposure to these toxic elements is through the diet (food and water). The contamination chain of heavy metals almost always follows a cyclic order: industry, atmosphere, soil, water, foods, and humans (Matta, 2015).

The most commonly found heavy metals in wastewater include arsenic, cadmium, chromium, copper, lead, nickel, and zinc, all of which cause risks for human health and the environment. On the other hand, however, deficiencies of essential heavy metals, such as zinc (Zn), copper (Cu), and manganese (Mn), and metalloids, such as selenium (Se) in agricultural soils are affecting agricultural productivity and

human health in many countries (Alloway, 2013). Neurotoxic effects of heavy metals are also well documented, especially for mercury and lead, with numerous reports of neurobehavioral changes after occupational exposure and of developmental effects in children with pre- or early postnatal exposure.

2.2.1 Lead

Lead (Pb) is an omnipresent lethal metal distinguishable basically in all periods of idle conditions and natural frameworks (Ghasemi, et al, 2013). Oduets (bind and pipes), ammo, and gadgets to shield X-beams leading to its introduction to the individuals working in these ventures. Utilization of lead in fuel, paints and earthenware items, caulking, and pipe bind has been drastically diminished as of late given well-being concerns. Ingestion of polluted nourishment and drinking water is the most widely recognized wellspring of lead presentation in people. Introduction can likewise happen using attentive ingestion of sullied soil/dustor lead-based paint. The most powerless populace to lead harming is youngsters, especially troopers, newborn children in neonatal periods, and the baby [Boucher, et al., 2012; Vallasca, et al., 2013]. A few audits and multi-created books on toxicology on lead are accessible (Artisan, 2014; Grandjean, 2014). It gets into water from the consumption of pipe materials. Lead harming (otherwise called

saturnism, plumbism, Devon colic, or painter's colic) is an ailment brought about by expanded degrees of lead in the blood (Heard, 2014).

2.2.2 Mercury

Mercury exists as metallic mercury, inorganic mercuric salt, and natural mercury. Metallic mercury is a fluid at room temperature. Mercury ties to chlorine, sulfur, or oxygen to shape inorganic mercurous (Hg^{1+}) or mercuric (Hg^{2+}) salts. The essential organometallic structures incorporate methylmercury (MeHg) and ethylmercury (ASTDR, 2010).

Mercury (Hg) happens in nature in a few physical and substance shapes, all of which can create harmful impacts in high portions. It is an exceptionally receptive and poisonous change component. Its zero oxidation state (Hg^0) exists as a fume or as fluid metal, its cationic mercurous state Hg^+ exists as inorganic salts, and its mercuric state Hg^{2+} may shape either inorganic salts or organomercury mixes. These three gatherings fluctuate in impact. The diverse concoction types of mercury incorporate essential mercury fume (Hg), inorganic mercurous (Hg II), mercuric (Hg III), and natural mercuric mixes (Hultberg, et al., 2001). These structures have harmful impacts on various organs, for example, the cerebrum, kidney, and lungs (Fitzgerald and Clarkson, 2000). Mercury harming can bring about a few sicknesses, including

acrodynia (pink disease), Itai Itai disease, and Minamata disease. Even though the particular instrument of activity of harm by mercury isn't known, it has been indicated that mercurous and mercuric ions bestow their toxicological impacts predominantly through subatomic communications by official to the thiol bunches present in various particles, for example, GSH, cysteine, and metallothionein (MT) (Zalups, 2000)

2.2.3 Arsenic

Arsenic is omnipresent on the earth, and human presentation can happen from heap regular and anthropogenic sources. Inorganic arsenic is a metalloid compound with known carcinogenic and noncancerous wellbeing impacts (Beth, et al., 2018). Arsenic is especially hard to portray as a solitary component since its science is so unpredictable and there is a wide range of arsenic mixes. It might be trivalent or pentavalent and is broadly appropriated in nature. The most widely recognized inorganic trivalent arsenic mixes are arsenic trioxide, sodium arsenite, and arsenic trichloride. Pentavalent inorganic mixes are arsenic pentoxide, arsenic corrosive, and arsenate, for example, lead arsenate and calcium arsenate. Natural mixes may likewise be trivalent or pentavalent, for example, arsenic corrosive, or may even happen in

methyated frames as a consequence of biomethylation by creatures in soil, new water, and seawater. The airborne arsenic is to a great extent trivalent arsenic oxide. Its testimony in aviation routes and retention from lungs are reliant on molecule size and synthetic structure (Hostynek, et al., 2000). It has been accounted for as a specialist, which may by implication actuate different cancer-causing agents dependable to create tumors in key organs of the body, for example, lungs, skin, liver, bladder, and kidney (Waalkes, et al., 2004; Puccetti, et al., 2004). After ingestion, inorganic arsenic quickly ties to hemoglobin in erythrocytes. Blood arsenic is redistributed rapidly (inside 24h) to the liver, kidneys, heart, and lungs and a lesser degree to the sensory system, GI tract, and spleen. Arsenic experiences hepatic bio-methylation to shape monomethyl arsenic and dimethyl arsenic acids that have generally lower danger (Guillaume, et al., 2004).

2.3 Sources of Exposure to Lead (Pb), Mercury (Hg) and Arsenic (As)

Heavy metals are well-known environmental pollutants due to their toxicity, persistence in the environment, and bioaccumulative nature. Their natural sources include weathering of metal-bearing rocks and volcanic eruptions, while anthropogenic sources include mining and

various industrial and agricultural activities. Heavy metal poisoning refers to when excessive exposure to a heavy metal affects the normal function of the body. Examples of heavy metals that can cause toxicity include lead, mercury, arsenic, cadmium, and chromium. Exposure may occur through the diet, medications, the environment, or in the course of work or play. Heavy metals can enter the body through the skin, or by inhalation or ingestion (Adal, 2016). Toxicity can result from sudden, severe exposure, or from chronic exposure over time. Symptoms can vary depending on the metal involved, the amount absorbed, and the age of the person exposed. For example, young children are more susceptible to the effects of lead exposure because they absorb more compared with adults and their brains are still developing. Nausea, vomiting, diarrhea, and abdominal pain are common symptoms of acute metal ingestion. Chronic exposure may cause various symptoms resulting from damage to body organs and may increase the risk of cancer. Treatment depends on the circumstances of the exposure.

2.3.1 Sources of Exposure to Lead

Lead is found at low levels in Earth's crust, primarily as lead sulfide (IARC, 2006) In any case, the far-reaching event of lead in nature is to a great extent the consequence of human action, for example, mining,

purifying, refining and casual reusing of lead; utilization of leaded oil (gas); generation of lead-corrosive batteries and paints; gems making, binding, earthenware production and leaded glass made in casual and house (locally situated) enterprises; electronic waste (UNEP, 2008); and use in water pipes and weld. Different wellsprings of lead in the earth incorporate common exercises, for example, volcanic movement, geochemical enduring and ocean shower discharges, and remobilization of noteworthy sources, for example, lead in soil, residue, and water from mining territories. As lead is a component, when it is discharged into the earth, it perseveres. As a result of lead's determination and potential for worldwide air transport, barometrical emanations influence even the most remote locales of the world (WHO, 2007).

2.3.1.1 Industrial processes

Lead is utilized chiefly in the generation of lead-corrosive batteries, plumbing materials, and composites. Different utilizes are in link sheathing, paints, coatings, and ammo (Fewtrell, et al., 2003). Human word-related introduction can likewise occur during the application and evacuation of defensive lead-containing paints, during the pounding, welding, and cutting of materials painted with lead-containing paints, for example, in shipbuilding, development, destruction ventures, and

creation of heavy lead glass and precious stone, and in gem cutting (IPCS, 2000). Mining, purifying, and casual preparing and reusing of electric and electronic waste can likewise be noteworthy wellsprings of introduction. Lead has been utilized generally as tetraethyl and tetramethyl lead as antiknock and greasing up specialists in oil, even though most lead is discharged from vehicles as inorganic particles. This utilization has been eliminated in many nations, which has brought about a huge decrease in human presentation and mean blood lead levels. In a couple of parts of the reality where leaded oil is still being used, in any case, it keeps on being a significant wellspring of presentation (Fewtrell, et al., 2003).

2.3.1.2 Food and Smoking

For the non-smoking inclusive community, the biggest commitment to the everyday admission of lead is gotten from the ingestion of nourishment, soil, and residue. The measure of lead in nourishment plants relies upon soil focuses and is most elevated around mines and smelters. Grains can contain significant levels of lead, and flavors might be tainted with lead. The utilization of lead-patched nourishment and refreshment jars (which is presently decreasing) may extensively build the lead substance of the nourishment or refreshment, particularly on

account of acidic food sources or beverages. As mixed beverages will in general be acidic, the utilization of any lead-containing items in their production, appropriation, or capacity will raise lead levels. Movement of lead into nourishment from lead-coated earthenware or ceramics dinnerware is additionally a wellspring of presentation. Smoking tobacco expands lead consumption (IPCS, 2000).

2.3.1.3 Drinking-water

Lead present in faucet water is once in a while the consequence of its disintegration from normal sources however is basically because of family plumbing frameworks containing lead funnels, fastens, and fittings. Water that has been in contact with lead along these lines for an all-encompassing period (for example medium-term) will have a higher focus. In this way, lead fixations can fluctuate throughout the day, and flushing the taps before use is a control instrument. Delicate acidic water breaks down the most lead (WHO, 2003).

2.3.1.4 Domestic sources

Polluted residue might be the primary wellspring of introduction for newborn children in nations that never again utilize leaded oil. The enduring, stripping or chipping of lead-based paints, for the most part, found in more established houses, assumes a job in youngsters'

presentation, particularly as some little youngsters eat the pieces or lick dust-loaded fingers. Lead-containing residue might be brought into the home on the garments of the individuals who work in ventures where such residue is produced. Some toys either are produced using lead or contain lead (for example a few plastics or paints) (WHO, 2007). Some conventional drugs and cosmetics (for example kohl) contain lead (IPCS, 2000).

2.3.2 Sources of Exposure to Mercury

Mercury is profoundly poisonous to human well-being, representing a specific danger to the advancement of the kid in utero and from the get-go throughout everyday life. It happens normally and exists in different structures: natural (or metallic); inorganic (for example mercuric chloride); and natural (e.g., methyl-and ethylmercury). These structures all have various toxicities and suggestions for well-being and for measures to avoid introduction (IPCS, 2000). Natural mercury is a fluid that disintegrates promptly. It can remain for as long as a year in the environment, where it very well may be shipped and saved all around. It eventually settles in the silt of lakes, streams, or narrows where it is changed into methylmercury, consumed by phytoplankton, ingested by

zooplankton and fish, and gathers particularly in extensive ruthless species, for example, shark and swordfish (WHO, 2007).

2.3.2.1 Industrial Processes

A large portion of the mercury in the earth results from human action, especially from coal-terminated control stations, private warming frameworks, and waste incinerators. Mercury is additionally present because of digging for mercury, gold (where mercury is utilized to shape an amalgam before being scorched off), and different metals, for example, copper, zinc, and silver, just as from refining tasks (WHO, 2007).

2.3.2.2 Food

Eating tainted fish and shellfish is the primary wellspring of methylmercury introduction, particularly in populaces that depend intensely on the utilization of ruthless fish. Cooking doesn't dispense with mercury from fish. WHO is setting up a direction archive for chance directors that will utilize national presentation appraisals to decide the suitable hazard the executives choose, remembering the nourishing advantages of fish utilization (WHO, 2007).

2.3.3 Sources of Exposure to Arsenic

- Arsenic is broadly circulated all through Earth's hull, for the most part as arsenic sulfide or as metal arsenates and arsenides. It very well may be discharged to the environment, basically as trioxide, for the most part in high-temperature forms (WHO, 2010). In the air, it is principally adsorbed on particles, which are scattered by winds and stored ashore and water. Arsenic can be discharged into the air and water in the following manners (WHO, 2010):
 - Natural exercises, for example, volcanic movement, the disintegration of minerals (especially into groundwater), exudates from vegetation, and wind-blown cleans;
 - Human exercises, for example, mining, metal purifying, ignition of petroleum derivatives, horticultural pesticide creation and use, and timber treatment with additives;
 - Remobilization of notable sources, for example, mine seepage water;
 - Activation into drinking water from geographical stores by boring cylinder wells.

2.3.3.1 Drinking-water

Represents the best risk to general well-being from arsenic. Inorganic arsenic is normally present at significant levels in the groundwater of various nations, for example, Argentina, Chile, China, India (West Bengal), Mexico, the US of America, and especially Bangladesh where around half of the all-out populace is in danger of drinking arsenic-sullied water from tube wells (Lokuge, et al., 2004). In one gauge, utilization of arsenic-sullied savoring water in Bangladesh came about in around 9100 passings and 125,000 handicap-balanced life years (DALYs) in 2001; (Lokuge, et al., 2004).

2.3.3.2 Industrial processes

Most arsenic in modern forms is utilized to deliver antifungal wood additives, which can lead to soil defilement (IPCS, 2002). It is additionally utilized in the pharmaceutical and glass enterprises, in the assembling of amalgams, sheep plunges, calfskin additives, arsenic-containing shades, antifouling paints, and toxin traps, and, to a decreasing degree, in the creation of agrochemicals (particularly for use in plantations and vineyards). Arsenic mixes are additionally utilized in restricted sums in microelectronics and optical enterprises. High arsenic levels in the air can be found in the workplace just as the general

condition around non-ferrous metal smelters, where arsenic trioxide might be shaped, and some coal terminated control plants (particularly those utilizing poor quality darker coal) IPCS (2002).

2.3.3.3 Smoking

The presentation of smokers to arsenic emerges from the characteristic inorganic arsenic substance of tobacco. This substance is expanded where tobacco plants have been treated with lead arsenate bug spray. Smelter laborers, who have a raised danger of creating lung malignancy because of arsenic presentation, further increase their hazard by smoking (WHO, 2000).

2.3.3.4 Food

In regions where arsenic isn't normally present at elevated levels, nourishment generally contributes most to the day-by-day admission of arsenic. Fish, shellfish, meat, poultry, dairy items, and oats are the fundamental wellsprings of dietary admission. In any case, the arsenic substance of fish and shellfish for the most part includes natural mixes (for example arsenobetaine) that are of low poisonous quality (IPCS, 2001). In regions where arsenic is normally present at significant levels, nourishment (for example rice) arranged with high-arsenic water and

nourishment crops inundated with polluted water additionally add up to everyday consumption (WHO, 2010).

2.4. Other Elements Found in Electronic Products

2.4.1 Beryllium

Beryllium is a well-being and security issue for laborers. Presentation of beryllium in the working environment can lead to a sharpening invulnerable reaction and can after some time create a ceaseless beryllium malady (CBD); CDC (2017) The National Organization for Word related Wellbeing and Wellbeing (NIOSH) in the US about these impacts as a team with a significant maker of beryllium items. The objective of this examination is to avoid sharpening and CBD by building up a superior comprehension of the work procedures and exposures that may show a potential hazard for laborers and to create powerful mediations that will decrease the hazard for antagonistic well-being impacts. NIOSH likewise directs hereditary research on sharpening and CBD, freely of this joint effort (CDC, 2017) The NIOSH Manual of Scientific Techniques contains strategies for estimating word-related exposures to beryllium (CDC, 2003).

Most revealed instances of beryllium exposures are identified with laborers associated with handling and assembling exercises, presentation

may likewise happen during the reusing of electrical and electronic hardware containing beryllium copper amalgams. Beryllium cleans might be created during destroying and crushing, or during high-temperature procedures, for example, those utilized at metal treatment facilities (Badel 2004, OECD 2003), which can lead to beryllium sensitivity and CDB in laborers (Newborn child and Newman 2004). Beryllium is both intensely and constantly dangerous to people, for the most part influencing the lungs. Breathing high centralizations of beryllium tidies or exhaust can bring about intense beryllium infection (ABD), with a scope of impacts including brevity of breath, hacking, chest torment, quick pulse, and demise in outrageous cases. Around 30% of ABD sufferers will in the long run create incessant beryllium illness (CBD) otherwise called berylliosis. Presentation to beryllium even at low levels and for brief timeframes, can lead to beryllium sharpening. A few people will proceed to create CBD, an incapacitating ailment with side effects including emphysema and fibrosis of the lungs that can now and again be lethal. Even though side effects can be stifled with steroids, CBD is right now hopeless (2001).

Roughly 35 micrograms of beryllium are found in the normal human body, a sum not thought about as destructive (Emsley, 2001). Beryllium is synthetically like magnesium and thus can dislodge it from proteins,

which makes them break down (Emsley, 2001). Since Be^{2+} is an exceptionally charged and little particle, it can undoubtedly get into numerous tissues and cells, where it explicitly targets cell cores, hindering numerous catalysts, including those utilized for integrating DNA. Its danger is exacerbated by the way that the body has no way to control beryllium levels, and once inside the body, the beryllium can't be expelled (Venugopal, 2013).

2.4.2 Cadmium

Cadmium is utilized in the production of capacity batteries, colors, adornments, electroplated materials, and neutron safeguards in atomic power plants.' Word-related presentation to cadmium can happen during its extraction and purifying or in the fabrication and utilization of materials containing the metal (NAS, 2000). Since cadmium and lead much of the time happen in a similar mineral body and have numerous comparable uses in industry, introduction to cadmium is habitually joined by lead presentation. Cadmium happens normally in minerals together with zinc, lead, and copper. Cadmium mixes are utilized as stabilizers in PVC items, shading color, a few amalgams, and, presently most ordinarily, in rechargeable nickel-cadmium batteries. Metallic cadmium has for the most part been utilized as an anticorrosion

operator. Cadmium and its mixes are utilized in various applications inside hardware items. Cadmium is utilized in certain contacts and switches, and numerous smartphones battery-powered Nickle-Cadmium (Ni-Compact disc) batteries. Cadmium mixes have additionally been utilized as stabilizers inside PVC plans, for example, those utilized for wire protection. Cadmium sulfide has been likewise utilized in more established cathode beam tubes (CRTs) as a phosphor covering, a material utilized on the inside surface of the screen to create light (OECD 2003).

Cadmium is likewise present as a toxin in phosphate manures. EU cadmium utilization has diminished significantly during the 1990s, fundamentally because of the progressive elimination of cadmium items other than Ni-Compact disc batteries and the usage of increasingly stringent EU environmental enactment (Mandate 91/338/ECC). Despite these decreases in Europe, cadmium generation, utilization, and discharges to the earth worldwide have expanded drastically during the twentieth century. Cadmium-containing items are seldom recycled, yet now and again dumped together with family unit squander, in this way debasing nature, particularly if the waste is burned. Regular just as anthropogenic wellsprings of cadmium, including mechanical discharges and the utilization of manure and sewage muck to cultivate land, may

lead to sully of soils, and expanded cadmium take-up by yields and vegetables, developed for human utilization. The take-up procedure of soil cadmium by plants is improved at low pH (Jarup, et al., 2003). Cigarette smoking is a significant wellspring of cadmium introduction. Natural observing of cadmium in the overall public has indicated that cigarette smoking may cause critical increments in blood cadmium (B-Compact disc) levels, the fixations in smokers being by and large (Hossn, et al., 2001) times higher than those in non-smokers (Jarup, et al., 2003). Despite proof of introduction from environmental tobacco smoke (Hossn, et al., 2001), in any case, this is likely contributing little to add up to cadmium body trouble. Nourishment is the most significant wellspring of cadmium introduction in the general non-smoking populace in many nations (WHO, 2000). Cadmium is available in many staples, however fixations shift significantly, and singular admission additionally changes impressively because of contrasts in dietary propensities (Hossn, et al., 2001).

2.4.3 References values / acceptable limits of Heavy Metals

Current metal exposures vary considerably, and excessive exposures are almost without exception due to anthropogenic sources. Metals that were rare in the unpolluted biosphere are now extracted from underground ores. The resulting dissemination causes exposure of

workers, consumers, and ecosystems. In some cases, human activities have resulted in metal pollution on a global scale. Furthermore, local conditions or dietary habits may add to geographical differences in metal exposure. Such variations will influence the metal levels in body fluids and tissues. Changes are minimized by regulatory, biochemical mechanisms operating for essential metals, while the absence of such mechanisms will allow metals to exhibit profound variations in body compartments. In addition, physiological factors, such as kidney function, may influence the retention time for metals in the body.

2.5 Health Effects of Lead, Mercury and Arsenic

2.5.1 Health Effects of Lead

- It has been estimated that lead exposure was responsible, in 2004, for 143 000 deaths and 0.6% of the global burden of disease (expressed in disability-adjusted life years, or DALYs), taking into account mild mental retardation and cardiovascular outcomes resulting from exposure to lead (WHO, 2009).
- Lead in the body is distributed to the brain, liver, kidney, and bones. It is stored in the teeth and bones, where it accumulates over time. Human exposure can be assessed directly through

measurement of lead in blood, teeth, or bones (bone and tooth lead reflect cumulative exposure)(WHO, 2004).

2.5.1.1 Acute Effects

Lead is classically a chronic or cumulative toxin; hence, acute adverse effects are usually observed only following short-term exposures to high concentrations. Acute exposures to lead may cause gastrointestinal disturbances (anorexia, nausea, vomiting, abdominal pain), hepatic and renal damage, hypertension, and neurological effects (malaise, drowsiness, and encephalopathy) that may lead to convulsions and death (IPCS, 2000).

2.5.1.2 Effects following chronic exposure

- Chronic lead exposure commonly causes hematological effects, such as anaemia, or neurological disturbances, including headache, irritability, lethargy, convulsions, muscle weakness, ataxia, tremors, and paralysis.⁹
- There is some evidence that long-term occupational exposure to lead may contribute to the development of cancer. The International Agency for Research on Cancer (IARC) has classified inorganic lead compounds as probably carcinogenic to humans

2.5.2 Health Effects of Mercury

- Elemental and methylmercury are toxic to the central and peripheral nervous system. The inhalation of mercury vapor can produce harmful effects on the nervous, digestive, and immune systems, lungs, and kidneys, and may be fatal. The inorganic salts of mercury are corrosive to the skin, eyes, and gastrointestinal tract, and may induce kidney toxicity if ingested (WHO, 2007 cited IPCS, 1991).
- Neurological and behavioral disorders may be observed after inhalation, ingestion, or dermal application of different mercury compounds. Symptoms include tremors, insomnia, memory loss, neuromuscular effects, headaches, and cognitive and motor dysfunction. Mild subclinical signs of central nervous system toxicity can be seen in workers exposed to an elemental mercury level in the air of $20\mu\text{g}/\text{m}^3$ or more for several years. Kidney and immune effects have been reported. There is no conclusive evidence linking mercury exposure to cancer in humans (WHO, 2007).
- Biological measurement of mercury, for example in hair and blood, allows exposure to be quantified and linked to possible health effects. It also permits estimates of the burden of disease

(BoD). WHO is applying its BoD framework approach to better quantify the health impacts (WHO, 2007).

2.5.3 Health Effects of Arsenic

Arsenic is relatively unique compared with other hazardous chemicals in that the majority of evidence of adverse health effects is derived from studies of human populations rather than animal studies. Widespread exposure to contaminated drinking water has generated a significant body of epidemiological literature linking chronic ingestion of Arsenic to both cancer and non-cancer health effects. Arsenic is well-established as a cause of cancer of the lung, bladder, and skin (IARC, 2012). There is less evidence of an association with other cancers, such as prostate, kidney, and liver. Non-cancer health effects of arsenic exposure have been described for numerous organ systems, including the respiratory, cardiovascular, hematological, gastrointestinal, immune, dermal, reproductive, and endocrine systems as well as the central and peripheral nervous system (WHO, 2010),

2.6 Symptoms of Lead, Mercury, and Arsenic poisoning

Heavy metal poisoning is caused by the accumulation of certain metals in the body due to exposure to food, water, industrial chemicals, or other sources. Symptoms of heavy metal poisoning depend on the type of

metal causing toxicity, and the duration of symptoms due to heavy metal poisoning varies depending on which type of metal you were exposed to. With arsenic and lead exposure, for example, symptoms may not show up for two to eight weeks, notes the National Organization for Rare Disorders. With cadmium poisoning, however, symptoms may arise hours after you're exposed. True heavy metal poisoning is rare, and it can be difficult to diagnose since many of the symptoms can be the same as other health problems, according to Oregon Public Health

2.6.1 Symptoms of Lead Poisoning

This includes; Constipation, nausea, memory and concentration problems, metallic taste in the mouth, fatigue, headaches, weight loss, stomach pain, and irritability.

2.6.2 Mercury poisoning symptoms

Adults with advanced mercury poisoning might experience; hearing and speech difficulties, lack of coordination, muscle weakness, nerve loss in hands and face, trouble walking, and vision changes

2.7 Toxicity and Toxicokinetics of Lead, Mercury & Arsenic

Toxicity, especially in environmental contexts. The term has particular application to cadmium, mercury, and lead, all of which appear in the

World Health Organization's list of 10 chemicals of major public concern

Metal toxicity or metal poisoning is the toxic effect of certain metals in certain forms. A toxic heavy metal is any relatively dense metal or metalloid that is noted for its potential and doses on life. Some metals are toxic when they form poisonous soluble compounds. Certain metals have no biological role, i.e. are not essential minerals, or are toxic when in a certain form.

2.7.1 Toxicity and Toxicokinetics of Lead

Human lead exposure occurs as the result of gastrointestinal absorption or pulmonary absorption, with ingestion being the most significant route of exposure. The bioavailability of the lead is dependent on the form of lead (i.e., inorganic, organic, or metallic), quantity ingested, age of the individual, and current dietary status. A diet high in calcium inhibits the binding of lead absorption through the intestinal binding sites. A calcium deficiency activates vitamin D and calbindin-D, a calcium-binding protein in the intestines enhancing the absorption of calcium. However, if calcium is not available in a sufficient quantity, lead and other trace metals will be absorbed in place of the calcium. Adults absorb approximately 15% of ingested lead; while children and pregnant

women absorb nearly 50% of ingested lead (Wigle, 2003). Pulmonary lead exposure is mainly a concern for occupational exposure (Lauwerys&Hoet, 2001). The health effects of lead are the same regardless of the route of exposure (ASTDR, 2019).

After absorption, 99% of the lead is bound to the hemoglobin portion of erythrocytes and is circulated via the vascular system to soft tissues (liver and kidney), bone, and hair. Lead has a half-life in the blood of approximately 30 days, consistent with the half-life of an RBC. As such, BLL indicates relatively recent lead exposure (American Academy of Pediatrics Committee on Environmental Health, 2005). During systemic circulation, lead interrupts the heme biosynthesis pathway primarily through inhibition of δ -amino levulinic acid, an effect observed when BLL exceeds 5 $\mu\text{g}/\text{dL}$ (Wigle, 2003).

2.7.2 Toxicity and Toxicokinetics of Mercury

The risk of mercury toxicity depends very much on the form of mercury and the route of exposure. Metallic mercury exposure can occur by inhalation of mercury vapor. Mercury vapor in the atmosphere is typically low and not considered a major route of exposure (Lauwerys&Hoet, 2001; ASTDR, 2019). However, mercury vapor is a potential occupational exposure in gold mining where mercury is used to

form an amalgam with gold during its extraction, in dentistry for tooth restoration, and in the manufacture of scientific instruments and electrical control devices. Amalgam fillings can provide exposure to mercury vapor, and it is estimated that 10 amalgam surfaces would raise urinary mercury concentrations by 1 µg/L. typically; exposures to mercury in the oral cavity have been considered relatively low enough to not warrant concern. However, during cases of excessive gum chewing in the presence of these amalgams, urine levels have been measured at more than 20 µg mercury per gram creatinine to approach occupational health safe limits (Clarkson, et al., 2003).

Mercury vapor can demonstrate substantial toxicity in this form as it easily penetrates the blood-brain and placental barriers to cause neurotoxicity, developmental toxicity, and at higher levels, mortality. Acute mercury poisoning occurs in 3 phases. In the first 1-3 days, flu-like symptoms appear, followed by severe pulmonary toxicity and then gingivostomatitis, tremors, memory loss, emotional lability, depression, insomnia, and shyness (Clarkson, 2002). Mercuric chloride (HgCl₂) is a potent nephrotoxin, altering renal glutathione levels, and increasing urinary albumin and β₂-microglobulin.

2.7.3 Toxicity and Toxicokinetics of Arsenic

Arsenic's toxicity depends largely on the valence state, solubility, and rate of absorption and elimination. The 3 major groups for arsenic include arsine gas (-3 oxidation state), inorganic, and organic forms. Arsine gas is the most toxic arsenic. Inorganic arsenic compounds that also have high toxic potential include arsenite (trivalent), arsenate (pentavalent), arsenic oxide, and gallium arsenide. Metabolites of inorganic arsenic compounds include methyl and phenyl derivatives of arsenic such as monomethyl arsenic acid (MMA) and dimethyl arsenic acid (DMA) and have moderate toxic potential. The methylated metabolites may arise from the environment or metabolism of inorganic arsenic (ASTDR, 2019). Arsenobetaine and arsenocholine are the most common organic forms, sometimes called “fish arsenic,” and are relatively nontoxic to humans. Ingestion of arsenic-containing foods and contaminated water is a primary route of exposure. Approximately 95% of an ingested dose of trivalent arsenic compounds is absorbed from the gastrointestinal tract (Rossman, 2007). In the workplace, inhalation of arsenic trioxide is a common form of airborne arsenic. It is estimated that 60%-90% of inhaled arsenic trioxide is absorbed through the lung. Following absorption, arsenic is taken up by RBCs and WBCs, leading to hematological changes such as macrocytic anemia, elevated

eosinophils, and basophilic stippling of RBCs. When arsenic is transported to the liver, pentavalent arsenic undergoes reduction by glutathione to trivalent arsenic. With the aid of methyltransferases, trivalent arsenic is methylated to form MMA and DMA, which are eliminated in urine (Baselt, 2004; Lauwerys&Hoet, 2001) Hepatotoxicity may occur during this process.

2.8 Safety Precaution of Lead, Mercury & Arsenic in a Work Environment

- **Training:** Students and employees who handle heavy metals must have read the Material Safety Data Sheet (MSDS) and receive training on the hazards of mercury from their respective departments. They must know what to do in the event of a spill or an exposure incident.
- **Eye Protection:** Chemical goggles or a face shield **MUST** be worn when handling heavy metals. Safety glasses are sufficient when handling solid mercury-containing organic/inorganic compounds or materials.
- **Gloves:** Always consult the manufacturer's glove selection guide when selecting gloves for working with heavy metals.

- Protection Clothing: A lab coat (full sleeves) along with full-length pants and close-toed shoes MUST be worn when handling heavy metals.
- Respiratory Protection: Lab personnel intending to use/wear a respirator mask must be trained and fit-tested by EHS.
- Ventilation: Ensure that your working environment is well-ventilated. i.e. there is an in-flow and out-flow of air. All operations involving open sources of liquid mercury or any mercury-containing organic/inorganic compounds must be carried out in a certified chemical fume hood.
- Absolutely no eating, drinking, or chewing gum where heavy metals are used.

2.9 Heavy Metal Blood Test

A heavy metal blood test is a group of tests that measure the levels of potentially harmful metals in the blood. The most common metals tested for are lead, mercury, arsenic, and cadmium. Metals that are less commonly tested for include copper, zinc, aluminum, and thallium. Heavy metals are found naturally in the environment, certain foods, medicines, and even in water (National Institutes of Health, 2018).

Heavy metals can get into your system in different ways. You might breathe them in, eat them, or absorb them through your skin. If too much metal gets into your body, it can cause heavy metal poisoning. Heavy metal poisoning can lead to serious health problems. These include organ damage, behavioral changes, and difficulties with thinking and memory. The specific symptoms and how it will affect you depend on the type of metal and how much of it is in your system. <https://medlineplus.gov/lab-tests/heavy-metal-blood-test/>; Accessed 1st of September, 2019.

2.10 Empirical Studies

Reference Levels of Heavy Metals in the Blood

According to Venkatesh *et al* (2000), reference values are proposed for the concentrations of As, Cd, Hg, and Pb in whole blood, and blood serum from adult human subjects was considered. Though by definition, reference values reflect the findings in a well-defined group of individuals, further it is expected that reference values are a reflection of natural concentrations. It is also recognized that e.g. age, sex, living environment, and diet influence the concentration of certain trace elements. In some cases, even habits such as smoking tobacco and

consuming alcohol should be considered. It was reported that in the whole blood and serum, the values are:

Table 2.2: Heavy Metal Concentration in Blood and Serum

Heavy metals	Whole Blood	Serum
	$\mu\text{g/L}$	$\mu\text{g/L}$
AS	2–23	1.7 – 15.4
Cd	0.3 – 7.0	B
Hg	0.6 – 59	2.2 - 5.8
Pb	8 – 269	b less than 1

The concentration of Pb in blood serum is less than $1\mu\text{g/L}$. The median Pb content in whole blood from women is $100\mu\text{g/L}$ and for men, it is $136\mu\text{g/L}$. A substantial part of this sex-related difference is explained by the difference in hematocrit and by the generally higher food intake by males. Also, exposure to the working environment considerably influences the amount of Pb in blood.

AS, Cd, and Hg occur at $\mu\text{g/kg}$ or $\mu\text{g/L}$ concentrations in most tissues and body fluids. Therefore, their determination in most clinical specimens presents a considerable challenge.

Concentrations of As are influenced by regional differences and are subject to short-term effects of intake (Heydon, K (2000). Because Cd is

almost totally bound to RBC, serum is generally not a preferred specimen to analyze for Cd. The Cd concentration in serum is low (about 0.1µg/L for non-smokers). The median Cd in whole blood for smokers is 1.7µg/L.

The dietary intake of Hg is reflected in whole blood rather than in serum because Hg readily binds to R.B.C. Thus, in populations consuming large quantities of fish and other seafood, it may be as high as 9-34µg/kg. It may also be as low as 1µg/L depending on the exposure.

According to Wilhelm *et al* 2006, reference values for various metals in the urine of German children include;

Arsenic (Ar) -----15µg/l (0.015mg/l)

Cadmium (Cd) -----0.5µg/l (0.005mg/l)

Mercury (Hg) -----1.0µg/l (0.01mg/l)

Lead (Pb) -----50µg/l (0.050mg/l)

In another study by Wilhelm *et al* in the year 2004, reference values for adults around the same country are;

Ar-----15µg/L (0.015mg/l)

Cd-----1µg/L (0.01mg/l)

Hg-----2.0µg/L (0.02mg/l)

Pb -----70µg/L (0.070mg/l) for females,

90µg/L (0.090mg/l) for males

CHAPTER THREE

MATERIALS AND METHODS

3.1 Research Design

The study used an experimental research design in collecting data from the respondents on the level of heavy metals (particularly lead, mercury and arsenic) in blood of electronic technicians in Port Harcourt Metropolis, Rivers State.

The experimental research design is preferred because the research work requires laboratory analysis of the samples collected, making sure that there is minimum bias in the collection of data.

3.2 Area of Study

The area of study is Port Harcourt Metropolis (Illabuchi area) considering the number of samples required. And more concentration is at Illabuchi area, where we have more than 90 percent technicians in Port Harcourt.

3.2.1 Study Location

This research is carried out in Port Harcourt (Metropolis), Rivers State. Port Harcourt (Ikwerre: *Igwuocha*; Pidgin: *Po-ta-kot*) also called Pitakwa is the capital and largest city of Rivers State, Nigeria. It lies along the Bonny River and is located in the Niger Delta. It is located at

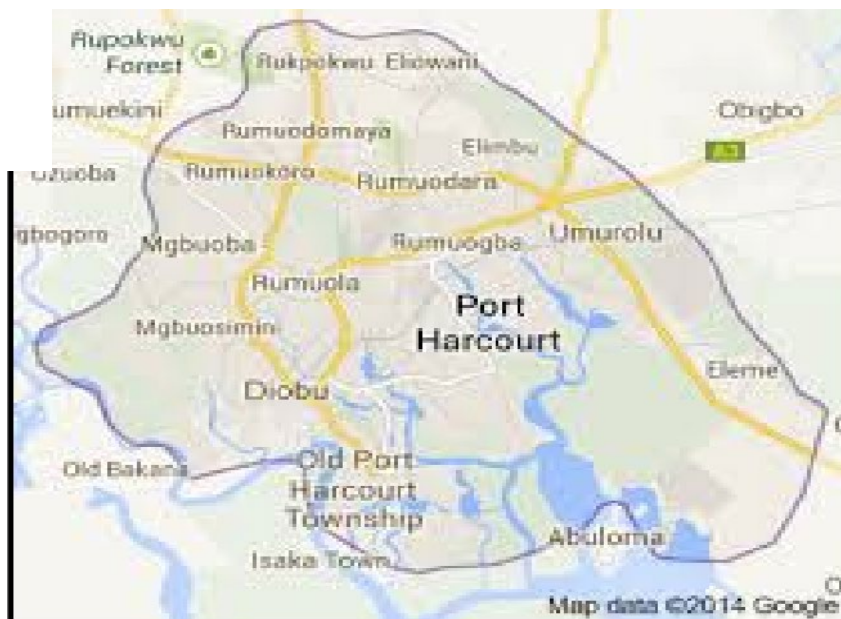
the Latitude of 4° 46' 38.71" N and Longitude of 7° 00' 48.24" E. As of 2016, the Port Harcourt urban area has an estimated population of 1,865,000 inhabitants, up from 1,382,592 as of 2006. There are a number of institutions of tertiary education in Port Harcourt, mostly government-owned. These institutions include, Rivers State University, University of Port Harcourt, Kenule Beson Saro Wiwa Polytechnic, Captain Elechi Amadi Polytechnic, Ignatius Ajuru University and Rivers State College of Health Science and Management Technology. The urban area (Port Harcourt metropolis), on the other hand, is made up of the local government area itself and parts of Obio-Akpor and Eleme accordingly. It is bounded to the south by Okrika, to the east by Eleme, to the north by Obio-Akpor and to the west by Degema. Port Harcourt, which is the current capital of Rivers State, is highly congested as it is the only major city of the state. Port Harcourt is a major industrial centre as it has a large number of multinational firms as well as other industrial concerns, particularly business related to the petroleum industry. It is the chief oil-refining city in Nigeria.

A considerable percentage of the populations are civil servants while some engage in trading as their main occupation. There are several primary and secondary schools both public and private. They

also have police stations, several denominational churches, mosques.

Port Harcourt metropolis speaks English Language generally.

Port Harcourt is one the fastest growing cities in Nigeria witnessing high influx of migrants seeking economic prosperity in the oil and gas companies . The electronics business has taken a stride over the market with the huge demand for electronics goods in the city of Port harcourt precisely Iloabuchi area in the Port Harcourt Metroplis. It is noted that the people of Port Harcourt metropolis which is the case study heavily rely on electronic goods for every other activity they do in general. In a busy lifestyle, everyone finds it much easier to take assistance from electronic gadgets.



Source: (<https://en.wikipedia.org/wiki/portharcourt>)

Figure 3.1: Map of Port Harcourt Metropolis

3.2.2: Study Occupation

Electronics technician repairs business or household electronic products such as televisions, computers or radios. Also, electronics technicians work with engineers and help develop electronic systems, components, or products. For example, the work that electronic technicians do might involve using computer design techniques to create models so products can be analyzed for flaws dangerous for consumers. An electronics technician also does safety checks to make sure design plans are workable under various types of conditions.

3.3: Study Population

The study population is about 50 registered technicians out of the 350 persons found at illoabuchi area of Port harcourt, and we have mainly males, as the profession is dominated by only men.

3.4 :Sample Size And Sampling Methods

A sample size of 44 persons was gotten using the modified Cochran formula on the population of 50 but only 40 volunteers was obtained from the total population while 4 declined.

The formula is shown below : $n =$

where n = New adjusted sample size. But,

A random sampling technique was used where all technicians were given equal opportunity to be selected who accepted and allowed their blood samples to be collected and out of the 44 only 40 technicians were sampled and this sampling was done at Illabuchi area where the population of Electronic technicians are localized with over 90 percent of individuals involved in this profession.

3.5: Method of Data /Sample Collection

-5mls needle and syringe was used to collect venous blood through venous puncture from all electronic technicians that volunteered to be sampled. Blood samples were collected from individual subjects with the use of a 5ml syringe into EDTA bottles.

Questions of years of working experience, age, marital status and what type of PPE used was asked during the interfacing with the respondents using the interview and observation methods of collecting data.

3.5.1 : Laboratory Analysis

3.5.1.1 ; The Apparatus includes; 250ml Analysis Beaker as Digestion vessel Hot plate or heating mantle Pipette, 5ml and 10ml Pasteur pipettes, Graduated measuring cylinder (50ml/ 100ml - Graduated once Funnel, Beakers (50ml, 100ml), Watchman filter paper (0.2mm), Wash bottle

3.5.1.2 : The Reagents are: Distilled water of ASTM, graded/quality Concentrated Perchloric Acid $HClO_4$ (Analytical grade) Concentrated Nitric Acid ($HN03$ - Analytical grade)

3.5.1.3 :Laboratory Procedure

Allow the Ice chest blood samples to acclimatize to ambient temperature, Measure (1-2ml) of the Blood sample into the digestion vessels .Then 6ml of concentrated Nitric Acid was added with 2ml of concentrated Perchloric Acid. Mix the solution with 20ml of Distilled water. Allow them to repercurate for half an hour before taken to the hot plate for the digestion is complete. This can be noticed in the pale-clear yellow colour of the solution, and has been reduced to one third of its original volume.

Transfer the Beaker from the hot plate and allow it to cool down for some minutes , then filter them through the watchman filter paper of 0.2mm that had been inserted into the funnel. Use the distilled water to rinse the digestion vessel into the measuring cylinder through the filter paper in the funnel with the aid of wash bottle. Make the filtrate in the measuring cylinder to mark with the distilled water, Keep the aliquot for aspiration with Flame Atomic Absorption Spectrometer (AAS) in the 50ml plastic bottle with cellophane cap. culled from ASTM 2011 Edition

3.5.1.4 :Atomic Absorption Spectrophotometry Analysis Procedure.

The Solar ThermoElemental AAS Model SE-71906 used in determining the content of heavy metals in the Acid digested samples. The Acetylene/ nitrous oxide gas and compressor or car pump was fixed and the compressor turned on, and the liquid trap blown to get rid of any liquid trapped. The Extractor and the SolarThermo Elemental AAS power was turned on, the capillary tube and nebulizer block were cleaned with cleansing wire and opening of the burner that is deemed with an alignment card. The worksheet of the *AAS* software attached to the computer was opened and the hollow cathode lamps were inserted in the lamp holder. The lamp was turned on; ray from cathode aligned to hit the target area of the alignment card for optimal light throughput, the machine was ignited and the capillary was placed in a 10ml graduated cylinder containing deionized water and aspiration rate measured, this was set to 4ml per minute. The analytical blank was prepared, and 3 series of calibration solutions of known amounts of analyte element (standards) were made. The blank and standards were atomized and turned into the nebulizer and mist and their responses measured. A calibration graph was plotted for each of the solutions, after which the sample solutions were atomized and measured. The various metal

concentrations from the samples were determined from the absorbance calibration in PP.

3.6: Data Analysis

The statistical technique includes:

- a) Descriptive statistics of mean \pm SD, coefficient of variance and standard error to validate the correctness of the work.
- b) A single factor Anova using F distribution is used to determine if there is significant difference in the level of exposure to the different metals. The values were expressed as mean \pm standard Error of the mean and the metal with the highest, least and intermediate concentration values was also determined. The individual students t-test was used to determine significant difference in the mean concentration of these metals. The anova was also used to determine the post hoc Multiple test for Heavy Metals in the exposed groups. This analysis was done with the use of Microsoft Excel 2007 and Statistical Package for Social Scientists (SPSS version 23).

3.7 : Ethical Clearance/Informed Consent.

The protocol and clearance for this study was received from the Rivers State Ministry of Health, and the individuals were met personally to inform them on the need and importance of the research.

An Oral informed consent was obtained from each subject used for this study, after deliberations with the members to be used for this work.

CHAPTER FOUR

Results

Table 1 Revealed that 28 of the subjects/respondents under study making about 70% of the total population are married, and about 12 of the subjects making about 30% of the total population are not married. Furthermore, the married population is greater than the unmarried population, meaning that more responsible people were sampled. The unmarried people could be apprentices or member of the family business who have also come to learn the trade.

Furthermore the table shows the sex of all the respondents in the study. The result revealed that all the respondents were male (100%) without any female in the study group. This implies that the work is predominantly a masculine occupation and not feminine.

Finally the it also shows the age distribution of the electronic technicians. The result shows that there are no technicians with ages 1 – 20 years. However, those with ages 21 – 40 years have about 17 representing 42.5% of the total number of respondents for those with ages 42 to 60, we also had 17 of them representing 42.5% also for those with ages 61 – 80 years, the value is 6 and representing 15% of the total population under study. This implies that 34 out of 40 technicians with ages beteen 21 and 60, dominated the work compared to 10 from ages 61 to 80.

Table 1 Socio-demographic Characteristics of Electronics Technicians

Status	Number	Percentage
MARITAL STATUS		
Married	28	70%
Single	12	30%
SEX		
Male	40	100%
Female	-	-
AGE		
1 – 20	-	-
21 – 40	17	42.5
41 – 60	17	42.5
61 – 80	6	15
81 – 100	-	-
	N = 40	N = 100

Source: Researcher's Field Survey, 2022

Table 2: shows the bioaccumulation levels of the heavy metals in blood of electronic technicians, for the various working years spent on electronic repairs and maintenance. The result shows that for those who worked for 1 to 10 years which represented 25% of the total sample under survey, the bio accumulation levels are 6.65 mg/L, 4.45mg/L, and 3.02mg/L for Pb, Hg and As.

For those who had worked for 11 to 20 years which has about 25% of the total population, the values are 12.41mg/L, 0.34mg/L and 1.60mg/L, the values for 21 to 30 years which represented 35% of the studied population, are 3.174mg/L, 0.374mg/L, and 1.604mg/L for Pb, Hg and As respectively. Also, for those who have worked for 41 to 50 years, representing 5% had values of 0.1224mg/L, 0.104mg/L, and 0.274mg/L for Pb, Hg, and As respectively. Finally for those who have worked for 51 to 60 years which represented 10% of the studied population the values are 0.244mg/L, 0.214mg/L, and 0.53 mg/L for Pb, Hg and As respectively.

Table 2: Bio-accumulation of Heavy Metals in the different Groups

Range for years of working experience	Frequency (f)	Percentage (%)	Amount Bio-accumulated (mg/L)		
			Pb	Hg	As
1 – 10	10	25	6.65	4.45	3.02
11 – 20	10	25	12.41	0.34	8.47
21 – 30	14	35	3.17	0.37	1.60
31 – 40	NIL	NIL	-	-	-
41 – 50	2	5	0.12	0.10	0.27
51 – 60	4	10	0.24	0.21	0.53
	N = 40	N = 100			

Source: Researcher's Field Survey, 2022

Table 3 Shows Mean \pm SEM, F and P values for Pb, Hg and As level in electronic technicians. The mean concentrations were 0.64218 ± 0.09245 ; 0.134505 ± 0.05766 and 0.399275 ± 0.107670 for Pb, Hg and As respectively. The result revealed that there was statistical significant difference in the mean concentration of these metals [$F(2, 117) = 8.243$, $P = 0.000$] in the blood of electronic technicians. The table also shows that we have Lead as the metal with highest concentration while Mercury has the least concentration in the body, Arsenic has the intermediate concentration of the metals.

Table 3. Anova Table Showing Levels of Metals in Electronic Technicians and The Metals with Highest and Least Concentrations in The Body

Metals	Mean \pm SEM	Concentration Levels
Pb	0.64218 \pm 0.09245	Highest
Hg	0.134505 \pm 0.05766	Least
As	0.399275 \pm 0.107670	Intermediate
F	8.243	
<i>P</i> -Value	0.000	
Remain	Significant	

Significant (at $P < 0,005$)

Table 4: The result depicted that the PPE's used were Nose Masks, Aprons and Handgloves / Goggles . furthermore, it was observed that all the age ranges studied did not make use of Nose Masks and Aprons. However 100 percent of ages 41 – 50 (2) and 51 – 60 (4) made use of only hand gloves/ goggles. This means that bio accumulation into venous blood could be through inhalation and dermal contact, rather than ingestion.

Table 4: Type of PPE (Personal Protective Equipment) Used

Range of years of working experience	Frequency (f)	Nose Masks		Aprons		Hand Gloves / Goggles	
		YES (%)	NO (%)	YES (%)	NO (%)	YES (%)	NO (%)
1 – 10	10	0	100	0	100	0	100
11 – 20	10	0	100	0	100	0	100
21 – 30	14	0	100	0	100	0	100
31 – 40	NIL	0	100	0	100	0	100
41 – 50	2	0	100	0	100	100	0
51 – 60	4	0	100	0	100	100	0
Total	N = 40						

Source: Researcher's Field Survey, 2022

Table 5 shows the multiple correlation between the years of exposure of pb is 0.461 while the coefficient of determination is 0.212 which is about 21.2% of the variation of pb in the blood of electronic workers. This can be explained by the number of years of exposure. The adjusted R-Square is 0.1913 with a standard error of 13.518. The result revealed that there was no correlation between the years of exposure with bioaccumulation of these metals since the coefficient is less than 5 with a P- value of 0.05. There is low or no significant correlation between bioaccumulation of lead and years of exposure . It revealed a negative correlation showing an inverse relationship. This means bioaccumulation is not a function of increase in exposure.

Table 5 Summary Output for Exposure to Pb

Regression Statistics

Multiple R	0.4605331
R Square	0.212090736
Adjusted R Square	0.191356282
Standard Error	13.51861539
<i>P</i> -Value	0.05
Observations	40

Source: Researcher's Field Survey, 2022

Table 6 also depicted that the multiple correlation between number of years exposed to the amount of Hg is 0.2623, and the coefficient of determination is 0.688 (6.88%) of the variation of Hg in the blood for the number of years exposed. The adjusted R-Square is 0.0443 and a standard error of about 14.696. The result revealed that there was no correlation between the years of exposure with bioaccumulation of these metals since the coefficient is less than 5 and a P value of 0.05. This low or no significant corelationship between bioaccumulation of lead and years of exposure. It revealed that negative corelationship showing an inverse relationship . This means bioaccumulation is not a function of increase in exposure.

Table 6. SUMMARY OUTPUT for exposure to Hg

<i>Regression Statistics</i>	
Multiple R	0.262330884
R Square	0.068817493
Adjusted R Square	0.04431269
Standard Error	14.69641859
<i>P</i> -Value	0.05
Observations	40

Source: Researcher's Field Survey, 2022

Table 7 shows that the correlation between number of years for exposure levels to As (Arsenic) is 0.2673 and the coefficient for determination is 0.0715 (7.15%) for the variation of Arsenic (As) in the blood of electronic technicians for the number of years exposed. The adjusted R-Square is 0.0470 with a standard error of about 14.675.

The result revealed that there was no correlation between the years of exposure with bioaccumulation of these metals since the coefficient is less than 5 and a P – value of 0.05. This low or no significant corelationship between bioaccumulation of lead and years of exposure was futher confimed. It revealed that negative corelationship showing an inverse relationship . This means bioaccumulation is not a function of increase in exposure.

Table 7: SUMMARY OUTPUT for Exposure to As

<i>Regression Statistics</i>	
Multiple R	0.26735698
R Square	0.07147975
Adjusted R Square	0.04704501
Standard Error	14.6753949
<i>P</i> -Value	0.05
Observations	40

Source: Researcher's Field Survey, 2022

CHAPTER FIVE

Discussion, Conclusion and Recommendations

5.1: Discussion

This work shows bioaccumulation of heavy metals in blood, identification of the mean total of heavy metals in the blood of electronic technicians, metals with highest and least concentrations in the blood of electronic technicians, comparisons of concentration between exposed and unexposed individuals, types of PPE used to indicate what method of exposure, correlation between the exposure rate and number of years of the different metals under study.

Blood is a body fluid in humans that circulate over the body and transport or distribute nutrients and other substances like oxygen, hormones, waste products etc., to the cells and organs (Elert G, 2012)..

The amount of heavy metal in the blood of Electronic Technician could be influenced by the degree or rate of exposure to these heavy metals either by inhalation, ingestion or injection by the recipient.

However, heavy metal has been proven to be a major threat to human health due to their ability to cause membrane and Deoxyribonucleic acid (DNA) – a molecule that carries genetic information for the development and functioning of an organ damage, and to perturb protein function and enzyme activity.

Electronic technicians are one of the groups of medium and small-scale enterprise (SMEs) that deals with repairs of faulty electronics, spanning from television (TV), radio, electric fans, home theater, blue-tooth, Air condition (AC) and other related appliances. Most of these group of skill professionals lacks occupational safety and personal hygiene since they do not go through formal education. Thus, they may have been inadvertently exposed to some of these heavy metals since most of the electronics components are made up of copper (Cu), lead (Pb), zinc (Zn), aluminum (Al), mercury (Hg), arsenic (As) and so many others. The degree of exposure could slightly be related to the amount of heavy metal present per unit area per unit time. This could enhance and promote bioaccumulation, bioavailability and bio-magnification if all other variables factors remain constant in the recipient serum. Furthermore, in the current study, out of forty respondents' twenty-eight 28(70%) were married and 12(30%) were unmarried. Again, the result indicated that all the respondents were male 40(100%). This simply reveals that Electronic Technician is a male dominated profession in this part of the country. The high percentage of married respondents could serve as a precursor that any negative impact due to heavy metal on the recipient could accentuate the economy life wire of the home of the Electronic Technician as most women are not independent.

Lead (Pb) is a toxic metal that is harmful to human health even at very low level. Authorities have averred that lead (Pb) is one of the persistent metals that can bioaccumulate in the body of human over time (WHO, 2021) (Alaye A.S, et al, 2022)

This study have been able to present the amount of the heavy metals that have Bio-accumulated in the blood of electronic technicians. It shows clearly that for technicians that have worked for a year to ten years. The amount of Pb, is higher than that of Hg which in turn is higher than that of and As and this shows that these technicians use more of Pb with increased bio-accumulation level in their system than Hg and As.

Also for the sampled population the accumulation for those with ages above 11years to 20 years in the job of repairing electronics we have more of Pb than As, which in turn is more than that of Hg . We have similar trends for those who have spent 21 – 30 years also having more values in lead than arsenic and mercury has the least value, also At age's 41 – 50 years, we have more of arsenic than lead and the least is mercury in the blood of the electronic technicians which validates the need for personal protective equipments as most of these persons used more of PPE's than the other groups under study. The same trend is seen in ages 51 – 60 for the various metals lead (Pb), mercury (Hg) and arsenic (As). On careful observation on the results presented above it

was noticed that the bio-accumulation level for those who had spent more years on the work had reduced levels of heavy metals as compared to those who had spent fewer years. This is as a result of the older generation taking more precautions than those who had spent fewer years.

Significantly the study shows that for Lead (Pb) the mean \pm SEM is about 0.64218 ± 0.09245 , for Mercury (Hg) we have 0.134505 ± 0.05766 and for Arsenic (As) 0.399275 ± 0.107670 with f value of 8.243 and *P* value of 0.000 which is significant at $P < 0.005$.

The mean values for the metals are above those compared with the values of vankatesh et al (2000) of the various metals.

Pb (0.008 – 0.0269mg/L) and Hg (0.0006– 0.0059mg/L) and As(0.002 – 0.023mg/L.)

The study also shows the type of heavy metal that has the highest values in the electronic technicians under survey, it shows that Lead (Pb) has the highest metal concentration with higher values than that of Arsenic (As) , while Mercury (Hg) has the least metal concentration.

The study further revealed that the values of Pb, Hg and As for individuals who were involved in this occupation were higher than

values presented by Wilhelm *et al* (2006) From the results also we could use the values to compare with reference figures for the levels of selected heavy metals in the blood of individuals within Port Harcourt Metropolis since these values are higher than reference values in other studies carried out on same metals, by CDC (2017) and Goulie *et al* (2015) and with standard reference values. Though as reported by other studies by Baranof (2015) that these metals have natural sources of entering our body and may have little bits of traces in our blood. Some may be found also in the form of hydroxides, oxides and sulphides, also some may be through anthropogenic processes..

It was also noted that the need for using PPE's at all times can not be overemphasised and the work have also demonstrated the most commonest mode or method of exposure of these metals. It reveals that only about 10% of the total number of individuals under study used PPE's and not a complete set of PPE's but used only a type of PPE which prevents substances being ingested, because they make use of goggles and hand gloves. It also shows that of all the individuals sampled purposively for this study, non amongst them used either nose mask or Aprons. This is in agreement with Godwin *et al* (2014) which shows that workers do not use basic protective devices such as Aprons, hand gloves and facemasks while working. The study has shown that non

of the exposed groups use either nose mask or apron to represent inhalation and dermal methods of exposure, but those who use PPE's normally use goggles and Hand gloves representing ingestion method of exposure.

The results depict that there is no correlation between the number of years of exposure and the amount of heavy metals in the blood of electronic technicians. As seen from the results the amount of metals depreciated as the number of years increased, this was clearly observed for Lead (Pb), Mercury (Hg) and Arsenic (As).

SUMMARY OF FINDINGS

1. The mean lead (Pb) of 0.64218 ± 0.9245 (mg/L) in this study was high.
2. The working experience range of exposure for lead (Pb) revealed that 11-20years has the highest bioaccumulation value of 12.41mg/L followed by 1-10years having 6.65mg/L respectively.
3. The least level of 0.12mg/L of Pb was recorded for 41-50years working experience.
4. All the values recorded in this study are far higher when compared with the blood lead reference value (BLRV) for children $<3.5\mu\text{g/dL}$ (NHANES, 2018; CDC, 2012).

5. The highest mercury value in the blood of Electronic Technician in this study was

4.45mg/L for an exposure-years of 1-10years working experience.

6. The least mercury value in the blood of Electronic Technician in this study was 0.10mg/L for an exposure-years of 41-50years working experience.

7. The high values of mercury obtain in this study could be due to deficiencies in the application of personal protective devices by the recipient (Electrician Technician).

8. The high value of mercury could have a debilitating health consequence on the exposed Electrical Technician possibly in the nearer future if no health assistance in terms of mitigation and treatment is observed.

9. The value of arsenic in the blood of Electronic Technicians from 11-12years of experience had the highest value of bioaccumulation of 8.47mg/L followed by 1-10years which recorded 3.02mg/L.

10. These two values of arsenic as recorded in this study are ricks factors to the recipient's health status since they are of higher values to the reference factor.

5.2: Conclusion

The research have been able to state that electronic technicians are predisposed to heavy metals bioaccumulation, and will eventually lead to various respiratory and dermal conditions. This is as a result of most of them not using or wearing protective equipments that may help reduce these metals from entering their body. It also revealed that the levels of these metals in the body increased as compared to the reference values . It was also observed that the results of the various heavy metals under study had varying increase in the blood of these technicians as compared with some of the reference values previously studied. The types of protective gears used also shows that the main problem was that those who spent few years are probably not well enlightened about the dangers of these metals in their blood when they bio accumulate to cause heavy metal poisoning.

5.3: Contributions of finding to knowledge

The findings have helped the researcher and other researchers to identify increased values of heavy metals in the blood of electronic technicians within Port Harcourt metropolis and to identify this increase as an occupational hazard for these technicians.

The government and private organizations will now be aware of risk factors associated with the profession and make useful regulations to be able to control this public health related conditions that may arise in the future.

The professionals and technicians will now know the risk associated with their occupation and hence make proper use of PPE' S when necessary as to reduce the route of entry of these metals

5.4: Recommendation

It is recommended that since the results depicted increase in accumulation levels of the various metals under study proper enlightenment be done and given to electronic technicians on the importance of always using PPE's and also the harm that these metals will cause if they continually increase the bio-accumulated levels in their body.

The government and other organizations should team up and also put in place measures that can help encourage the technicians in using protective equipments and gears.

More studies should be carried out on the toxicity levels and health risk assessment levels of these metals when they bio-accumulate in the system of both occupationally exposed and non exposed individuals.

5.5: Limitations Of Study

The major limitation and constraint was on getting the samples from respondents, the superstition to most individuals was that it is not possible to release their blood, and that the government must have sent us to them so as to come up with new policies that will affect their business, and that probably there is plan to close up their shops if it is found that the research had high values. Then the issue of illegal refining and what we as researchers have done before coming to determine the heavy metals in their blood. It took almost two weeks of convincing and giving them advice on the need of the research, after which only few of them about 40 persons agreed to volunteer and their blood to be collected and sampled.

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APENDICES

Appendix A

Certificate of Analysis

Client: Ekine, Dumoteinm (08056033745)

Type of Sample: Blood samples of Electronic Practitioners/Technicians

Analysis Required: For the determination of three selected Heavy metals (Pb, Hg, and As) in the Samples in ppm or mg/l

S/No.	Sample Identity	Age	Sex	Marital status	Type of PPE used	Number of Years	The concentration of Trace Metal elements obtained in		
							Lead (Pb)	Mercury (Hg)	Arsenic (As)
1.	Blood sample 1	43	M	MARRIED	Non	23 years	0.3147	0.0214	0.2149
2.	Blood sample 2	35	M	MARRIED	Non	20 years	1.4062	0.0374	0.04728
3.	Blood sample 3	25	M	SINGLE	Non	7 years	0.05941	1.6932	0.3169
4.	Blood sample 4	24	M	SINGLE	Non	5 years	1.4172	0.1428	1.1516
5.	Blood sample 5	44	M	MARRIED	Non	23 years	0.0328	0.0078	0.0394
6.	Blood sample 6	24	M	SINGLE	Non	1 year	0.6192	0.1291	0.01426
7.	Blood sample 7	32	M	SINGLE	Non	12 years	1.3447	0.0374	2.0591
8.	Blood sample 8	68	M	MARRIED	Gloves	52 years	0.0612	0.0516	0.1327
9.	Blood sample 9	35	M	MARRIED	Non	13 years	1.3447	0.0374	2.0591
10.	Blood sample 10	45	M	MARRIED	Non	24 years	0.3147	0.0214	0.2149
11.	Blood sample 11	45	M	MARRIED	Non	26 years	0.0328	0.0078	0.0394
12.	Blood sample 12	23	M	MARRIED	Non	3 years	0.6192	0.1291	0.01426
13.	Blood sample 13	38	M	MARRIED	Non	19 years	1.4062	0.0374	0.04728
14.	Blood sample 14	41	M	MARRIED	Non	21 years	1.4062	0.0374	0.04728
15.	Blood sample 15	68	M	MARRIED	Goggles	51 years	0.0612	0.0516	0.1327
16.	Blood sample 16	30	M	SINGLE	Non	11 years	1.3447	0.0374	2.0591
17.	Blood sample 17	45	M	MARRIED	Non	21 years	0.0328	0.0078	0.0394
18.	Blood sample 18	23	M	SINGLE	Non	4 years	0.6192	0.1291	0.01426
19.	Blood sample 19	45	M	SINGLE	Non	23 years	0.3147	0.0214	0.2149
20.	Blood sample 20	44	M	MARRIED	Non	23 years	0.3147	0.0214	0.2149
21.	Blood sample 21	69	M	MARRIED	Gloves	52 years	0.0612	0.0516	0.1327
22.	Blood sample 22	43	M	MARRIED	Non	23 years	0.0328	0.0078	0.0394
23.	Blood sample 23	23	M	SINGLE	Non	2 years	0.6192	0.1291	0.01426
24.	Blood sample 24	65	M	MARRIED	Gloves	48 years	0.0612	0.0516	0.1327
25.	Blood sample 25	44	M	MARRIED	Non	23 years	0.0328	0.0078	0.0394
26.	Blood sample 26	23	M	SINGLE	Non	2 years	0.6192	0.1291	0.01426
27.	Blood sample 27	67	M	MARRIED	Goggles	52 years	0.0612	0.0516	0.1327
28.	Blood sample 28	30	M	SINGLE	Non	12 years	1.3447	0.0374	2.0591
29.	Blood sample 29	41	M	MARRIED	Non	23 years	0.3147	0.0214	0.2149
30.	Blood sample 30	40	M	MARRIED	Non	20 years	1.4062	0.0374	0.04728
31.	Blood sample 31	41	M	MARRIED	Non	20 years	1.4062	0.0374	0.04728
32.	Blood sample 32	43	M	MARRIED	Non	20 years	1.4062	0.0374	0.04728
33.	Blood sample 33	43	M	MARRIED	Non	22 years	0.3147	0.0214	0.2149

34.	Blood sample 34	44	M	MARRIED	Non	21 years	1.4062	0.0374	0.04728
35.	Blood sample 35	28	M	SINGLE	Non	7 years	0.05941	1.6932	0.3169
36.	Blood sample 36	28	M	MARRIED	Non	6 years	1.4172	0.1428	1.1516
37.	Blood sample 37	40	M	MARRIED	Non	23 years	0.0328	0.0078	0.0394
38.	Blood sample 38	25	M	SINGLE	Non	2 years	0.6192	0.1291	0.01426
39.	Blood sample 39	30	M	MARRIED	Non	11 years	1.3447	0.0374	2.0591
40.	Blood sample 40	67	M	MARRIED	Gloves	50 years	0.0612	0.0516	0.1327

Control Samples

41.	Blood sample 41						0.0142	<0.001	0.01147
42.	Blood sample 42						0.0062	0.0021	<0.001
43.	Blood sample 43						<0.001	<0.001	0.0042
44.	Blood sample 44						0.0113	0.0117	0.0132
45.	Blood sample 45						0.0206	<0.001	<0.001
46.	Blood sample 46						0.0206	<0.001	<0.001
47.	Blood sample 47						0.0142	<0.001	0.01147
48.	Blood sample 48						0.0113	0.0117	0.0132
49.	Blood sample 49						0.0062	0.0021	<0.001
50.	Blood sample 50						0.0142	<0.001	0.01147
51.	Blood sample 51						0.0142	<0.001	0.01147
52.	Blood sample 52						0.0062	0.0021	<0.001
53.	Blood sample 53						<0.001	<0.001	0.0042
54.	Blood sample 54						0.0113	0.0117	0.0132
55.	Blood sample 55						0.0206	<0.001	<0.001
56.	Blood sample 56						0.0206	<0.001	<0.001
57.	Blood sample 57						<0.001	<0.001	0.0042
58.	Blood sample 58						<0.001	<0.001	0.0042
59.	Blood sample 59						0.0062	0.0021	<0.001
60.	Blood sample 60						0.0113	0.0117	0.0132

Methods: Atomic Absorption Electro thermal spectrometry techniques
Instruction: Solar Thermo-Elemental Atomic Absorption Spectrometer
Model SN-SG 710960

Appendix B

ANOVA

Metal in Blood

	Sum of square	Df	Mean square	F	Sig
Between Groups	80.000	23			
Within Groups	.000	96			
Total	80.000	119			

DESCRIPTIVES

Concentrations

	N	Mean	Std Deviation	Std Error	95% confidence interval for mean		Minimum	maximum
					Lower Bound	Upper Bound		
Pb	40	.6422	.58473	.09245	.4552	.8292	.03	1.42
Hg	40	.1345	.36469	.05766	.0179	.2511	.01	1.69
As	40	.3993	.68096	.10767	.1815	.6171	.01	2.06
Total	120	.3920	.59242	.05408	.2849	.4991	.01	2.06

ANOVA

Concentrations

	Sum of square	Df	Mean square	F	Sig
Between Groups	5.158	2	2.579	8.243	.000
Within Groups	36.606	117	.313		
Total	41.764	119			

Post hoc test

Multiple comparisons

Dependent Variable: Concentration

Turkey HSD

(I) Metals In Blood	(J) Metals in blood	Mean Difference(I-J)	Std Error	Sg	95% Confidence Interval	
Pb	Hg	.50768 *	.12507	.000	.2108	.8046
	As	.24291	.12507	.132	-.0540	.5398
	Pb	-.50768 *	.12507	.000	-.8046	-.2108
Hg	As	-.26744	.12507	.091	-.5617	.0321
	Pb	-.24291	.12507	.132	-.5396	.0540
As	hg	.26477	.12507	.091	-.0321	.5617

*The the mean difference is significant at the .05 level

HOMOGENOUS SUBSETS

Concentration

Turkey HSD

Metals in Blood	N	Subset for alpha = 0.05
Hg	40	
As	40	.3993
Pb	40	.6422
Sig		.132

Means for groups in homogenous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 40.000.

Modified Cochran formula;

where $Z = 1.96$, $P = 0.5$ and $q = 0.5$

$$= = 384.16$$

$$n = = = 44.56 == 44$$

Appendix C



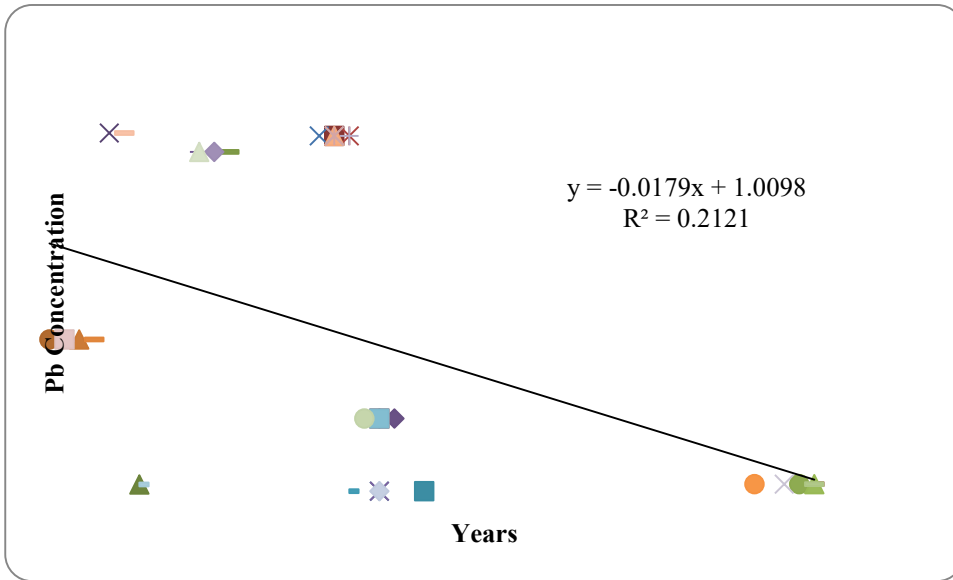


Figure 1 Relationship between no of years exposed and Pb concentration in Blood

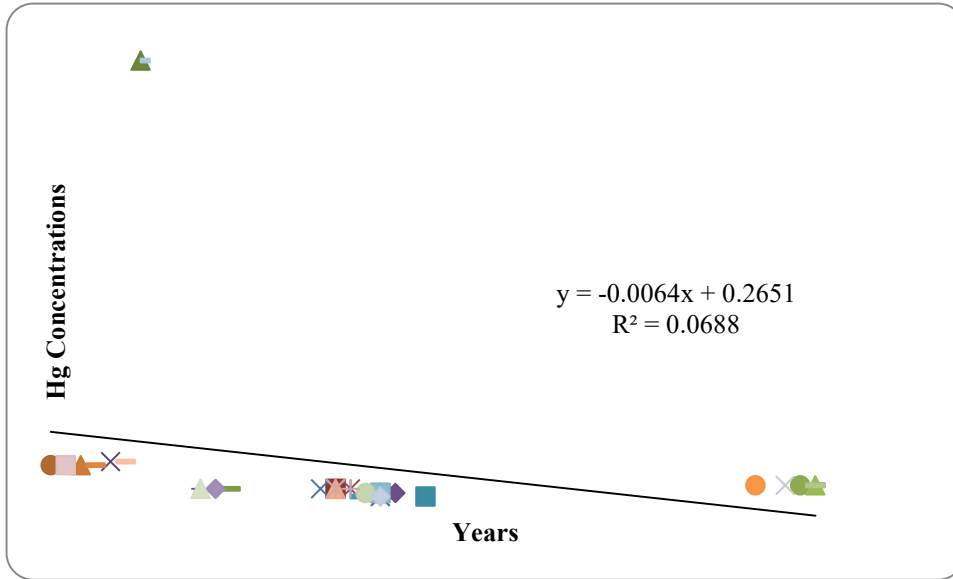


Figure 2 Relationship between no of years exposed and Hg concentrationsn in Blood

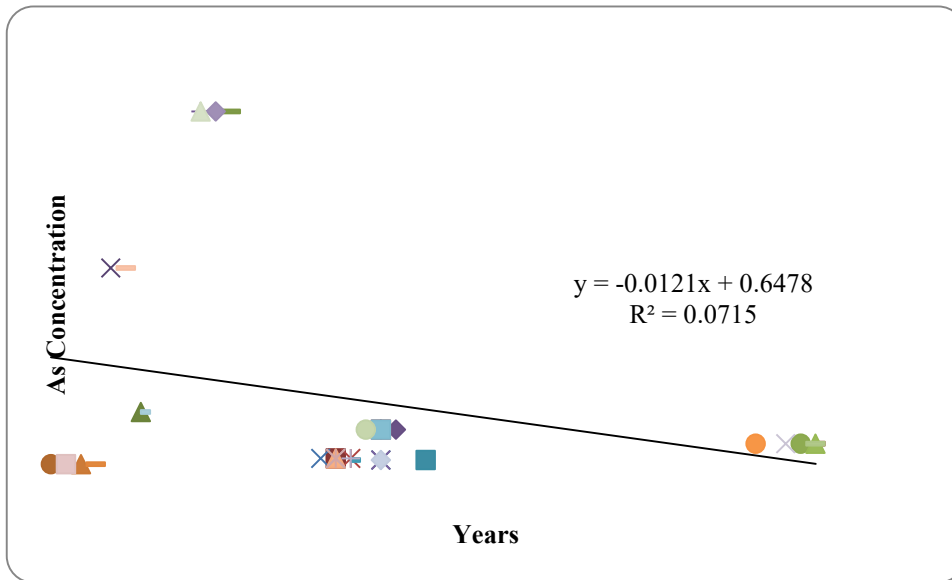


Figure 3

Relationship between no of exposure and As Concentration in Blood