SCHOOL OF PUBLIC HEALTH

COLLEGE OF HEALTH SCIENCES

UNIVERSITY OF GHANA

INTEGRI PROCEDAMUS

HEAVY METALS AND LIVER CELL DAMAGE AMONG ADULTS LIVING CLOSE TO OPEN DUMPSITES: A CROSS SECTIONAL STUDY AT ABOKOBI

BY

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DECLARATION

I, Jacqueline Asante-Mensah hereby declare that with the exception of the references made to other peoples' work which I have duly acknowledged, this proposal is my original work and has neither in whole nor in part been presented to any University or elsewhere for another degree.

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Date ...23/10/2017.......................................

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(Principal Investigator)

Signature ....

Date ...23/10/2017.......................................

Dr. Reginald Quansah

(Academic Supervisor)

DEDICATION

I dedicate this thesis to my family especially my mother. May God continue to use you as blessing in my life.

ACKNOWLEDGEMENT

I acknowledge the favour of God in my life and I would like to thank Him for seeing me through. It has been a struggle but He has seen me through again. My gratitude goes to my supervisor, Dr. Reginald Quansah for his supervision and most importantly his patience. I am also thankful to Mr. Sherriff Enti Brown of Ghana Atomic Energy Commission Laboratory, Dr Naa Dodua Dodoo for her contribution.

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Finally, to my family, I appreciate the support and prayers

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LIST OF ABBREVIATIONS

ABS -	Absorbance
ALT -	Alanine Aminotrasferase
ALP -	Alkaline Phosphatase
AST -	Aspartate Aminotransferase
As -	Arsenic
Akg-	alpha Ketoglutarate
Cd -	Cadmium
EDTA -	Ethylenediaminetetraacetric acid
HN03 -	Nitric acid
MeOH -	Methyl alcohol
Pb -	Lead

DEFINITION OF TERMS

Liver function test: A group of biochemical blood tests that give information to help diagnose and monitor liver disease or damage.

Liver cell damage: Damage to the liver parenchyma causing an excess release of liver enzymes into the blood.

ABSTRACT

Background of study

Improper management of waste remains a major developmental issue and contributor to air pollution especially in developing countries. The most widely used waste disposal method is landfill which is usually open dumpsites without recovery systems to prevent gases and leachates from escaping into the environment. Due to the inability to prevent these pollutants, human beings are exposed to different air pollutants which include heavy metals. Heavy metals such as cadmium and arsenic have been associated with adverse effects on liver function (Oyeku et al,2010)

Abokobi open dumpsite , due to its proximity to human settlement ,exposes the indigenes of the community to various air pollutants which include arsenic and cadmium. This study aimed to assess the potential health implications of adults residing 1-4 km from the dumpsite and recommend methods of reducing liver dysfunction.

General objective

To assess the liver function of adults residing around the Abokobi dumpsite.

Methods:

A cross sectional study was conducted from May to July 2017 among fifty-two respondents. Interviews, liver enzyme sampling, blood analysis were used to collect data from the respondents. Analysis of the data was performed on all the respondents. Mean values and standard deviation of the cadmium (Cd) and arsenic (As) and the ALT, AST and ALP were recorded. Multivariate linear regression analysis was used to assess the association between the heavy metals in the blood and the indicators of liver cell damage.

Results:

The mean age of the respondents was 36.82 and 48% of the respondents lived at a proximal level within 1-2 km from the Abokobi dumpsite. The mean concentration (standard deviation) of the heavy metals ranged from As 10.71 µg/L (2.739) and Cd 9.38 µg/L (8.71) and the mean concentration(standard deviation) of the liver enzymes were ALP 93.56 IU/L (45.31) , AST 35.96 IU/L (30.24) and ALT 15.49 IU/L (10.38).

Conclusion:

This study showed normal activity in the Alanine aminotransferase (ALT) and alkaline phospahtase (ALP) level and a slightly elevated level in the Aspartate aminotransferase (AST) level is the respondents. The respondents all had normal levels of cadmium and arsenic in their blood. There was however no significant association between the liver parameters and the cadmium and arsenic level.

Key words: ALT, AST, ALP ,Cadmium ,Arsenic ,liver cell damage

CHAPTER ONE

INTRODUCTION

1.1 Background

Rapid growth in population due to migration from rural settlement to urban towns such as Accra has resulted in the increase of the amount of waste produced. This unparalleled increase exceeds the city's ability to accommodate the amount of municipal waste produced. (Thompson, 2003.) Ghana is estimated to have a population of 23 million residents with an average of 0.4 kg of waste generated per person. About 2000 metric tonne of municipal waste is estimated to be produced per day, yielding a massive total of about 76000 tons per year (Nartey et al, 2012) .Without proper management of waste, humans are exposed to pathogens that are causative agents for diseases such as diarrhoea, skin diseases, respiratory diseases, cholera and cancers. In order to prevent these diseases proper waste management strategies must be exercised. Waste management measures include combustion, recycling, recovery, reducing, composting and landfill,with landfill being the most commonly used method (Maheshwari et al.,2015). In Ghana, all types of solid waste are usually sent to the dumpsite, the waste is not separated to retrieve recyclable and recoverable materials. Waste from hospitals, electronic waste which includes discarded electrical and electronic devices, domestic waste from our homes, radioactive waste, etc. all end up at the same place contrary to our environmental and sanitation laws. The dumping of hazardous wastes in uncontrolled environments such as the landfill leads to the release of heavy metals into our environment. Some of these heavy metals include arsenic, barium, beryllium, lithium, nickel, vanadium, mercury. Some of these metals have no biological functions and are considered as non-essential whiles others cause DNA damage and lead to carcinogenesis. Due to their high toxicity of heavy metals such as arsenic, cadmium, chromium lead and mercury are ranked among priority metals of public health importance (Khillare et al.,2015). Materials that include plastics, fishing tools, glass usually contain lead. Sources of metals such as mercury can also be found dentals amalgam, lamps, batteries whiles chromium and cadmium can be found in paints, textile and batteries (European Commision, 2002). Multiple routes of exposure of these heavy metals from the environment to residents living close include inhalation of dust, dermal contact with contaminated soil and water, directly ingesting contaminated water and soil. (Zhuang et al, 2014). Excessive exposure to heavy metals could compromise kidney dysfunction, predispose to lung and skin cancers as well as other skin disorders i.e. pigmentation changes,other features which include nausea, abdominal cramps, dyspnea, muscular weakness and vomiting. (Järup, 2003); Duruibe et al, 2007). Ghana like any other developing country continues to face constraints in the management of waste.

The Abokobi open dumpsite serves the greater part of the Accra metropolis. Its services extend from the La Kwantanang to the east, the Ga East Municipal assembly,to the Ledzorkuku Krowor and Adenta Municipalities. Heavy metals are released in the stacked gases that are emitted from the waste by burning. Potential routes of exposure are different for the nearby residents. Waste sifters scavenge for metals and scraps that may be economically useful to them. They set ablaze certain portions on the dumpsite in order to obtain the scraps they would need. Dumping of e-waste at the dumpsite which contains these heavy metals would have some of its contents deposited into the soil as there are no regulatory measures on the type of waste that is brought to the dumpsite. Residents may also be exposed by drinking water from wells and boreholes that may be contaminated with leachates (Davoli et al., 2010). Making residents highly exposed to trace metals which studies have shown would make them prone to liver dysfunction. It is therefore, important to assess the level of trace metals and its association with the liver function.

1.2 Problem statement.

Nearly 3.7 million deaths globally were attributed to air pollution in 2012 and 88% of these deaths occurred in low and middle income countries (WHO, 2014). Many epidemiological studies have shown that exposure to polluted air is positively related with increased mortality such as cardiovascular diseases and respiratory diseases. However, studies have also proven that air pollution can induce liver cell damage (Kim, Park, Lim, Lee, & Kim, 2014) According to an article from the Liver Support Network on a research conducted by Professor Edwin Wiredu of the School of Allied Health of the University of Ghana, liver diseases are at a rise of 0.3 percent per annum in Ghana. It has been reported that liver diseases are usually related to cirrhosis caused by excessive alcohol intake and viral hepatitis. with less relevance given to its genesis from pollution and effect of air toxicants such as cadmium, mercury, lead, arsenic, chromium in our system. (Hyder et al., 2014); Duruibe et al., 2007)

Nonetheless residents close to dumpsites are exposed to these heavy metals in contaminated soil from the dumpsites and unregulated boreholes. Perennial water shortage in the area compels most residents to resort to boreholes as their major source of water (Environmental & Development, 2008) According to media report from Graphic online in 2013, the Abokobi dumpsite which started as a temporary dumpsite for solid waste generated in the now Ga East Municipality stands at about 800 square meters.

Smoke from the dumpsite usually plunges the community into darkness when the dump is g burnt while leachate from the dumpsite contaminates the boreholes (Oyeku & Eludoyin, 2010) dies have been conducted on the effect of heavy metal on the liver of the occupational groups but ublished study has been conducted in the communinty in Ghana. This necessitates the assessment ıe level of heavy metals and its association with liver cell damage.

1.2.1 Conceptual Framework

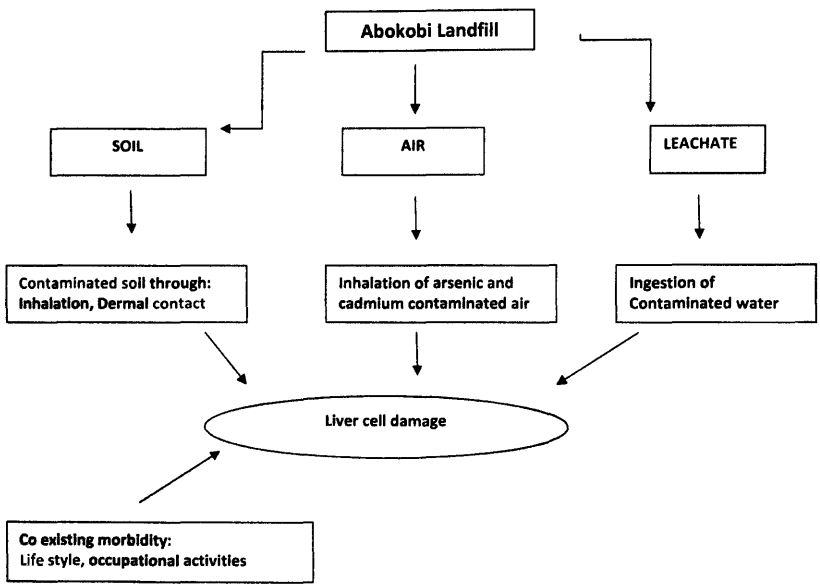

Figure 1: A conceptual framework showing the exposure of heavy metals to residents

The conceptual framework (Figure 1) indicates the exposure to heavy metals by adults living close to the Abokobi landfill and its association to liver cell damage. Heavy metals such as cadmium and arsenic have an expansive spread on the environment and originate naturally through soil erosion , natural weathering of the earth's crust and human activities involving industrial batteries, plastics, glass, pesticides, coal combustion residues and paints (Wuana & Okieimen, 2011) . Due to their biodegradable nature heavy metals are emitted and enter the waste stream.

Given the pervasive nature of these heavy metals, their entry and accumulation in the body contributes to disorders such as intellectual disability in children, dementia in adults, disorders in the central nervous system, visual disturbances, kidney and liver disease (Ali, 2011).

1.3 Justification

As the world advances, so does technology. We need microwaves to warm our food quicker, televisions to keep us entertained and informed. However, with the advancement in technology new models are produced and the old models usually get discarded and disposed and eventually end in the environment. Most heavy metals sink into the soil and are usually released into the atmosphere by anthropogenic activity. However, their concentrations usually stay intact no matter how long they are in the soil thereby causing a risk to human health and the ecosystem (Wuana & Okieimen, 2011). Recycling activities to recover the heavy metals increases the amount of heavy metals in the environment and ground water is contaminated through the leachate containing heavy metals.

Heavy metals cause harm to agricultural and other source of food for the human population. They accumulate slowly and some of their effects are most internally mediated .Exposure is usually via ingestion, inhalation or dermal exposure.

Exposure can be chronic or acute and depending on the intensity can cause gastrointestinal infection, skin infections, respiratory, kidney and liver diseases and may lead to death. It is necessary to determine the presence of the heavy metals in biological samples. This will serve as a guide in various remediation activities and also create awareness concerning human exposure in the locality.

The outcome of this research would provide an overview of the crucial state of individuals precisely adults above age 18 years living around dumpsites.

1.4 Objectives of the Study

1.4.1 General Objective

The general objective of this study was to assess liver function markers as measures of liver cell damage and blood levels of cadmium and arsenic among adults living within 4 km of the Abokobi dumpsite

1.4.2 Specific objectives:

1. To determine the mean levels of markers of liver cell damage (i.e. ALP, AST, ALT) among the study participants.

2. To quantify levels of blood arsenic and cadmium among study participants.

3.To determine the association between blood arsenic and cadmium levels and markers of liver cell damage.

CHAPTER TWO

LITERATURE REVIEW

2.1 Scope of the Review

The study comprises review of theoretical and empirical literature relevant to the association between arsenic and cadmium on liver cell damage caused by hepatoxicity in adults aged 18years and above residing around the Abokobi dumpsite. The literature review will include an overview of the sanitary state in Ghana particularly Abokobi, and the relationship between certain heavy metals and liver cell damage.

2.1.1 Sanitation

Sanitation remains a major fall back worldwide. In 2012, in spite of this, 2.5 billion people still had no access to improved sanitation facilities (UNICEF, 2014). Developing countries in Africa Asia and Latin America are hit the most by sanitation and hygiene problems. Approximately ten percent of diseases in Africa are pinned on sanitation and hygiene. The major environmental health hazards associated with sanitation and hygiene include indoor and outdoor air pollution, contaminated food, vector control and improper waste disposal (Opio-Odongo, 2013).

Different schools of thought have their definition of waste. Waste as defined by the Basel Convention adoption by the European union in 1993 are substances or materials that are disposed or intended to be disposed of or are required to be disposed or are required to be disposed by the provision of national laws. The United Statistic division however defines waste as material that is prime products for which the individual who produced the waste has no purpose of it.

Africa and for that matter Ghana is overwhelmed with the amount of waste collected due to urbanization. Between 2000 and 2005 the rate of change of urbanization increased by 3.3 per cent making it the highest in urban population change in the world (Songsore, 2013). This increase in population has made it challenging for government to meet up with the responsibility of providing effective public service of which solid waste service is inclusive.

In major cities in Ghana, mountains of waste are found in open spaces with landfill spaces getting filled. There is therefore immense pressure on the government's budget to find alternative means to manage waste. The Accra Metropolitan Assembly (AMA) in 2008 spent about 82% of its funds on solid waste management basically on collection and transportation of the waste. It is for this reason why the first Saturday of every month was declared national sanitation day throughout the country to try and get rid of country's waste by the former president of the republic on the 31st of October 2014. Over the years, the AMA has used at least seven temporary dumping sites to dispose the waste generated from the city (Themelis, 2013). Of these seven include the Abokobi landfill. The Abokobi landfill is situated in the Ga East municipality found in the northern part of greater Accra. The municipality has a grave concern with the generation of waste. More than one and half of the households in the municipality dispose their solid waste via waste collection. An estimated 385 ton of solid waste is generated per month of which 67% of this waste is collected leaving a substantial amount of heap causing health hazards to the people. (Environmental & Development, 2008). The Landfill like any other landfill emit gases of which methane and carbon dioxide and the major constituents, combustion products from landfill gas control such as carbon monoxide, oxides of nitrogen, hydrogen chloride and particulate matter and heavy metals (US EPA, 1995).

Heavy metals tend to leach into the underground water. When ingested they react with body biomolecules and combine with enzymes and protein to form stable biotoxic compounds and therefore, change the original structures of the body biomolecules. Thereby affecting their reactions and functions in the body (Duruibe et al., 2007).

2.2. Cadmium

Cadmium exists naturally and is soluble in water. They are usually transferred from the ambient air to soil and can be absorbed by plants thereby making its way into our food chain. In landfills the main sources of cadmium are steel plating, iron smelters and batteries. Cadmium has a whole-body half lie of between 15-30 years and mainly accumulates in the kidney and the liver. There are many interactions between cadmium and proper functioning of the liver. Cadmium levels are usually low in drinking water except in communities where industries of cadmium emissions i.e. industries that are involved in the production of alloy, battery production plastic production and waste management areas where incinerators and landfills are managed (Services, 2012) .The blood level of cadmium in a general population is <50µg/Blood cadmium is usually reflective of recent exposure.

The main entry route of cadmium is via ingestion. Averagely, human intake of cadmium is between 10-50 micrograms. This usually increases by several hundred in highly polluted, areas (World Bank, 1998). According the US EPA cadmium is a human carcinogenic. Certain occupations are greatly exposed to cadmium. Cadmium body burden increases with age and women have shown to have higher levels of cadmium than men. Cadmium is also an important constituent of tobacco during the natural nature of nicotiana species to concentrate. Exposure of cadmium with acute and chronic contact have adverse effects on the cells and tissues of various organs. The liver structure can be altered from exposure of toxicants and therefore exposure of cadmium can cause liver injury and eventually lead to liver dysfunction (Rafati et al., 2015) .

Research conducted in a general population in the United States showed association between urinary cadmium levels and hepatic necroinflammation. Persons in the top quartile of urinary cadmium had more than 3-fold increased risk of liver mortality. The research considered a general population that were exposed to cadmium in the third national health and nutrition exam survey from 1998 to 1994. Individuals in the study had biological samples taken for alanine aminotransferase (ALT) ,aspartate aminotransferase (AST), alkaline phosphates (ALP) and bilirubin and urinary cadmium levels after the individuals had been classified according on basis of their smoking habits, history of cardiovascular diseases , hepatitis B and hepatitis C status, Individuals who tested positive for hepatitis B and hepatitis C were exempted from the study as presence of hepatitis contributed to high liver enzymatic parameters. Heavy metals generally tend to effectively destroy cell membranes. This destruction of the cell liberates cytoplasmic enzymes into the blood stream and cause there to be elevated level of AST, ALP and ALT in the serum of the exposed individual (Selvaraj et al, 2017).

Studies from the experiment proved that hepatic enzymatic parameters elevated as urinary levels of cadmium increased with men having about 56% increased risk of the hepatic inflammation as compared to women who recorded 23% risk (Hyder et al., 2014).

2.2.1 Arsenic

Arsenic is the most abundant toxic metalloid and constituents 0.0001% of the Earth's crust.it is naturally found in the environment. Arsenic in its inorganic state causes danger to humans. The major inorganic forms of arsenic include the trivalent arsenite and the pentavalent arsenate. The main routes of exposure of this heavy metal consist primarily from ingesting arsenic contaminated food or/and water, inhalation of air and via dermal absorption (Ratnaike, 2003).

Worldwide exposure to inorganic arsenic contaminated water is a public health issue of grave concern in not only developing countries but industrialized countries as well. A whooping 13 million people in the United States reside in communities where arsenic contamination in potable water exceed the required cut off value of 10μg/L as provided by the united states environmental protection agency. In parts of India and Bangladesh, arsenic level has been recorded to be as high as 1.5 to 3.4 mg/L and has been a serious hazard to the health of indigenes in about nine districts (Mazumder, 2015).

Exposure to arsenic affects the function of a wide range organs depending on the degree and duration of exposure meted, acute exposure to inorganic arsenic results in cardiac failure, anemia and or death, whereas chronic exposure can cause cancers, injury to the kidney and liver damage. The extent of arsenic toxicity is usually due to the reliance on local geochemistry and the level and proximity to varying manmade activity such a dumpsite and mines (Santra, 2015). After absorption of arsenic after being exposed, arsenic spread to different parts of the body in organs such as the skin, kidney, liver and spleen. The liver being the major organ for biotransformation of toxic inorganic arsenic absorbs the most. (Page, 2013). To ascertain the concentration of inorganic arsenic the body is burdened with the biomarker usually used is urine. However according to Hall et al., (2006), urine as a biomarker of arsenic exposure may not reflect the actual tissue burden. Concentration of arsenic in blood could also be used to reflect exposure that may be recent and with continuous exposure within a short period could serve well as biomarker of arsenic (Hughes, 2006) even though Arsenic has a short half-life in blood.

In a study in Calcutta, India to assess the prevalence of liver involvement associated with chronic exposure of arsenic. Contaminated water from two study areas was measured for arsenic content. Enlargement of the liver was recorded in 2.99% of the participants who drank water that contained arsenic less than 0.05mg/L whereas the highly-exposed group had drunk the contaminated ground water contained arsenic level greater than 0.05mg/L recorded 10.21% of the population. Ground water contamination is the most important exposure pathway of arsenic (Santra, 2015).

had 10.21% of the participants drinking water that contained arsenic at greater than 0.05mg/L (Santra, 2015). The required level of arsenic in blood in unexposed individuals is <1µg/L.

The mechanism by which arsenic causes hepatoxicity Inorganic trivalent arsenite (As III) is 2–10 times more toxic than pentavalent arsenate as (V). By binding to thiol or sulfhydryl groups on proteins, as (III) can inactivate over 200 enzymes. This is the likely mechanism responsible for arsenic's widespread effects on different organ systems. As (V) can replace +phosphate, which is involved in many biochemical pathways. One of the mechanisms by which arsenic exerts its toxic effect is through impairment of cellular respiration by the inhibition of various mitochondrial enzymes, and the uncoupling of oxidative phosphorylation. Most toxicity of arsenic results from its ability to interact with sulfhydryl groups of proteins and enzymes, and to substitute phosphorous in a variety of biochemical reactions (Tchounwou et al, 2014). Arsenic in vitro reacts with protein sulfhydryl groups to inactivate enzymes, such as dihydrolipoyl dehydrogenase and thiolase, thereby producing inhibited oxidation of pyruvate and beta-oxidation of fatty acids. The major metabolic pathway for inorganic arsenic in humans is methylation. Arsenic trioxide is methylated to two major metabolites via a non-enzymatic process to monomethylarsonic acid (MMA), which is further methylated enzymatically to dimethyl arsenic acid (DMA) before excretion in the urine. It was previously thought that this methylation process is a pathway of arsenic detoxification, however, recent studies have pointed out that some methylated metabolites may be more toxic than arsenite if they contain trivalent forms of arsenic (Mazumder, 2015).

2.3. Liver

The liver is the largest organ in the human body, it plays a major role of protecting the body from infections and cleansing the blood of toxins. It also produces enzymes that dense fat and break down protein and carbohydrates in the body (Giannini, Testa, & Savarino, 2005).

The proper functioning of the liver can be altered by several factors such viral hepatitis, scarring of the liver, excessive intake of alcohol and drug consumption such as antimalarial drugs like amodiaquine and antiretroviral drugs (Singh et al, 2011,Hyder et al., 2014) Exposure to heavy metal according to Margeli et al (1994) is also reported to cause hepatic necrosis. Abnormal liver levels are defined as values that are elevated beyond the upper reference limit. When the liver cell damage or there is injury to the liver there are abnormal transaminase levels and the aspartate transaminase (AST) and alanine transaminases (ALT) are usually elevated. There are also elevated levels in the alkaline phosphatase (ALP) levels (Giannini et al., 2005). The cut off points for AST is 5.0-34.0 IU/L, ALT 10-36.0 IU/L and for ALP <=240IU/l. The cut off points may however differ within clinical settings. Alanine aminotransferase is the most relied liver cell damage marker due to the relevant role of the enzyme it plays in amino acid breakdown. Elevated levels of the enzyme are released into the blood during liver damage of injury and a mean of the enzyme is important in specifying liver abnormalities (Singh et al., 2011).

CHAPTER THREE

RESEARH METHODOLOGY

3.1Study Area

The Study area concentrated on communities residing proximal to the Abokobi dumpsite. The Abokobi dumpsite is based in the Ga East municipal assembly close to the Pantang Hospital. It occupies about 800 square metres (0.08 hectares) of land. Operation on the dumpsite commenced in 2003 to cater for the Abokobi community and its outskirts. However, with the increasing population the dumpsite also receives waste from the Ga West Municipal Assembly, Accra Metropolis, Ledzorkuku Krowor Municipal Assembly and Ga central Municipal Assembly. The closest populace is within 100 m from the dumpsite

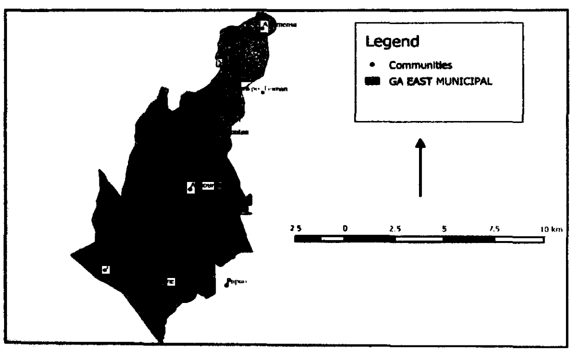

Figure 2: Map showing the communities within the Ga East Municipal

Figure 3: Abokobi dumpsite and its proximity to human settlement

3.2 Study population

The population for the study included adults residing in households within >1 to 4km of the Abokobi open dumpsite. A house to house interview was done within the geographical jurisdiction. A sample size of 52 participants was conveniently selected to provide blood samples. All respondents met the inclusion criteria before they were included in the study.

3.2.1 Inclusion criteria

The participants met the following inclusion criteria. The participant was (i) a male or a female above 18 years (ii) A permanent resident within the study area and (iii) did not have viral hepatitis B and /or hepatitis C.

3.2.2 Exclusion criteria

The exclusion criteria included (i) a male and/or a female in a household aged below 18 years (ii) non-permanent residents in the study area and (iii) a male or female with known medical records of hepatitis B and C or known liver disease.

3. 3 Study variables

3. 3.1 Main determinants

The main determinants of interest were blood levels of cadmium and arsenic.

3.3.2 Outcomes of interest

The main outcome of interest was liver cell damage. Liver cell damage is usually characterized by elevated levels of certain biochemical markers in the liver like alanine aminotransferase (ALT), aspartate aminotransferases (AST), and alkaline phosphates (ALP).

3.3.3. Confounding variables

The following variables were considered as potential confounders based on literature ;occupation of participants, educational level of participant, smoking habit of participants, drinking habit of participant and gender of participants(Smith et al, 2000).

3.4 Data Collection Procedure

The field work was implemented in three (3) phases: (i) stakeholder meeting, (ii) selection and enrollment of study participants, (iii) data collection

3.4.1 Stakeholder meetings

Series of meetings were held with stakeholders in and around the dumpsite to seek their view on the conditions in and around the dumpsite. The stakeholders expressed interest and agreed on the relevance of the study.

3.4.2 Selection and enrollment of study participants

A house to house interview was conducted within the areas that fell within >1 to 4 km around the dumpsite. The study was explained to the household and interested participants who fell within the age range were then screened for viral hepatitis B and C using the one step test kit for Hepatitis B and C. The respondents who qualified were then given the date and time to converge at the Ablor Adjei Presbyterian church venue for sampling and data collection.

3.4.3 Data Collection

Collection of the data was conducted on the 27th of June 2017 at 9 o`clock in the morning, the participants were first enrolled after which they filled a questionnaire with assistance of the principal investigator (when they need clarification) after which they proceed to have their blood samples drawn. The questionnaire elicited information on personal characteristics, environmental exposures, medical conditions,occupation and lifestyle factors.

3.4.3.1 Blood Sample Collection

Following explanation of the test procedure, 5.0 milliliters (mls) of whole blood was collected by trained phlebotomists from the median cubital and distal veins into two tubes one containing a clot activator (for serum separation) for analyzing the liver parameters and an EDTA tube for analyzing the heavy metal. The venipuncture was done using a butterfly needle and a tourniquet. Precautional measures were put in place during the blood sampling. And all used needles were disposed in biohazard sharps bin. Quality assurance were put in place for the management of any blood spillage by having a chlorine concentration at hand. The samples were placed by an impregnable system using transit containers with ice packs and transported immediately for the analysis of the liver parameters. The blood samples with the clot activator in the serum separator tube were centrifuged and the supernatant.

Sera were collected for analysis at FOCOS Orthopedic Hospital Laboratory by Mr. Erving Laryea Torgbor (Senior Biomedical Laboratory Scientist).

3.4.3.2 Laboratory Analysis

The liver markers were analyzed using the Mindray BS 120 manufactured in China with a photoelectric system that measures the absorbance of the reaction mixture(see Appendix 6,page 48) that were dispensed in the cuvettes of the machine.

3.4.2 Liver Parameter Measurement

The measurement of the ALT ALP and AST were performed according to the guidelines set by the American College of Gastroenterology. Calibration of the equipment, Mindray BS 120 and the standards of the individual reagents for testing were performed to ascertain that the right concentrations would be reported. The age and sex were entered for the different respondents.

3.5 Blood Sample Analysis for heavy metals (Cd and As)

Methyl alcohol (meOH) was first used to prepare the Atomic Absorption spectrophotometer. The beakers and pipettes were washed with 1M HNO_3 and demineralized water . The blood samples were diversified for about 20 seconds.One Triton ($C_8H_{17}C_6H_4$ $(OCH_2CH_2)_n$ OH) was pipetted into a sample cup at 100μL , after which 100μL of the blood sample of the participant was added. The function of triton was to reduce the surface pressure of the red blood cells to aid in decomposition brought about by high temperatures. Quality control was done on the Atomic Absorption Spectrophotometer, after which the thoroughly mixed sample was loaded. The Spectrophometer was then propelled for analysis of the heavy metals.

3.5.1 Data Analysis

The data collected was cross checked to ensure that there were no mistakes in documentation. Means and standard deviations were calculated for continuous variables. Proportions were computed for categorical variables. Correlation analyses were used to assess the relationship between the levels of arsenic and cadmium and liver parameters. A multivariate regression model was used to adjust for confounders, with statistical significance set at $p < 0.05$. All analyses were done using Stata 14.

3.6 Informed consent

Informed consent was sought and obtained from all participants. An oral script introducing the study was read to for all participants, who can read and write and by a translator for those who do not communicate in English. Individuals interested in participating in the study read the written consent form and/or it was read to them by a translator and any questions raised by were answered. The interview was conducted when the respondents agreed to participate.

3.6.1 Protection of subjects' privacy

Any question the participant found invasive did not have to be answered. Also, participants were under no obligation to participate in any section of the study that they found presumptuous.

3.6.2 Provision to prematurely end a particular subject's participation in the study

A participant had the option to choose a location that they found more comfortable to be interviewed. In the case of any detrimental happening or event, a subject's participation in the study was ended.

3.6.3 Record storage and protection

All research record and data have been secured from accidental loss and inappropriate disclosure to protect all classified data. Data has been stored in bound access on a secure laptop with passcodes. Routine electronic back up was performed. There will be an appropriate safe destruction of data.

3.6.4 The data and/or any specimens were destroyed at the conclusion of this study

All blood samples were destroyed after all necessary laboratory analysis were conducted. The questionnaires were stored for a period of time after which they would be destroyed. Data on the identities of the participants were however retained as some participants showed interest in knowing the outcome of the study.

3.6.5 Incentives for participation

Each participant was given a token gift worth 15 Ghana cedis for participation in this study. Incentives were given at the end of the specimen collection.

3.6.6 Ethical Consideration

The Ghana Health Service Ethical Review Board provided the ethical clearance before the data collection began. The leaders of the community, the Ga East District Assembly and the University of Ghana also granted permission to use the community for academic study. Every participant also provided oral and written consent and were informed of the benefits, risks and the procedures for research. All necessary information was read out to the participant to their full understanding before they signed the forms. Any question the participants had were also answered.

CHAPTER FOUR

RESULTS

4.1 Demographic Characteristics of participants

The demographic characteristics of participants (Table 4.1) and characteristics of the households (Table 4.2) are summarized below.

Table 4.1: Socio-demographic characteristics of participants (n=52)

	Categories	Responses	Percentage %
Gender	Male	14	27.45
	Female	38	72.54
Age (In Years)	20-29	18	33.30
	30-39	12	23.50
	40-49	15	29.40
	above 50	7	13.70
Educational Level	No Formal Education	6	11.80
	Primary	23	43.10
	Secondary	16	31.40
	Tertiary	7	13.70
Occupational Status	Employed	41	78.43
	Unemployed	11	21.57

Table 4.2: Socio demographics of participants' Households (n=52)

	Categories	Responses	Percentage %
Housing Type	Brick House	39	72.55
	Wooden Structure or Shed	13	27.45
Number of Occupants	1-3	10	18.90
	4-6	32	64.00
	above 6	15	29.40
Residential Duration (In Years)	1-2	23	44.2
	2-3	19	36.5
	3-4	10	19.2
Residential Proximity to dumpsite (In kilometers)	1-2	25	48.07
	2-3	11	21.60
	3-4	16	30.76
Drinking Water Source	Borehole	30	57.69
	Poly tank	1	1.96
	Tap-water	21	41.18
Cooking fuel Type	Charcoal	27	51.92
	LPG	20	38.46
	Wood	5	9.61

Majority of the respondents were female (72.54%). The age range of the respondents span between 20 to 65years. Of the respondent majority of them, (33.30%) fell within the age range of 20-29 years. Majority of the respondents had their education level up to primary school (43.1%) and were employed (78.43%). Among the respondents, 72.55% lived in brick houses and had relative protection from smoke, fumes and other irritants from getting into the homes .19.2% of the respondents had lived in the community for longer than four years and 48.07% lived within 1-2 km from the dumpsite. By means of ground water, 57.69 % used borehole as their primary source of drinking water. Of the respondents 50.98% used charcoal as their major source of cooking fuel.

4.2 Exposure to environmental hazards

The respondents were interviewed about their exposure to environmental hazards such as smoke, fumes, aerosols, irritant gases that they were exposed to in their homes and their work places.Of the participants, 76.5% of them were exposed to dust in their homes, whereas 65.30% were equally exposed to dust at their work places. Smoke was eminent in most of the homes of the respondents accounting for 72.5% and 61.25% in their work places. They were therefore interviewed about their use of personal protective equipment (PPE). Majority of the respondents, 70.59% did not use any PPE in performing their various tasks in their work places. Of the participants, 7.84% barely had any idea on what PPE was.whereas the remaining 21% used nose masks and gloves.

Table 4.3: Percentage Distribution of the Exposure of hazards (n=52)

Hazards	House	Work
	N (%)	N(%)
Dust	39(76.50)	32(65.30)
Smoke	37(72.55)	31(61.25)
Odors	35(68.60)	28(57.10)
Heat	35(68.60)	32(65.30)

4.3 Summary of Liver parameters

The respondents were tested for liver cell damage by measuring their levels of AST, ALP and ALP in their blood. The mean (standard deviation) values of the enzymes were 15.49IU/L (10.38IU/L), 35.96IU/L (30.24IU/L) and 93.56IU/L(45.31 IU/L) for ALT, AST and ALP respectively.

Table 4. 4: Summary Statistics of the Liver Parameters

Statistic	ALT(IU/L)	AST(IU/L)	ALP(IU/L)
Minimum	5.60	2.20	18.80
Maximum	52.20	233.60	261.60
Mean	15.49	35.96	93.56
Standard Deviation	10.38	30.24	45.31
25th Percentile	9.08	25.03	68.30
50th Percentile	11.85	32.25	81.85
75th Percentile	17.90	39.13	106.76

4.4 Mean values of Heavy metals (cadmium and arsenic) in blood of participants

Table 4. 5: Summary Statistics of the Chemicals(n=52)

Statistic	As(μg/L)	Cd(μg/L)
Minimum	5.00	4.00
Maximum	18.00	70.00
Mean	10.71	9.38
Standard Deviation	2.74	8.71
25th Percentile	9.00	7.00
50th Percentile	10.00	9.00
75th Percentile	13.00	10.00

4.4.1 Association between Liver parameters, Heavy metals and Age

A correlation matrix was run between the liver parameters. For heavy metals and age, ALT, AST and ALP did not show any significant association with age with corresponding p values of 0.352, 0.588 and 0.572. However, arsenic and cadmium had p values of 0.024 and 0.010 respectively, establishing a correlation between the chemicals to age (Table 4.6).

Table 4. 6: Correlation Matrix between Liver Parameters, Heavy Metals and Age

Parameters	Age	
	Coefficient	P-value
ALT	-0.133	0.352
AST	0.078	0.588
ALP	0.081	0.572
As	-0.315	0.024
Cd	0.357	0.010

4.4.2 Independent t -test of liver parameters between males and females

Liver parameters did not differ significantly by sex. The p values for the Levene test for equality of variance were all above 0.05. This indicates homogeneity of variance meaning that any difference observed were not statistically significant.

Table 4. 7: Independent T-test of Liver Parameters between Males and Females

Liver Parameters		Equality of Variances	Equality of Means	
		P-values	P-values	Mean Difference
ALT	Equal variance	0.555	0.72	1.915
	Unequal variance		0.734	1.915
AST	Equal variance	0.330	0.596	5.1197
	Unequal variance		0.432	5.1197
ALP	Equal variance	0.102	0.618	7.2440
	Unequal variance		0.704	7.2440

4.4.3 Independent t test of heavy metals between males and females

There was no significant difference between the sex of the respondents and the blood levels of cadmium and arsenic. The p values of the Levene test of equality of variance showed p values greater than 0.05 indicating that there was no difference in the blood levels heavy metals in males and females.

Table 4. 8: Independent T-test of Heavy metals between Males and Females

Heavy metals		Equality of Variances P-values	Equality of Means P-values	Mean Difference
As	Equal variance	0.581	0217	-1.0309
	Unequal variance		0.263	-1.0309
Cd	Equal variance	0.559	0.361	2.5560
	Unequal variance		0.161	2.5560

4.5 Association between heavy metals and the liver parameters (AST, ALT and ALP)

A correlation analysis was conducted to find an association among the variables of the study. There was no correlation between the study variables (Table 4.9) .When linear regression analysis was also conducted, no association was found between the blood levels of cadmium and arsenic and the liver parameters. When adjusted for age , sex, smoking habit, alcohol intake and dumpsite proximity , there was no association between heavy metals and liver parameters (ALT,AST, and ALP).

Table 4. 9 Pearson product moment correlations between heavy metals and liver parameters

Variable	As	Cd	ALT	AST	ALP
As	1				
Cd	0.0203	1			
ALT	0.2068	-0.0792	1		
AST	0.1143	-0.0098	0.2792	1	
ALP	0.1823	-0.0316	0.585	0.1503	1

Table 4. 10 ***Association between heavy metal concentration and ALT among respondents (n=52)***

Heavy Metal parameters	Crude β (95% CI)			Adjusted β (95% CI)		
	β	95% CI	P-value	β	95% CI	P-value
As Blood	0.784	-0.26,1.837	0.141	0.827	-0.393,2.040	0.180
			0.57	-0.013	-0.440,0.419	0.953

:ohol intake, dumpsite proximity

For every unit increase in the levels of As in blood, there is a corresponding 0.827 increase in the levels of ALT Adjusting for age, sex, smoking habit, alcohol intake, dumpsite proximity. **(A β = 0.827, p-value= 0.18)**

For every unit increase in the levels of Cd in blood, there is a corresponding 0.013 decrease in the levels of ALP among respondents. Adjusting for age, sex, smoking habit, alcohol intake, dumpsite proximity. **(A β = 0.827, p-value= 0.95)**

Table 4. 11 ***Association between heavy metal concentration and ALP among respondents (n=52)***

Heavy Metal parameters	Crude β (95% CI)			Adjusted β (95% CI)		
	β	**95% CI**	**P-value**	**β**	**95% CI**	**P-value**
As Blood	3.01	-1.604,7.635	0.196	4.76	-0.53,10.05	0.077
Cd Blood	-0.071	-1.541,1.390	0.924	-0.21	-0.440,0.419	0.823

*Adjusted for age, sex, smoking habit, alcohol intake, dumpsite proximity

For every unit increase in the levels of As in blood, there is a corresponding 4.76 increase in the levels of ALP Adjusting for age, sex, smoking habit, alcohol intake, dumpsite proximity. **(β = 4.76, p-value= 0.077)**

For every unit increase in the levels of Cd in blood, there is a 79% decrease in the levels of ALP among respondents aadjusting for age, sex, smoking habit, alcohol intake, dumpsite proximity. **(β = -0.21, p-value= 0.077)**

Table 4. 12: ***Association between heavy metal concentration and AST among respondents (n=52)***

Heavy Metal parameters	Crude β (95% CI)			Adjusted β (95% CI)		
	β	**95% CI**	**P-value**	**β**	**95% CI**	**P-value**
As Blood	3.012	-1.604,7.635	0.196	2.121	-1.372,5.616	0.228
Cd Blood	-0.033	-1.012,0.945	0.945	0.077	-1.223,1.235	0.990

*Adjusted for age, sex, smoking habit, alcohol intake, dumpsite proximity

For every unit increase in the levels of As in blood, there is a corresponding 2.12 increase in the levels of AST adjusting for age, sex, smoking habit, alcohol intake, dumpsite proximity. **(β = 2.12, p-value= 0.023)**

For every unit increase in the levels of Cd in blood, there is a 0.077 increase in the levels of AST among respondents adjusting for age, sex, smoking habit, alcohol intake, dumpsite proximity. **(A β = 0.077, p-value= 0.99)**

CHAPTER FIVE

DISCUSSION

5.1 Summary of Main Findings

The residents of the community were aware of the implication of the dumpsite on their health. They reported of discomforts such as being exposed to odour, smoke and fumes in their homes. The concentration of the cadmium and arsenic in the blood did not however have any significant influence on the liver parameters used as measure of liver function.

5.2 Methodological Validity

This was the first study among residents that assessed for any potential association between exposure to heavy metals and liver cell damage parameters using only blood as a biomarker of toxicity. The study controlled for age, smoking habit and alcohol intake and educational level. The major limitation of the study was limited funding as the analysis of heavy metal proved to be very costly.

5.3 Comparing result of study with previous findings

The study sought to find an association between exposure to cadmium and arsenic and liver cell damage among respondents who resided close to the Abokobi open dumpsite. The study was controlled for confounders such age, smoking habits and alcohol habit. Most of the respondents were females. A study by Neila et al(2017)reported that sex had an effect on heavy metals. However there was no significant difference between the sex of the respondent and the blood levels cadmium and arsenic. Findings from a study by Berglund et al (2011) showed that females had relatively higher concentrations of heavy metal to their male counterparts. Among the respondents, 54% had achieved primary education and most of them were employed. The respondents were exposed to environmental hazards nearly as much as they were exposed to in their homes. Due to their low educational level, most of the respondents were involved in low income jobs that did not involve them having to commute to areas that were far from their place of residence .Therefore they still stayed within a considerable distance from the Abokobi dumpsite while they worked and they were still exposed to dust, smoke and odour. However, majority of the respondents did not use any PPE whiles working and may contribute to the buildup of the cadmium and arsenic. Research by Tyrell et al showed there was an association between socioeconomic status and education with both cadmium and arsenic and this was usually influenced by smoking habit and occupation. This finding emphasizes the need to educate the respondents about the use of protective equipment to reduce the number of environmental hazards that they would be exposed to.

The mean ALT level was 15.49IU/L (10.38) and fell within the recommended cut off point of 10.0 to 36.0 IU/L, the mean ALP was 13.56 IU/L and also fell within the recommended cut off point of < =240. This could have been attributed to the fact that the respondents were healthy and there could have been an issue of selection bias. The mean AST level was 35.96IU/L and was slightly elevated above the cut off level of 5.0 to 34.0. findings from a study carried out by Giannini, Testa, & Savarino, (2005) showed that the respondents gave information on their co-morbid conditions and the ingestion of medications, taking into account the duration for which these medications were taken during the interview. There may therefore have been bias in the information was sought from the respondents as this information was not included in the present study. Giannini and colleagues further concluded that over the counter drugs and herbal remedies may also contribute to the abnormal level in the enzyme and could alter enzymatic reactions. In addition nonalcoholic fatty liver disease may be a contributing factor in mild alterations in the mean level in the AST enzyme.

The mean concentrations of cadmium among the respondents was recorded as 9.38µg/L

of arsenic was 10.71 µg/L (2.739).The concentration

hold of toxicity at 50µg/L and

exceeding 12 μg/L for cadmium and arsenic respectively. A similar study by Hyder et al., (2014) reported the mean concentration of cadmium was 65 μg/L for women and 85 μg/L for men. The inconsistencies between the present finding and that of Hyder et al could be attributed to Hyder measurement of urinary levels of cadmium as opposed to the present study where blood was used as the biomarker. In reporting the smoking habits of the respondents, 29.3% in the study also reported being current smokers as at the time of the study and may have increase their cadmium levels. However in the present study 94.2% of respondents had never smoked and were generally healthier with regards to smoking habits.

Following regression analysis, results revealed that there was no significant association between variables of the study due to the adequate sample size. Respondents who used borehole water as the major source of drinking water constituted 51.92 % of the respondents and could have been exposed to high level of arsenic concentrations in their blood. However, the mean concentration of arsenic was normal. However, a similar study by Suntra (2015) conducted in India where ground water contaminated was with arsenic level of arsenic exceeded recommended limit. The inconsistencies between the two studies could arise from residents in the reference study being exposed to the ground water for a longer time and this may have been their only source of water.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

In conclusion, this study showed normal activity in the ALT and ALP level and a slightly elevated level in the AST level in the respondents. The respondents all had normal levels of cadmium and arsenic in their blood. There was however no significant association between the liver parameters and the blood levels of cadmium and arsenic level.

6.2 Recommendation

Waste is constantly being generated at the Abokobi open dumpsite and many more people continue to reside at a close distance to the dumpsite. There is urgent need to regulate the dumpsite and segregate the waste that is off loaded there. This would reduce the waste product and toxins emitted from the waste.

Finally, further studies with a larger cohort should be replicated on the urinary, hair and nail deposition of the cadmium, arsenic and other heavy metals to assess their effect on the health of the residents.

REFERENCES

Ali, A. (2011). Glutathione as an antioxidant in inorganic mercury induced nephrotoxicity Review Article mercury induced nephrotoxicity, (May 2015). https://doi.org/10.4103/0022-3859.74298 *Journal of postgraduate medicine.57.72-7*

Davoli, E., Fattore, E., Paiano, V., Colombo, A., Palmiotto, M., Rossi, A. N., … Fanelli, R. (2010). Waste management health risk assessment: A case study of a solid waste landfill in South Italy. *Waste Management*, *30*(8–9), 1608–1613. https://doi.org/10.1016/j.wasman.2009.10.013

Duruibe, J. O., Ogwuegbu, M. O. C., & Egwurugwu, J. N. (2007). Heavy metal pollution and human biotoxic effects. *International Journal of Physical Sciences*, *2*(5), 112–118. https://doi.org/10.1016/j.proenv.2011.09.146

European Commision. (2002). Heavy Metals in Waste Heavy Metals in Waste, (February).

Environmental, T., & Development, S. (2008). Ga East district assembly town Environmental sanitation development.

Giannini E,Testa R,Savarino (2011) Liver enzyme alteration: a guide for clinicians .*Canadian medical association journal 172 (3) 367-379*

Group,World Heath Organization. (1998). Health Impacts of Exposure, (July), 212–214.

Hall, M., Chen, Y., Ahsan, H., Slavkovich, V., Geen, A. Van, Parvez, F., & Graziano, J. (2006). Blood arsenic as a biomarker of arsenic exposure : Results from a prospective study, *225*, 225–233. https://doi.org/10.1016/j.tox.2006.06.010. *Volume 225, Issues 2–3, 15 August 2006, Pages 225-233*

Hughes, M. F. (2006). Biomarkers of Exposure : A Case Study with Inorganic Arsenic, *1790*(11), 1790–1796. https://doi.org/10.1289/ehp.9058*Environ Health Perspect. 2006 Nov; 114(11): 1790–1796.*

Hyder, O., Chung, M., Cosgrove, D., Herman, J. M., Li, Z., Gurakar, A., Pawlik, T. M. (2014) cadmium exposure and l[illegible]er diseases, *17*(7), 1265–1273.

0-9.Cadmium. *Journal of Gastrointestinal Surgery*
5–127

Järup, L. (2003). Hazards of heavy metal contamination, *68*, 167–182.

https://doi.org/10.1093/bmb/*ldg032* British Medical Bulletin, *Volume 68, Issue 1, 1 December 2003, Pages 167–182,*

Khillare, K., Khillare, Y. K., & Wagh, U. (2015). "Bioaccumulation of Heavy Metals In Freshwater Fishes from Aurangabad District, Maharashtra," *4*(9),*World journal of pharmacy and pharmaceutical science volume 4 issue 09 , 511–520.*

Kim, J. W., Park, S., Lim, C. W., Lee, K., & Kim, B. (2014). The role of air pollutants in initiating Liver disease.*Toxicological Research,30*(2),65–70.

https://doi.org/10.5487/TR.2014.30.2.065.

Maheshwari, R., Gupta, S., & Das, K. (2015). Impact of Landfill Waste on Health: An Overview, (2013), 17–23. *IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT) e-ISSN: 2319-2402,p- ISSN: 2319-2399.*

Management, T. E., Ac, P., Clean, T., Act, A., Municipal, T., Regulations, R. M., Regulations, A. (2002). Health and Environmental Effects of Burning Municipal Solid Waste, *2002*(Empa).

Margeli, A., Theocharis, S., Skaltsas, S., Skopelitou, A., & Mykoniatis, M. (1994). Effect of Cadmium on Liver Regeneration after Partial Hepatectomy in Rats, 273–276.*Envioronmnetal health Perspectives,102 (suppl 3) 273-*276Archives of Toxicology
February 1994, Volume 68, Issue 2, pp 85–90

Mazumder, D. N. G. (2015). *6. Health Effects Chronic Arsenic Toxicity. Handbook of Arsenic Toxicology*. Elsevier Inc. https://doi.org/10.1016/B978-0-12-418688-0.00006- *Indian Journal of Medical Research*

Nartey, V. K., Hayford, E. K., & Ametsi, S. K. (2012). Assessment of the Impact of Solid Waste Dumpsites on Some Surface Water Systems in the Accra Metropolitan Area, Ghana, *2012*(August), 605–615. *Journal of water resource and protection.4,605-615*

Neila C, Hernadez –Moreno,D Fidaldo LE ,Lopez Beciero Soler F (2017) Does gender influence the level of heavy metal in the liver of wild boar? *Exptoxicological Environ Saf Journal* Jun;

)17.02.025

Opio-Odongo, J. (2013). Africa environment Outlook (AE03) : Our envioronment,our health.Summary for policy makers IBSN : 978-92-807 3315-0

World Health Organization. (2014). Burden of disease from Household Air Pollution, *35*(February).

Oyeku, O. T., & Eludoyin, A. O. (2010). Heavy metal contamination of groundwater resources in a Nigerian urban settlement, *4*(April), 201–214

Rafati, A., Hoseini, L., Babai, A., Noorafshan, A., Haghbin, H., & Karbalay-doust, S. (2015). Mitigating Effect of Resveratrol on the Structural Changes of Mice Liver and Kidney Induced by Cadmium; A Stereological Study, *20*(June), 266–275.*Prevention Nutrition and Food Science Journal*

Ratnaike, R. N. (2003). Acute and chronic arsenic toxicity, 391–396. *Postgraduate Medical journal 2003 79:391-396*

Santra, A. (2015). *Arsenic-Induced Liver Injury. Handbook of Arsenic Toxicology*. Elsevier Inc. https://doi.org/10.1016/B978-0-12-418688-0.00012-5.

Selvaraj M,Kalist Shagistha , Jaya Paul Renugader,. (2017). Naringenin in Combination with Vitamins C and E Potentially Protects Oxidative Stress- Mediated Hepatic Injury in , (July). https://doi.org/10.3177/jnsv.57.177. *Nutrition Science Journal*

Faroon O,Ashizawa A,Wright S, Tucker P,Jenkins K,Rudswill C. (2012). Toxicological profile for cadmium, https ://doi: 10.5487/TR.2016.32.1.065 .*Toxicological Research Journal*

Singh, A., Bhat, T. K., & Sharma, O. P. (2011). Clinical Biochemistry of Hepatotoxicity. *https://doi.org/10.4172/2161-0495.S4-001. Journal of Clinical toxicology*

Songsore, J. (2009). The urban transition in Ghana: urbanization, national development and inequality. Department of Resource and geography, University of Ghana

Themelis, R. A. (2013). Analysis of Waste Management in Accra, Ghana and Recommendations ineering Center , Columbia University.

Thompson, B. I. A. (2010). Domestic Waste Management Strategies in Accra , Ghana and Other Urban Cities in Tropical Developing Nations .

US EPA. (1995). Municipal Solid Waste landfills,Economic Impact Analysis for the proposed New subpart to the new source performance standards *1*, 1–19.

Wuana, R. A., & Okieimen, F. E. (2011). Heavy Metals in Contaminated Soils : A Review of Sources, Chemistry, Risks and Best Available Strategies for Remediation, *2011*. *International Scholarly Research Notice Journal, Volume 2011,Article 1D 402647* https://doi.org/10.5402/2011/402647

Zhuang, P., Lu, H., Li, Z., Zou, B., & Mcbride, M. B. (2014). Multiple Exposure and Effects Assessment of Heavy Metals in the Population near Mining Area in South China, *9*(4), 1–11. https://doi.org/10.1371/journal.pone.0094484

APPENDICES

APPENDIX 1: Questionnaire

Dear Participant,

We would be very grateful if you would assist in helping us carry out an important study at the School of Public Health at the University of Ghana.

This study will provide you with some helpful information that will help you to maintain good health.

Could you please help us complete this questionnaire by answering a few questions about yourself, your occupation, liver health and medical history? Your participation is vital to the success of this research project.

We would like to assure you that whatever information you give us will be confidential and will be known by only the researchers. The information will be reported in statistical summary form only.

Should you have any questions about the study, or problems with questions in this questionnaire. please do not hesitate to contact the Principal Investigator whose contact information is provided below.

Thank you for your willingness to participate in this important research project.

Ms. Jacqueline Asante-Mensah (Student)

Phone number: 0277483836

Email: jacqueasmens@live.com

Firstly, could you please tell us about yourself?

A. General Information

1. In which year were you born? Year ....

2. What is your gender? □ Male □Female

3. What is your highest level of education? □ No formal education □ Primary □ secondary

B. The next set of questions is about your work

4. How long have you lived in this community? □ 6months -1year □ 2-4years □> 4years.

5. How far do you live from the dumpsite? □about 1 km □ about 2km □about 3km □4km

6. Does the dumpsite expose you to any of the following hazards? Tick (√) as appropriate

Dust	
Smoke	
Irritating gases and liquids	
Heat	
Fumes	

7. Are you exposed to any of the following hazards at your work place? Please kindly tick (√) as appropriate.

Dust	
Smoke	
Irritating gases and liquids	
Heat	
Fumes	
Aerosols	

8a. Do you think this environment can harm your health in any way? □ Yes □No □ Don 't know

8b) If Yes please specify how ....

8c. Do you wear any personal protective equipment when you are working?

□ Never □ Sometimes □Don't know what it is

C. This set of questions is about your health in relation to your working environment?

9a. Do you have any illness you know about? □ Yes □No

9b. Have you had any liver illnesses before? □ Never □ All the time □I don't know

9c. Was it diagnosed by a doctor? □ Yes □No

D The next set of questions is about your habits/ lifestyle.

10a. Do you smoke cigarettes? □Yes □No □In the past

10b. If yes, how many sticks do/did you smoke per day? □ < 5 sticks □ 5-10 sticks □ > 10sticks.

10c.How long have you being smoking? □1-5 years □6-10 years □ >10 years

11a. Do you take alcohol? □Yes □No

11b. how long have you been taking alcohol? □1-5 years □6-10 years □ >10 years

11c.Which type of alcohol do you usually take? Please tick (√) as appropriate.

Spirits	
Bitters	
Beers	
Other	

11d. How much alcohol do you take per day? □ <5 tots □ 5-10 tots □ > 10 tots.

12.Do you take any medication

□Yes □No

a.If yes which one...
b. What is it for...
c. For how long... how often ....

Thank you very much. We really appreciate your participation in this study.

APPENDIX 2: CLINICAL EXAMINATION

Liver Function

ALT...

AST...

ALP......................................

Appendix 3. Informed Consent

Title:

Principal investigator: Jacqueline Asante-Mensah

Qualification: BSc.

Address: School of Public Health, University of Ghana, Legon.

General information about the research

This research is being conducted to assess the liver cell damage among adults residing 1-4km from the Abokobi dumpsite. The entire research will over a 3-month period.

The dumpsite exposes them to dust, smoke and heavy metal pollution which are injurious to human health.

The study is purely an academic exercise and it forms part of the researcher's work towards the award of a Master of Science Degree in Biological Environmental and Occupational health.

Description of level of research burden

Study participants would be requested to answer a questionnaire and participant in sampling for liver function test.

Possible benefits

The benefit to the participants is that, those who require treatment will be advised to contact the nearest health facility for treatment. Also, findings of the study will reposition the EPA to work more on effective preventive health policies to address environmental causes of liver diseases and injury.

Confidentiality

Confidentiality will be assured. The study participants will be assured that all their information will be confidential and will not be disclosed to anyone without their permission.

Data security

All information obtained, would be kept in locked files by the principal investigator with secured pass codes.

Plans for record keeping

The study materials (data on test results, questionnaires, inform consents) would be labelled with participant's names but rather a unique identification number for each study participant.

Person responsible and phone number

The person responsible for the data storage is

Jacqueline Asante-Mensah (Student)

School of Public Health, University of Ghana, Legon.

Mobile number: 0277483836.

Voluntary participation and the right to leave the research

Participating in this research is entirely voluntary. Declining to enter the study, answering a question will have no negative consequences.

Contacts for additional information

Please call the person responsible for this study, Jacqueline Asante-Mensah on 0277483836 if you have questions about the study. If you have any questions about your rights as a research participant or feel you have not been treated fairly, you may contact any of the following:

- GHS/ Ethical Review Committee Administrator, Hannah Frimpong (mobile: 0507041223)
- School of Public health, University of Ghana, Legon, for further clarification or redress.

APPENDIX 4: CONSENT FORM

The above document describing the benefits, risks and the procedures for the research title ("Heavy metals and liver cell damage among adults living close to open dumpsites: A cross sectional study at Abokobi") has been read and explained to me. I have been given the opportunity to ask questions and all the questions that I have asked about the research have been answered to my satisfaction. I agree to participate as a volunteer.

....

Date   **Signature or Thumbprint of Participant**

If volunteers cannot read the form themselves, a witness must sign here:

I was present while the benefits, risks and procedures were read to the volunteer. All questions were answered and the volunteer has agreed to take part in the research.

....

Date   **Signature of witness**

I certify that the nature and purpose, the potential benefits, and possible risks associated with participating in this research have been explained to the above individual.

....

Date   **Signature of persons who obtained consent**

APPENDIX 5: MEDICAL REFERRAL FORM

MEDICAL REFERRAL FORM

Date:

RE: ....

Patient's Date of Birth........................

Dear Dr...................................

The above named client was recently involved in a research project where liver function was examined. The following abnormalities were noted:

We are therefore referring him/her to your facility for appropriate medical care. We are very grateful for your assistance.

Yours faithfully,

....

Jacqueline Asante-Mensah (Biomedical Scientist)

Principal investigator

School of Public Health

University of Ghana

APPENDIX 6: Standard operating procedure for AST and ALT

Principle of the method Transamination is the process in which an amino group is transferred from amino acid to an a-keto acid. The enzymes responsible for transamination are called transaminases. The substrates in the reaction are a-ketoglutaric acid (a KG) plus L-aspartate for AST, and aKG plus L-alanine for ALT. The products formed by enzyme action are glutamate and oxaloacetate for AST and glutamate and pyruvate for ALT. Addition of 2,4, dinitrophenyl hydrazine results in the formation of hydrazone complex with the ketoacids. A red colour is produced on the addition of sodium hydroxide. The intensity of colour is related to enzymic activity.

APPENDIX 7: Analysis of heavy metals

Principles of acid digestion

This technique is usually accomplished by exposing a sample to a strong acid and moderate temperature which leads to a thermal decomposition of the sample and the solubility of heavy metals in solution, it is possible to quantify the sample through elemental techniques.

Reagent

- 30% of concentrated Hydrogen Peroxide (H_2O_2)
- 65-67% of concentrate Nitric Acid (HNO_3)

Glass ware and apparatus

- 50ml of measuring cylinder
- 100ml class A beaker
- Test tube
- Fume chamber
- Clean film
- Hot plate
- A 3ml dropper
- Wash bottle

Hot Plate Acid digestion on Blood sample

Protocol

- Take 2g of sample in a 100ml class A beaker.
- Add 20ml of conc. HNO_3 and 2ml of conc. H_2O_2 in the fume chamber.
- Cover the beaker with a cling film, place it on the hot plate and digest it for 3 hours at a temperature of 45°C.
- After the acid digestion, transfer the sample into a 50ml measuring cylinder and top it to the 30ml mark with distilled water.

- After that, transfer the whole content into a test tube for AAS analysis.

Atomic absorption Spectro

The digestate was then assayed for the presence of Lead (Pb) using VARIAN AA 240FS-Atomic Absorption Spectrometer in an acetylene- air flame.

Reference standards used for the elements of interest, blanks and duplicates of samples were digested under the same conditions as the samples. These served as internal positive controls.

Reference standards used are from FLUKA ANALYTICAL, Sigma-Aldrich Chemie GmbH, a product of Switzerland.

QC/QA:

The following Quality Control and Quality Assurance techniques were used during the analysis:

BLANKS: They were to check contamination during sample preparation.

Duplicates: To check the reproducibility of the method used.

STANDARDS: To check the efficiency of the equipment used.

RECOMMENDED INSTRUMENT PARAMETERS

ATOMIC ABSORPTION: WORKING CONDITIONS.

ELEMENT	WAVELENGTH nm	LAMP CURRENT mA	SLIT WIDTH nm	FUEL	SUPPORT
Pb	217.0	5	1.0	ACETYLENE	AIR

Ref: VARIAN. Publication No 85- 100009-00 Revised March 1989.