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EXPOSURE TO ARSENIC IN DRINKING WATER AND HEALTH SYMPTOMS IN TAMSO, TARKWA.

BY

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DECLARATION

I make a declaration to the effect that this work is the result of my own research and any references made to other works have been acknowledged accordingly. This work was supervised by Dr. Reginald Quansah. However, this work has not been submitted elsewhere for the award of any degree of a sort.

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DEDICATION

With all gratitude I dedicate this thesis to my family and friends especially Madam Vincentia Zaney and Miss Eunet Xenyo. May God bless all our endeavors. Amen.

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My sincere gratitude goes to the almighty God for his grace and mercies through this programme. My sincere gratitude goes to my supervisor Dr. Reginald Quansah for his guidance, time and inputs to make this research a success. I am grateful to Prophet Paul Allotey for his encouragements and supports.

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ABSTRACT

Background: Mining and ore processing produces effluents and waste which contains heavy metals such as Arsenic, Cadmium, lead, Mercury and Chromium which are deleterious to human health. The activities of the mine even though it is economically important has also introduced biological and environmental dilemmas to communities that live close to these mines and such the reason for this study. Increased environmental and biological levels coupled with long exposure to these metals results in bioaccumulation in target organs which results certain health symptoms. Previous research works have confirmed increased levels of heavy metals in the tarkwa-Nsuaem municipality. However, no studies have been conducted to confirm its presence in the natives living around the mines.

Objective: The primary objective of this study is to assess exposure to Arsenic (As) and its association with self-reported health symptoms among residents in Tamso, Tarkwa.

Methods: A cross sectional study was conducted from May to June 2018 among 106 purposively sampled residents of Tamso in the Tarkwa-Nsuaem municipality. Interviews were conducted using a structured health symptoms questionnaire. In a sub sample of 50 residents, urine and drinking water samples were taken accordingly. Mean values and standard deviations of arsenic in drinking water and urine were computed. The relationship between the level of arsenic in drinking water and urine and health symptoms were assessed.

Results: The mean age the study participants was 40.2 years. Most (83.96%) of the participants were aware that their drinking water source was polluted by mining activities and 83.01% were also certain that the pollution could lead to certain health problems in the future. Headache (83%), excessive phlegm production (65%), Itchy eyes (70%) and

skin rash (69%) were common among study participants. Mean level of arsenic in drinking (WAs) was 5.63µg/L and that in urine (UAs) was 6.36µg/L. There was a significant association between UAs and memory (p=0.04) but not for the other health outcomes. Again, WAs was associated with excessive phlegm production (p=0.05). Living within 250m of a mining activity was associated with excessive phlegm production (p=0.035) and itching eye (0.038).

Conclusion: Some self-reported symptoms were identified among study participants. Arsenic level in water was within the WHO guideline of 10 µg/L. Study participants living within 250m were at risk of selected health outcomes.

Keywords: Heavy metal, Arsenic, Health symptoms, Mining, Drinking water, Urine, Tamso

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

As – Arsenic

Cd – Cadmium

Co – Cobalt

Cr – Chromium

Cu – Copper

EPA - Environmental Protection Agency

FDA – Food and Drug Authority

Hg – Mercury

Mn – Manganese

Ni – Nickel

OSHA – Occupational Safety and Health Administration

Pb – Lead

UAs -- Concentration of Arsenic in Urine

WAs — Concentration of Arsenic in Drinking water

WHO – World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 Background of study

Metalloids such as arsenic are almost and always introduced into our surroundings by natural and human processes. Such processes which include: natural breakdown of the earth's layer, Legal or Illegal mining, different types of soil erosions, industrial discharges, runoff water, sewage discharges, pest or disease control chemicals applied to plants, air pollutants and through some other processes. (Morais, Costa, & Pereira, 2012).

Heavy metals generally play an important role in our daily lives and almost all living and non-living things rely on metals at some point. In some physiological processes, metalloids such as cobalt, zinc and selenium are required for enzyme activations and can act as co-factors of enzymes but other heavy metals such as Arsenic (As), Cadmium (Cd), Mercury (Hg) and Lead (Pb) in trace amounts can predispose an individual to deleterious health symptoms. Amongst the many potential metals that may contaminate agricultural and ecological systems, arsenic (As), cadmium (Cd), Lead (Pb), chromium (Cr), copper (Cu), mercury (Hg), nickel (Ni), cobalt (Co) and zinc (Zn) are said to be the main culprits.

The fast paced development and increase in industrialization which involves mining activities over recent years in Tarkwa has introduced significant Biological and environmental dilemmas. Often than not, numerous exploratory studies have documented contamination that is widespread in this area. These studies found traces of mercury and arsenic, in soil , food, plant, water and humans (Bortey-Sam et al., 2015).Tamso our zone of study is a sub community of Tarkwa. Ghana, for a very long time has depended on its natural resources as a source of economic growth and foreign exchange. Mining in general has played a pivotal role in the economic, social and political life of the nation for

many centuries. Currently, most Ghanaians have become wary of the damaging consequences of gold processing while appreciating it's all important position in improving the national economy leading to development (Obiri et al., 2016). Heavy metal is a description given to metalloids whose density is greater that 5g/cubic centimeter. These metals are known to bio-accumulate and bio-transform over time in human tissues and target specific organs in the body that predisposes an individual to certain health symptoms.

During and after the processing of ores, spill offs and dumping of waste releases toxic chemicals into the environments that leads to pollution of the soil, air and natural or artificial water bodies which include streams/rivers and boreholes. Interactions between communities, environment and the mines is inevitable as most rural communities depend on their environment to earn a living and in so doing may ingest, inhale or have dermal contact with the most commonly found chemicals described as Heavy Metals. Heavy metal when released into the environment infiltrates the underground water sources thereby becoming manifest in Boreholes and streams which are the sources of drinking water in the rural communities around the mines.

Some research undertaken by (Bortey-Sam et al., 2015) and (Hayford, Amin, Osae, & Kutu, 2008) on the consequences of gold mining on soil and foods gathered around mining communities in Tarkwa confirmed increased levels of some toxic metals including As and Hg. Similarly, work done by (Sante & Tow, 2009) confirmed high concentrations of Arsenic (As) and manganese (Mn) in boreholes, wells and river/stream water in Tarkwa. Some of these metalloids are actually required by humans in small quantities (Cr, Ni, Co, Cu) while others are carcinogenic or toxic, causing problems to the central nervous system, the kidneys, liver, skin, bones and teeth (World Health Organization, 2011). The use of bio-markers to quantify the presence of these heavy metals is very

important as it is a true reflection of the level of exposure and subsequent health symptoms. The assessment of these metalloids in biological fluids is the simplest way of quantifying biomarkers of exposure to heavy metal by occupational health organizations such as the American Congress of Governmental Industrial Hygienists(Goyer & Group, 2003). There is the probability that exposure to Arsenic levels above 100 micrograms per cubic meter for a short period will result in sore throats and irritated lungs (ATDSR, 2007).

Natives of Tamso are exposed to these heavy metals in all ways as they live around these mines and interact with their environment and even indulge in illegal mining which may affect their health and also pollute their environment. Studies have shown that there is very little literature that looks at the presence of heavy metals in humans.

In a systematic review study by Armah, Quansah, & Luginaah (2014) "A disproportionately large number of papers (about 80%) focused exclusively on environmental media. Out of the 54 articles reviewed, twelve papers devoted attention to heavy metals in either cooked (fish) or uncooked food (vegetables, fruits) or other plants (lichens). Papers focusing on bio-monitoring and human health were few and far between. In total, 10 articles focused on Heavy metals in humans." There is therefore the need for further studies on heavy metals in humans and its associated health symptoms among communities living around mines.

1.2 Statement of the problem

Generally, exposures of humans to heavy metals are through dermal contact, ingestion and inhalation but also proximity and residence could play an important role. Individuals who Work in or reside close to industrial sites that puts such metalloids and their compounds to

use, increases ones risk of exposure, as well as residing near sites where these metalloids are being improperly disposed or due to their natural arsenopyrite rock concentration blasting (Subcommittee, Metals, Committee, & Council, 2003). Itai- itai disease is as a result of Cadmium in the body and mercury in the body also leads to mina-mata disease. Arsenic, another heavy metal also causes poisoning due to drinking water contamination(Kumar Sharma & Agrawal, 2005). Natives of this community depend solely on boreholes/wells and streams for drinking and in so doing introduce these heavy metals into their system. The fact that heavy metals bio-accumulate and bio-transform in target organs over a period of time will lead to physical and clinical symptoms associated with these organs when they become compromised. Kidney problems, stomach aches, neurological disorders, respiratory irritation, gastrointestinal effects, eye irritations and skin rashes/lesions are some of the signs and symptoms that are usually experienced. Some research works done by (Bortey-Sam et al., 2015) and (Hayford et al., 2008) on the influence of gold mining on crops and soils collected around the mining communities in Tarkwa indicated elevated concentrations of some toxic metals and these included Hg and As. Similar works by (Sante & Tow, 2009) also indicative of levels of Arsenic (As) and manganese (Mn) in boreholes, well and stream water in Tarkwa. These researches have all confirmed that there are elevated levels of these metalloids in the area of study hence the need to investigate the presence of these heavy metals among the natives and the common health symptoms that are experienced.

1.3 Conceptual Framework

As shown in figure.1 on **page 6**, metalloids such as arsenic are almost and always introduced into our environment by natural and human means. Such sources which include: natural breakdown of the earth's layer, Legal or Illegal mining, different types of

soil erosions, industrial discharges, runoff water, sewage discharges, pest or disease control chemicals applied to plants, air pollutants and through some other processes (Ming-Ho, 2005).During the mining process, there is the breaking down of rocks, use of chemicals in attracting gold and then the disposal of waste or effluents from the process. Introduction of these metalloids into nature occurs through various processes and pathways, including through the air (e.g. during combustion, extraction and processing), to open water sources (through runoff and releases from storage and transport) and to the soil (and hence into groundwater that is used by crops) (Järup, 2003). Heavy metals are introduced into our bodies either through inhalation or ingestion, which are the main pathways of entry for populations(Kumar Sharma & Agrawal, 2005).

Prolonged exposures to arsenic in water for drinking is strongly linked to elevated risks of skin cancer, but also some other cancers, as well as other skin complications such as hyperkeratosis and skin color changes, similarly severe mercury exposure may give result in damage lungs. Prolonged poisoning is associated with neurological and psychological symptoms, such as tremors, changes in personality, restlessness, anxiety, sleep disturbance and depression(Järup, 2003).

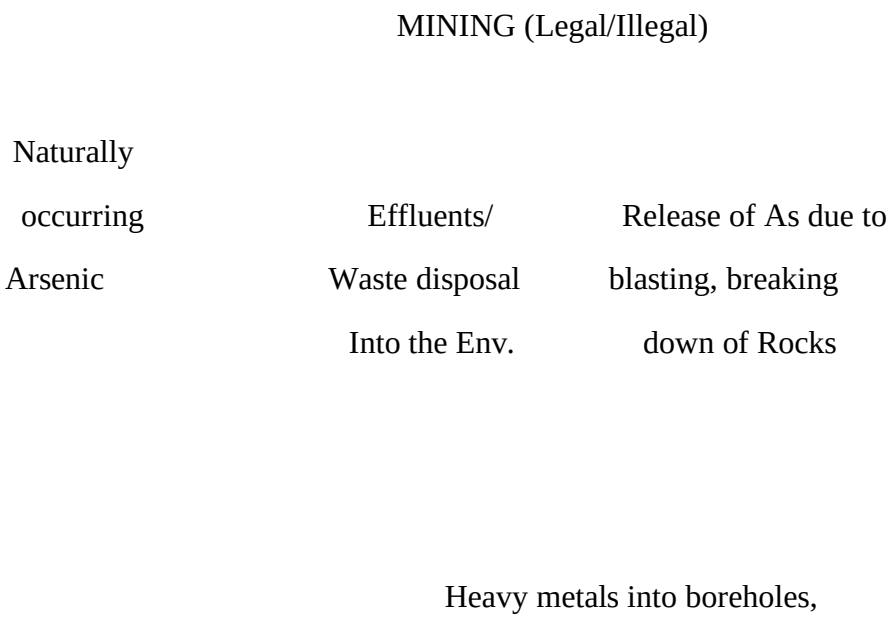


Figure 1. Pathway linking heavy metal exposure to health symptoms

1.4 Justification

Mining is generally a capital intensive and lucrative venture that serves as a source of financial support for families and individuals directly or indirectly. According to the Ghana Chamber of Mines, Mining contributed up to 6% of GDP (Gross Domestic Product

in 2011 and that division improved by 23.5% in 2012 and also reimbursed about USD 3.2 billion indicating 72% of their mineral income through the Bank of Ghana and the Commercial Banks in the year 2012.

Aside these great economic benefits are serious health issues associated with the activities of mining. The process of mining and improper waste disposal results in the release of heavy metals into the environment at the expense of communities living around.

In general the toxicity of metalloids to a human or animal system has to do with the reactivity of the chemical ions with cellular structural proteins, enzymes and membrane system. The target organs of specific metal toxicities are usually those organs that accumulate the highest concentrations of the metal in vivo(Mahurpawar, 2015).

The main metalloids that produce the most common health symptoms when exposure to are lead, cadmium, mercury and arsenic. There have been studies to show their effects on human health and as such, their levels in any medium is constantly being reviewed by international bodies such as the WHO(Järup, 2003).

Since all these informations are well documented, there is then the need for Government to ensure that these mining companies use improved technologies that will less pollute the environment. Quantifying the burden of disease from heavy metal pollution will be important for strategizing, minimizing and improving the health of our environment and its people.

1.5 Study Objectives

1.5.1 General Objectives

The general objective is to assess exposure to Arsenic (As) and its association with self-reported health symptoms among selected residents at Tamso, Tarkwa.

1.5.2 Specific Objectives

i. To determine the burden of respiratory symptoms, neurological symptoms, gastrointestinal symptoms and other physiological symptoms among the participants.

ii. To determine the mean level of Arsenic in urine and drinking water

iii. To determine the association between distance from mine, mean arsenic levels in drinking water/urine and self-reported health symptoms

1.6 Research Question

i. Is there an association between Respiratory (phlegm production and wheezing), Neurological (sleeplessness, memory loss, headache and change in vision/hearing) Gastrointestinal (diarrhea and vomiting) and other health symptoms (itchy eyes, sore throat and skin rashes) and the drinking water in the community?

ii. Could there be a relationship between living close to the mining site and some self-reported health symptoms.

iii. Is there an association between Arsenic levels in urine and arsenic levels in drinking water.

CHAPTER TWO

LITERATURE REVIEW

2.1 Scope of Review

This main idea of this review is to discuss the additive and singular results of these metalloids on mammalian health. To discuss if Single doses of certain heavy metals may have deleterious health symptoms as strong as a cocktail of heavy metals or vice-versa. Due to bio-accumulation, these heavy metals target organs through different biochemical and physiological means.

In general, the ability of these metalloids to cause disease in the human systems is as a result of the chemical reactivity of the ions with cellular structural proteins, enzymes and membrane systems. The main organs that get targeted are those organs that can hold the highest concentrations of the specific metalloid in-vivo (Mahurpawar, 2015).

2.2 Legislation on Heavy metals

Ghana has a lot of legislations on every pertinent issue but the problem of enforcing the laws by the appropriate agencies has led to the assumptions that the laws do not exist. The EPA is the governing body responsible for enforcing environmental protection bills that are passed. The constitution of Ghana clearly outlines the basis for the safeguarding of our environment and also mandates the state to employ the most efficient measures required to protect the national environment for the future; and to work hand-in-hand with other countries, regions and bodies for the purpose of safeguarding the environment for mankind to promote health, safety and wellbeing of all individuals in employment, and set the basis for the full distribution of the creative potential of all Ghanaians (Constitution of

Ghana, 1992).Bearing on this , it is the right of every citizen to have a clean environment but this is never the case.

2.3 Importance of heavy metals

From literature, only a small proportion of these metalloids are not known to be important to mammalian health but may have some important benefits at decreased levels of exposure and these are silicon, nickel, boron, and vanadium but have deleterious defects at increased levels and again silicon, nickel, boron, and vanadium have been demonstrated to possess some biological functions in crops and some animals but its importance for humans has not been seen due to the fact that human studies are limited. (Goyer & Group, 2003).

Some selected heavy metals and their functions are described below as follows:

Copper is an important component of different enzymes including ferro-oxidase (ceruloplasmin), cytochrome – c – oxidase, superoxide dismutase and others. It has an important function in iron metabolism, melanin production and central nervous system function. The copper content of the human body is said to be between 50-120 mg. Elevated concentrations are found in liver, brain, heart, spleen and kidneys. Selenium which is also an important component of the enzyme glutathione peroxidase, which protects protein, cell membranes, lipids and nucleic acids from oxidant molecules. Chromium increases the action of insulin in patients with decreased glucose tolerance. The suggested intake (in adults) is 50-200 micrograms/day(World Health Organization, 2011). A little increase above these guarded levels then there's health problem to be dealt with.

2.4 Health Symptoms of Heavy Metals

Chemicals play an important part in humans. Living and non-living things all make use of some type of heavy metal at some point. Most heavy metals can, when employed appropriately lead to the enhancement of the quality of life, health and well-being. Other chemicals that are also potentially dangerous can also deleteriously affect our well-being and environment when negligently managed(World Health Organization, 2011).

New trends have shown that metalloids are fast emerging as human carcinogens. These five transition metals; arsenic, cadmium, chromium VI, beryllium, and nickel are accepted as human carcinogens in one form or another. (NTP, 2002). Routes of exposure and type of heavy metal usually determine which organ is affected and the type of health symptom that will be experienced.

High exposures to mercury have led to death but the most commonly seen defects are neurological and renal which is as a result of breathing in mercury vapor. Other health symptoms associated with inhaling the vapor includes memory loss, emotional instability, sleeplessness, tremors , neuromuscular changes, and headaches as well as kidney and thyroid defects.(World Health Organization, 2011).

Some current evaluation indicates that exposure to Arsenic in drinking water is related to lung cancer, kidney, bladder, skin defects and the last of which is preceded by directly observable precancerous lesions. Even though other studies may mention other health defects, there could be a school of thought that would look at the additive effects of all these heavy metals on an individual.

2.4.1 Arsenic

There are four oxidation states in which Arsenic is known to exist and these are -3, 0, 3 and 5. It is found to be naturally occurring throughout Earth’s crust, most often as

arsenides, arsenic sulfide or as metal arsenates. In water, it exists as arsenate, with an oxidation number of 5, when the water is not oxygen deficient(Cooksey, 2012).

Introduction of Arsenic into the environment is mostly by natural weathering of rocks and mining activities and it has uses in the processing of glass, pigments, wood preservatives, paper, textiles as well as an alloying agent. According to WHO, Arsenic in humans has a half-life of 2-40 days which allows the internal dose of inorganic arsenic in individuals to be determined by measuring the arsenic species in urine since it is excreted by the kidney. Thus, measurement of urinary arsenic levels is generally accepted as the most reliable indicator of recent arsenic exposure, and proved useful in identifying above average exposures in populations living near industrial point sources of arsenic.

With the exception of individuals who are occupationally exposed to arsenic, the most common route of exposure is via the oral ingestion of food and drinking-water, including beverages made from those types of drinking water. In any type of drinking water, the mean daily intake is pegged at 10 µg/l (World Health Organization, 2011).

Prolonged exposure to arsenic in drinking water some time ago in Taiwan resulted in the Black foot disease which was described as the damage done to the blood vessels of the lower limbs which led eventually to progressive gangrene (Mahurpawar, 2015).

Keratosis, kidney damage , hyperpigmentation, liver damage and anemia are however caused by chronic poisoning of Arsenic and Other effects of arsenic include peripheral vascular disturbances resulting in gangrene(Kumar Sharma & Agrawal, 2005). Confirmations of these health symptoms were also outlined by a few studies performed on Populations exposed to arsenic via drinking water and showed excess risk of mortality from lung, bladder and kidney cancer, with risk increasing with increased exposure. There is also an increased risk of skin cancer and other skin lesions, such as hyperkeratosis and

pigmentation changes (Järup, 2003). Arsenic exposure is also believed to induce hypertension. All the above information describes the heavy metal Arsenic and its deleterious health effects according to route and length of exposure.

2.4.2 Mercury

Mercury stands tall as one of the most toxic heavy metals known to man(Castro-González & Méndez-Armenta, 2008). Apart from the toxic nature of this heavy metal, it has some benefits. Production of batteries, light bulbs, switches, dental fillings and thermometers employ the use of metallic and also in the manufacture of chlorine gas and caustic soda.(Griswold & Martin, 2009).

Regulatory authorities have set limits as to the level of this toxic metal that an individual could be exposed to. According to the Environmental Protection Authority and Occupational Health and Safety Administration of the United States of America, the limits are to be strictly adhered to.

According to these agencies, the regulatory limits are 2 parts per billion in drinking water, 1 part of methyl mercury in a million parts of sea foods, 0.1 milligram of organic mercury per cubic meter of workplace air and 0.05 milligrams per cubic meter of metallic mercury vapor in an 8 hour shift job and 40 hour work per week(Kuipers, Maest, MacHardy, & Lawson, 2006) .If these limits are exceeded over long periods then the health symptoms associated with target organs will be experienced.

The sensitivity of the nervous system is to all forms of mercury. Exposure at Increased levels can damage the brain permanently as well as developing fetuses and the kidneys. Some defects of the brains functions will result in changes in vision or hearing, shyness, memory problems, tremors and shyness. Short term exposure to high levels of vapors of

metallic mercury may cause lung damage, diarrhea, nausea, skin rashes, eye irritations and increased blood pressure(Griswold & Martin, 2009).

2.4.3 Cadmium

Cadmium is introduced into the air by mining industries, metal-smiths and other manufacturing industries that employ compounds of Cadmium for batteries, alloys and plastics although most countries have set strict rules and regulations on its discharge into the environment(Morais et al., 2012).

Cadmium bio-accumulates in the mammalian body and as a result affects several organs like the kidneys, brain, liver and the central nervous system (Castro-González & Méndez-Armenta, 2008). The Environmental Protection Agency set a maximum allowable contaminant level for cadmium in drinking water at 0.005 mg/L whereas the World Health Organization did adopt an increased but provisional contamination guideline of 0.003 mg/L (WHO, 2004a).

Studies have shown that non-smokers are less exposed to cadmium than smoker and the type of deleterious health symptoms experienced is linked strongly to how long an individual is exposed. Vomiting and diarrhea are associated with ingesting high levels of cadmium. Chronic exposure at decreased levels bio-accumulate and bio-transform in kidneys resulting in possible kidney disease, fragile bones, and possible lung damage (Griswold & Martin, 2009).

2.4.4 Chromium

Chromium is found in rocks, plant, animals and soils and may exist in the gaseous, liquid or solid state. Chromium has been found to have a strong affinity for soft tissues and soils particles, it does not always migrate into underground water sources but found in sediment in water (Kojadinovic et al., 2008). Chromium is employed in the production of materials

such as magnetic tapes, rubber, magnetic tapes, floor coverings, paper and other materials. Regulatory limits set for this metal in the environment for drinking water is 0.1 ppm (parts per million. The Food and Drug Authority stipulates it should go above 1 milligram per liter (1 ppm) in pet bottled-water and the OSHA sets it as a range of between 0.0005 and 1.0 milligram per cubic meter for workplace air on an 8-hour job day, 40-hours for a week, with regards to the type of compound. Inhaling increased levels of this heavy metal can induce irritations in the nose such as runny nose, nose ulcers and breathing complications such as shortness of breath, wheezing, asthma, or coughs. Allergic reactions of the skin to this heavy metal were noted as severe redness and swelling of the skin. Continued exposure can lead to damaged liver, nerve tissue damage and kidneys.

In summary, Mining and some natural processes release these heavy metals (Arsenic) into the environment which contaminates the soils, water and air. Exposure of the natives to these heavy metals via ingestion, inhalation and dermal contact in their daily lives and over the years will result in the deleterious health symptoms. Several studies have confirmed the presence of heavy metals in foods, water and soils of this locality but not in the natives residing in this area. This is the main aim this study is looking to address.

CHAPTER THREE

METHODOLOGY

3.1 Overview

This Chapter clearly spells out the methods that were used in this research; giving descriptions of the study design, study procedures, sampling methods, study area, data collection and data analysis as well as ethical considerations.

3.2 Study Area

The Tarkwa-Nsuaem Municipality is one of the twenty-two districts in the Western region of Ghana. It has a total land area of about 2,354 square kilometers. The vegetation is evergreen with mountainous ranges, which presents appealing aesthetic viewing pleasure for those living in the area. Fortunately or unfortunately, these ridges are the main gold-nuggets and as such are targeted for open cast mining which has caused them to undergo tremendous mining-related developments in recent years.

According to the 2010 Population and Housing Census, the total population was about 90,477, with relatively more males (51.6%) than females (48.4%). The population of the Municipality is youthful, with about two-fifths (38.1%) aged below 15 years and a smaller proportion of (4.4%) are elderly persons (aged 60 years and older). The total age dependency ratio for the Municipality is 69.6 with the females ratio (72.6) being higher than that of males (67.1).

The Tarkwa mine is a large open cast mine that is situated northwest of the town, and Nsuta manganese mine is situated east. Tarkwa has a long history of gold mining and perhaps the greatest concentration of mining companies including illegal mining (galamsey) activities in the West African sub-region.

Tamso which is our selected sub community for the study is approximately 5.2 km away from the mines. Mining activities results in release of heavy metals which are ingested in drinking water, inhaled through breathing and by contact which may compromise the health of the natives.

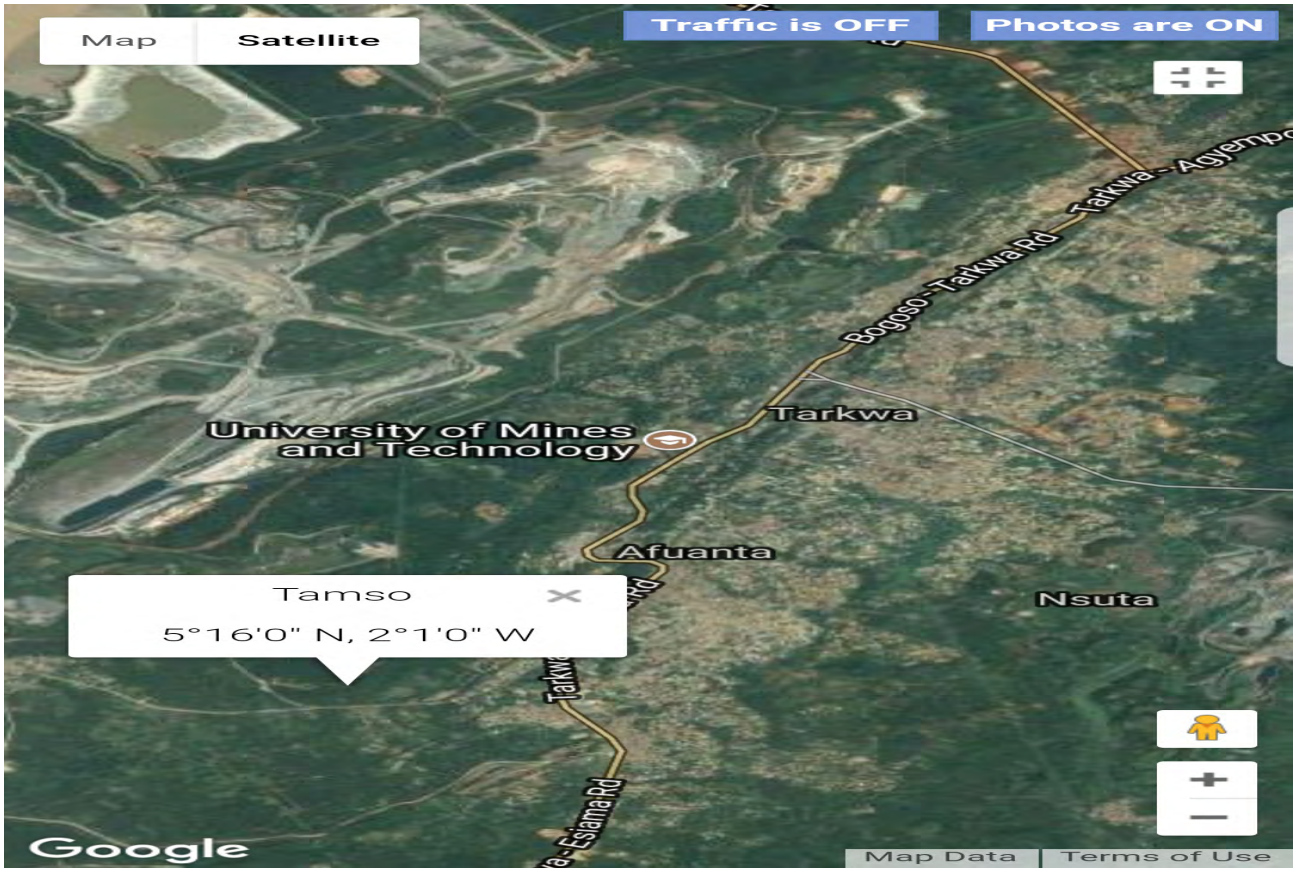


Figure 2: Map showing Tamso in Tarkwa-Nsuaem Municipality, source: Google maps.

3.3 Study Design

A cross sectional study was carried out in May to June 2018 to assess the exposure to heavy metals in drinking water and its associated health symptoms among residents of Tamso who live around the mines. This is a cross sectional design in which data on drinking water, Urine and respiratory, Neurological, Gastrointestinal and other health symptoms were collected. The drinking water and urine samples were tested using an

Atomic absorption spectrometer to ascertain the levels of As. A well-structured health symptom questionnaire was also administered to participants in view of identifying common self-reported health symptoms associated with the exposure to Arsenic. The health symptoms were categorized as respiratory (phlegm production and wheezing), Neurological (headache, memory loss, sleeplessness, change in vision/hearing), Gastrointestinal (Diarrhea and vomiting) and other health symptoms (itchy eyes, sore throat and skin rash).

3.4 Source/ Study population

A community of about 2500 residents who engage in various activities from farming, livestock rearing and small-scale mining are all exposed to this effluents from the mines. A sample of 106 residents were recruited using the simple randomized sampling technique to provide their urine and water samples from the drinking water used in their homes as well as complete a four section questionnaire. The sample analysis was based on the number of natives recruited.

3.5 Study Variables

3.5.1 Independent variables

The three indicators of arsenic exposure used in this study included: (i) Levels of Arsenic in Urine and drinking.

(ii) Proximity to the mine (<= 250 m vs >250 m). (iii) Age, sex, occupation and level of education

3.5.2 Dependent variables

The main dependent variables were: (i) Respiratory (wheezing and phlegm production), Neurological (sleeplessness, headache, memory loss and change in vision/hearing)

Gastrointestinal (diarrhea and vomiting) and other physiological (itchy eyes, sore throat and skin rash) self-reported health symptoms.

3.6 Sampling Procedures

All 106 residents were actively recruited from homes using the simple purposive sampling where every native that arrived at the community center was asked to pick any of the two ballot papers that answered yes or no. Individuals that picked yes were allowed to enter the study. All samples were collected at the premises of the community center where some research assistants and a qualified laboratory technician were stationed for collating all samples and administering the questionnaires. The eligibility criteria for participating in the study were willingness to partake in the study, consenting and signing a consent form and being a resident native. Individuals who did not want to participate or had any medical incapacitations were allowed to leave the study.

After thoroughly explaining the aim of the study to the participants and receiving an informed consent, the participants completed the questionnaire with the help of research assistants who were trained during pretesting. Interpreters were also called upon when language became a barrier.

The participants had their drinking water samples taken by qualified laboratory technician after which they were required to wash their hands with soap under running water before given urine containers for their urine sample collection.

3.7 Data Collection Tools

The data collection tools included a modified health symptoms questionnaire, urine sampling kit for Urine sampling and a drinking water sampling kit.

3.7.1 Drinking Water Specimen Collection kit

Non-sterile plastic water containers were used to collect 50ml of drinking water from the homes of participants since we had to be sure if that drinking water was what was being used.

3.7.2 Urine sample collection kit

Non-sterile plastic urine containers were used to collect 50 ml of urine from each participant. The urine containers were labelled to coordinate with drinking water containers as well questionnaire numbers. The urine samples were stored on ice and transported to Ecolab in Accra for heavy metal analysis.

3.7.3 Questionnaire

The interview questionnaire was in four parts. Part one handled information on demographic and personal data such as age, Marital status (married, single, co-habiting) and highest level of education (No formal education, primary, Junior High School, Senior High School). Part two also asked information pertaining to drinking water quality, work (farmer or illegal miner), and length of residence in the community, types of exposure at work and home (pesticides on farm, source of drinking water) and health safety issues. Part three was about lifestyle (alcohol intake, smoking) and part four was also about experienced health symptoms (phlegm production, diarrhea, skin lesions, coughs, vomiting, itchy eyes, sleeplessness, Change in vision/hearing, Diarrhea and the presence of non-healing wounds/Ulcers.

3.8 Sample Collection Procedure

3.8.1 Urine Sample Collection

In the collection of all samples, non-sterile sample collection kits and standard procedures were followed. All materials and instruments were washed with 1M nitric acid and demineralized water.

The participants were provided with clean water and soap for hand washing before handing out the sterile metal-free plastic urine containers. They were told void the first portion of urine before collecting 50 ml midstream urine into the container. These urine samples after being taken were refrigerated but stored on ice at (4-8^{0}C) and then transported from Tarkwa to Ecolab in Accra for analysis of heavy metals.

3.8.2 Drinking water sample collection

Research assistants collected 50ml of drinking water from homes of participants into non-sterile plastic water kits and stored on ice at (4-8^{0}C) before it was also transported to Ecolab for biological sample analysis for estimation of heavy metals.

3.9 Laboratory analysis

3.9.1 Urine and Drinking Water sample Analysis for Heavy metal (As)

Pipettes and calibrated analytical balances were employed in the measure of all samples. Samples of Urine were pretreated with nitric acid and allowed to stand for 3 hours in a process called digestion whereas the water samples did not need to be digested. Digestion is done to improve the rate of detection of analytes by the Atomic Absorption spectrometer. Samples were analyzed using high resolution continuum source atomic absorption spectrometer (PinAAcle 900T, PerkinElmer) with a detection limit of 1.51

µg/L. The detection limit is that value below which analytes in a sample cannot be detected.

3.10 Quality control

Certain measures were undertaken to ensure that the data collected were of good quality so as to assure validity. Research assistants received training in questionnaire administration, Urine and drinking water sampling. Participants were also asked to wash hands with soap under running water before urine sample collection. Both Urine and drinking water samples were stored over ice just to maintain high quality standard of samples bound for the laboratory. The responses were transcribed using Microsoftq` Excel v.2013 and then later imported into STATA V15. To ensure coordination, the questionnaires were labelled with unique numbers and alphabets to link with the urine and drinking water samples.

3.11 Data processing and Analysis

The data that collected was cross examined for inconsistencies and incomplete values. Data was entered into Stata v.15 and Excel spreadsheet. Means and standard deviations were computed for continuous values. Multiple and correlational analysis were used to state relationships between heavy metals and health symptoms while confounders will be controlled.

3.12 Ethical Considerations

Ethical clearance was sort from the Ethical review Board of the Ghana Health Service. Permission was also sought from the leaders of the community and from the school of public health, University of Ghana.

3.13 Informed Consent

A written consent form was issued to every participant. Before individual participant gave their Consent, the participant information leaflet and the consent form that contained the benefits, risks and the procedures for the research were read out and explained to each participant before they appended their signatures or thumbprints. Participants in the study were informed that, there were direct benefits to the participants of this study. However, the information provided will contribute to the overall knowledge of heavy metal exposure and its health symptoms. They participants had the liberty to ask questions, and to seek clarifications or Withdraw unconditionally.

CHAPTER FOUR

RESULTS

4.1 Section 1 Demographics of Participants

Table 4.1: Socio-demographic characteristics of participants (n=106)

Variables	Frequency	Percentage
Age (mean (SD))	**40.2 (16.22)**	
Sex		
Male	46	43.4
Female	60	56.6
Marital status		
Single	36	33.9
Married	70	66.1
Highest educational status		
No	27	25.47
Primary	27	25.47
JHS	40	37.74
SHS	12	11.32
Smoke cigarettes		
Yes	12	11.32
No	94	88.68
Alcohol use		
Yes	45	42.45
None	61	57.55
Occupation		
Farmer	43	40.57
Small scale Miner	13	12.26
Other	50	47.17

***other occupation: petty traders, students, food vendors, house wives and unemployed.**

The mean age (standard deviation) of the study participants was 43.3 (16.22) years. Majority of the participants were females (56.60%) who were married (66.1%) and were mostly educated till the Junior High School level (37.74%). They were employed in other businesses (47.17%) apart from farming and small scale mining, however, they were mainly nonsmokers (88.68%) and non-alcohol users (57.55%).

4.2 Self-Reported Health Symptoms

The data collected on self-reported health symptoms that exposures to arsenic contamination predisposes the participants to always or sometimes were categorized under respiratory (wheezing and phlegm production), neurological (sleeplessness, headache, memory loss and change in hearing/vision), gastrointestinal (diarrhoea and vomiting) and other physiological symptoms. Phlegm production (61.32%) was commonly reported amongst the respiratory symptoms by the participants. Headache (78.3%) and change in hearing/vision (60.38%) were also reported severally under the neurological symptoms. The phenomenon of itchy eyes (74.53%) and skin rash (65.09%) were all also reported as seen in (**Table 4.2)** below.

4.2.1 Health Symptoms.

Table 4.2.: Self-reported health symptoms among participants. (n= 106)

Symptoms	Always/sometimes (%)	Never (%)
Gastrointestinal symptoms		
Diarrhea	35 (33.02)	71 (66.98)
Vomiting	32 (30.19)	74 (69.81)
Respiratory symptoms		
Phlegm production	65 (61.32)	41 (38.68)
Wheezing	44 (41.51)	62 (58.49)
Neurological symptoms		
Headache	83 (78.3)	23 (21.7)
Change in vision/hearing	64 (60.38)	42 (39.62)
Memory loss	63 (59.43)	43 (40.57)
Sleeplessness	54 (50.94)	52 (49.06)
Other symptoms		
Skin rashes	69 (65.09)	37 (34.91)
Itchy eyes	79 (74.53)	27 (25.47)
Sore throat	45 (42.45)	61 (57.55)

Table 4.2 above shows how the health symptoms are distributed among the natives when asked if they always/sometimes or never experience such health symptoms.

4.3. Indicators of Arsenic exposure

Table 4.3: Arsenic levels in different media (n=50)

Variables	Mean	SD	Median	(LQ, UQ)
Arsenic level in water	5.63	1.39	6.132	(4.97, 6.63)
Arsenic level in urine	6.36	1.04	6.7155	(5.63, 7.19)

The Table 4.3 above shows the mean (S.D) of arsenic in various media. The mean (SD) 5.63(1.39) levels in drinking water was below the WHO guideline of 10 µg/l. This mean (SD) 6.36(1.04) level of arsenic in urine was recorded but because there are no guidelines to urine arsenic levels, it is not known if it is high or low but could be a reference.

Table 4.4. Proximity to mine as indicators of arsenic exposure (n = 106)

Parameter	Number (n)	Percentage (%)
proximity to mine		
<250 meters	92	86.79
>250 meters	14	13.21

The **Table 4.4** above shows the numbers and percentages of proximity to mine used as indicators for level of arsenic exposure. Most (86.79%) of the participants lived within 250m of the mine.

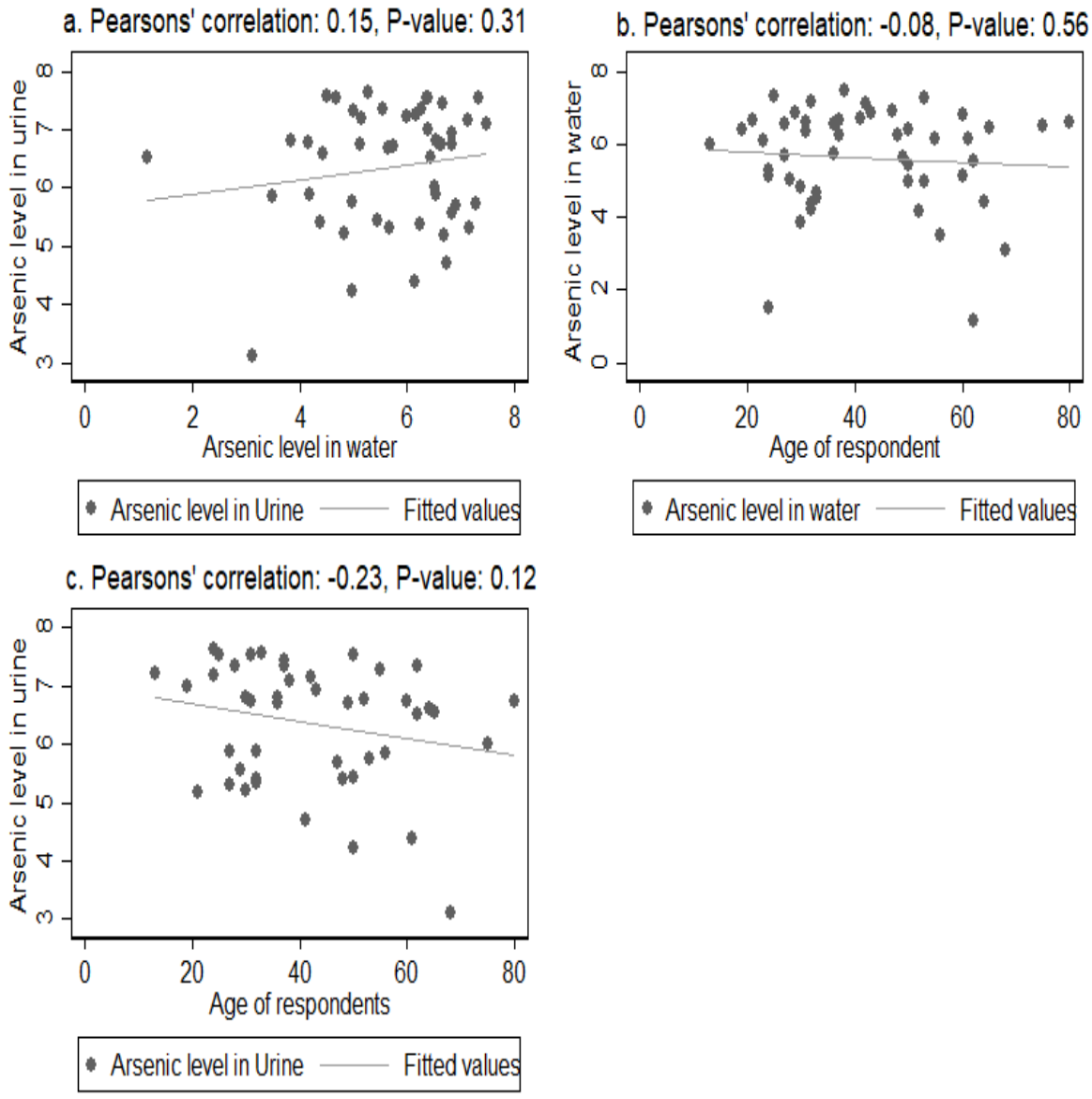
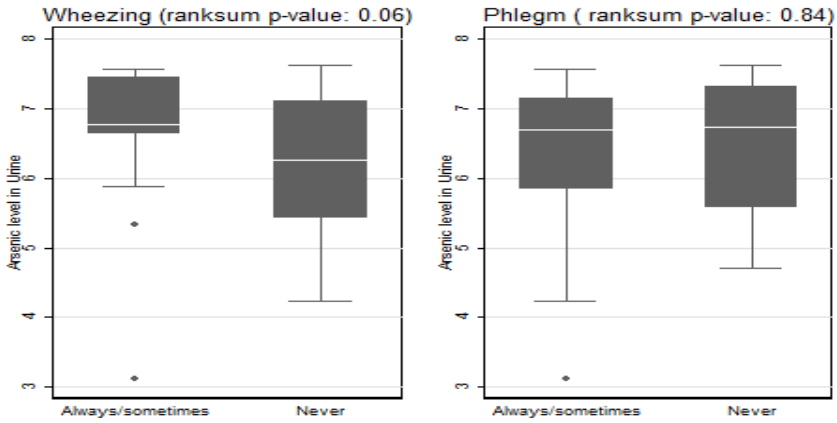


Figure 3: Correlational analysis: a) Urine As level vs. Water Arsenic b) water As level vs. age of participants c) Urine Arsenic level vs. age of participants.

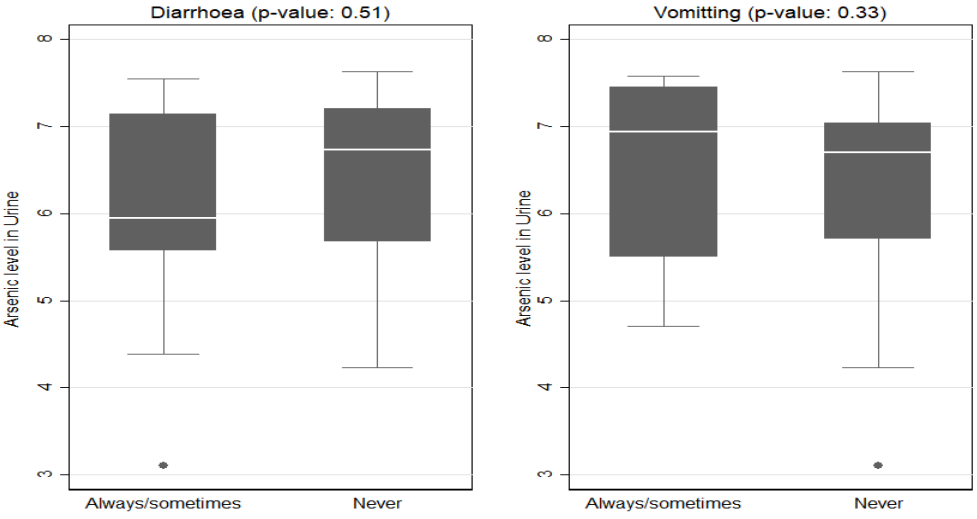
The analysis above describes the correlation between age of respondents, water arsenic and urine arsenic**. Figures 3 b and c** were correlated negatively while **figure 3a** was positively correlated but none of **figure 3 a, b, or c** were statistically significant, however, there was a moderate correlation between Water arsenic and urine arsenic.

Figure 4: A distribution of Urine Arsenic against respiratory, gastrointestinal, neurological and other health symptoms.



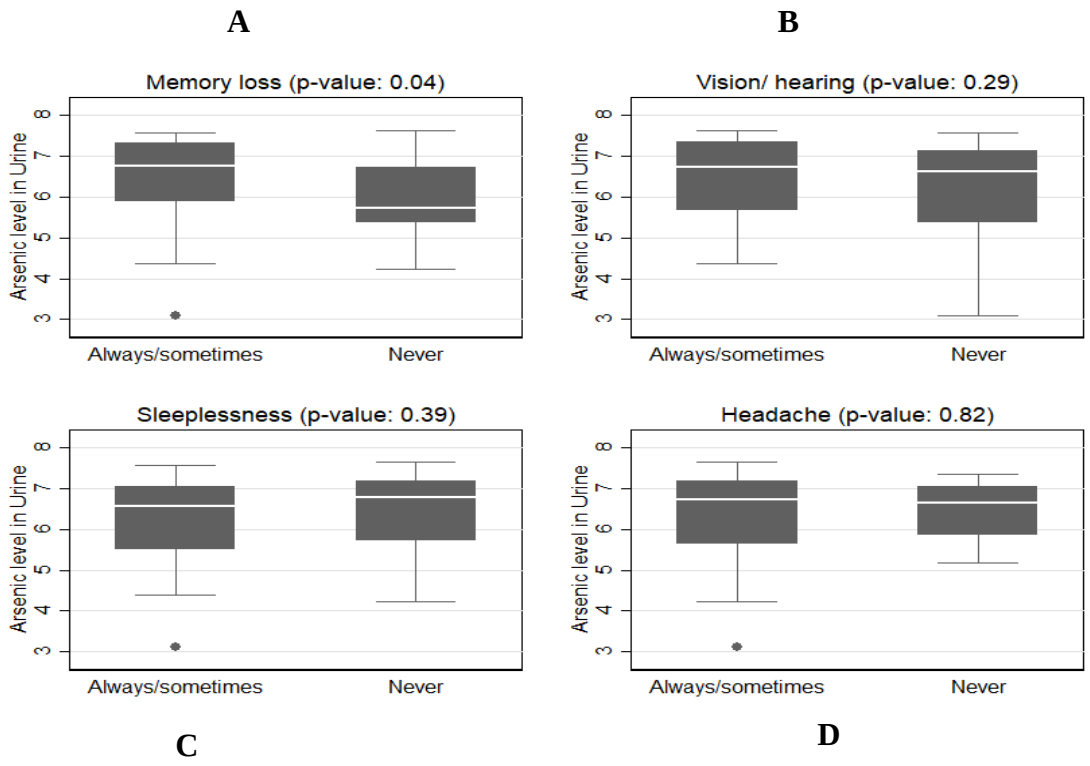
A **B**

Distribution of Arsenic level in urine against A.wheezing and B. phlegm production

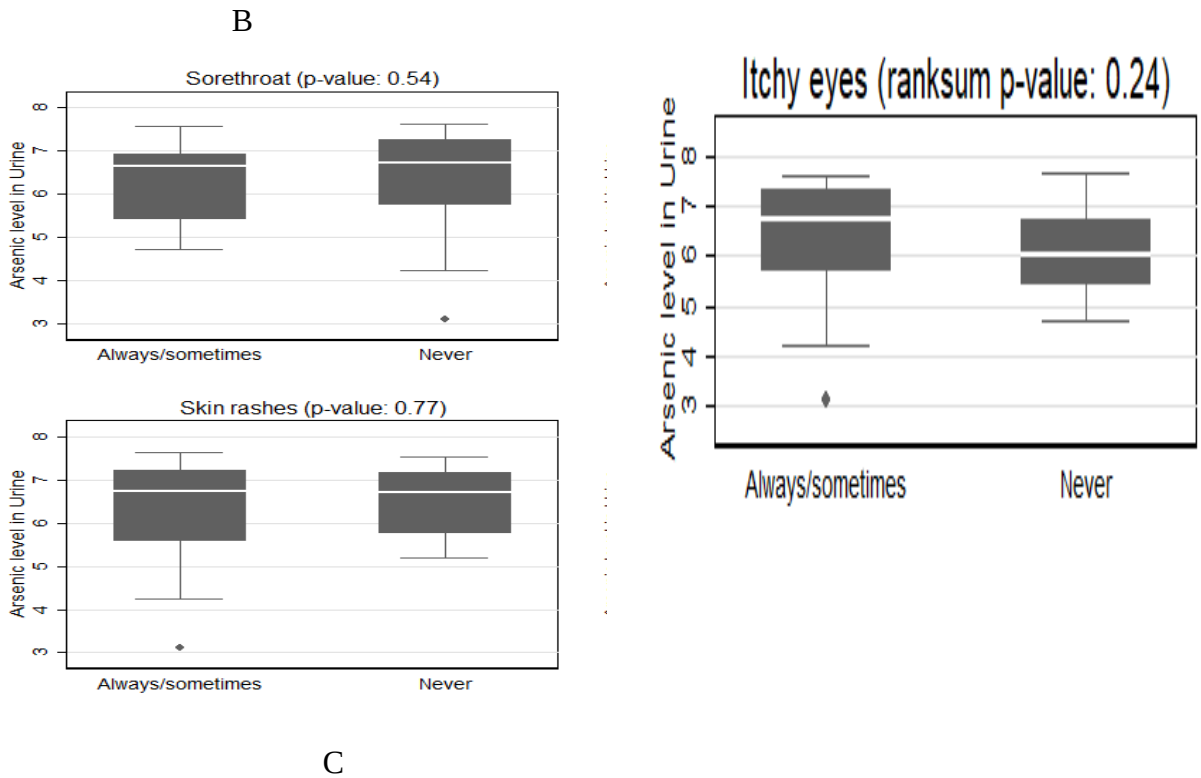


A B

Distribution of Arsenic level in urine against A. Diarrhoe B.Vomiting



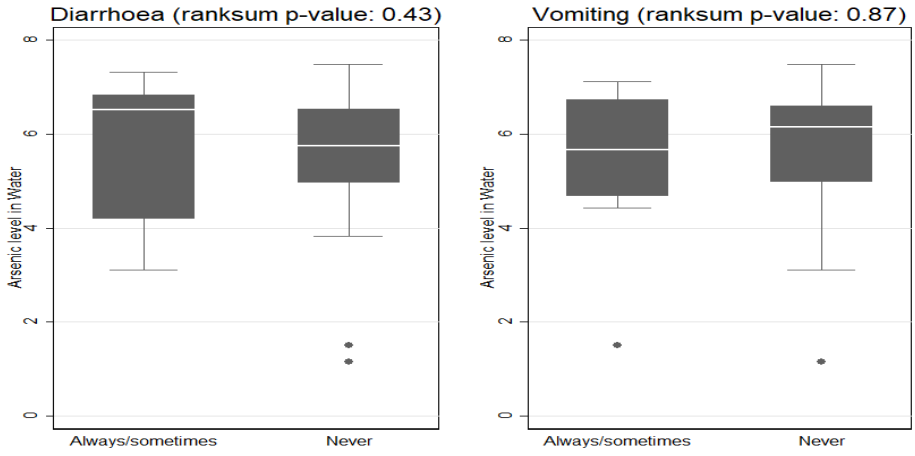
Distribution of Arsenic level in urine against a, b, c and d.



D: ***Distribution of Arsenic level in urine against A.sore throat B.itchy eyes and C.skin rash***

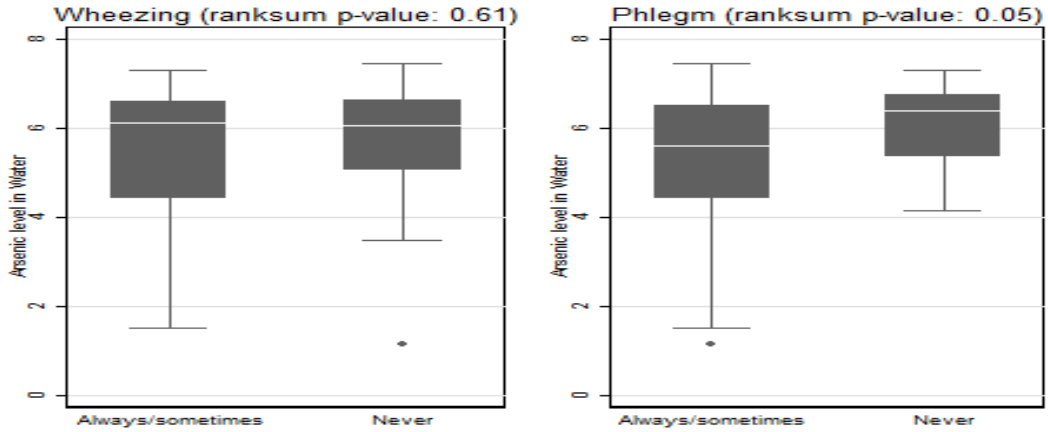
The boxplots in **figure 4** above shows the distributions of self-reported health symptoms versus Urine arsenic levels. The distribution looked at the burden of health symptoms likely to be experienced when the levels of arsenic in urine have been confirmed by analysis with atomic absorption spectrometry. Most of the health symptoms were not statistically significant when they were compared with the urine arsenic levels except for the memory loss which was found under the category of neurological health symptoms with mean(lower and upper quartiles) of 6.76 (5.89-7.33) and (p=0.04).

Figure 5: Distribution of water arsenic versus grouped health symptoms



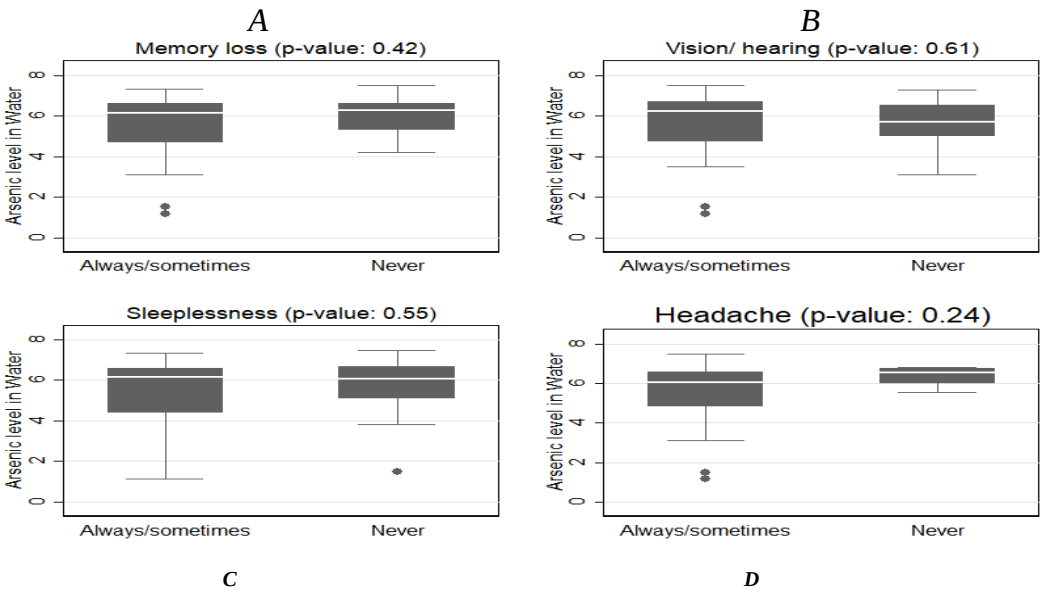
A B

Distribution of Arsenic level in water against A. Diarrhoea and B. Vomiting

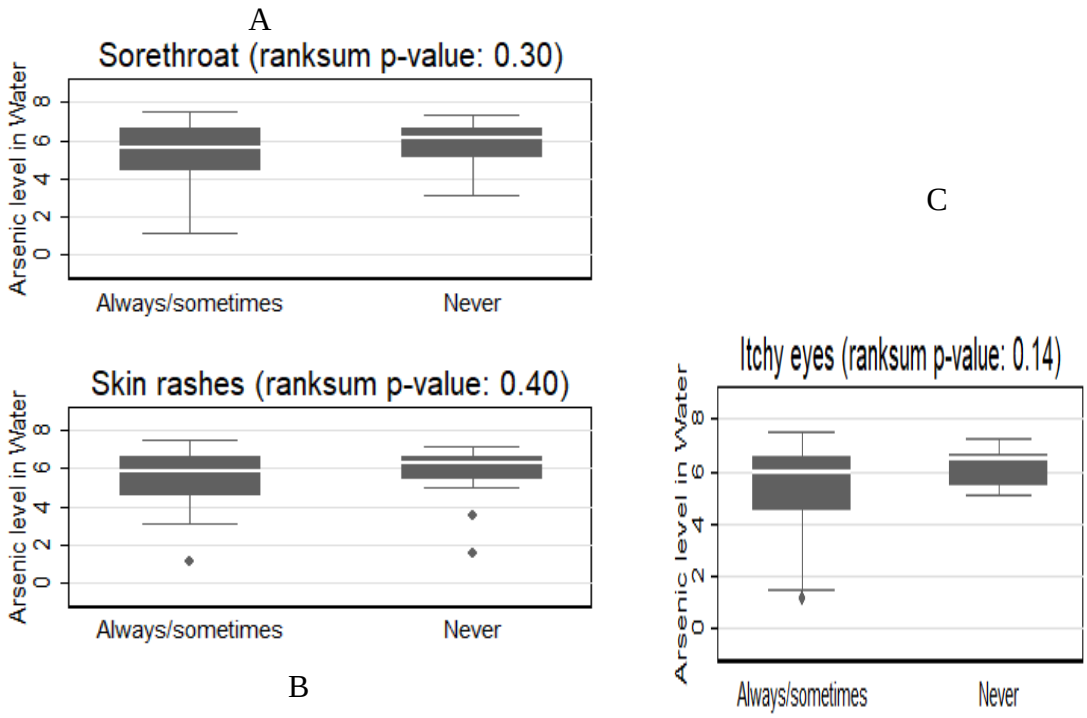


A B

Distribution of Arsenic level in water against A.wheezing and B.phlegm production



Distribution of Arsenic level in water against A.memory loss B.vision/hearing C.sleeplessness and D.headache



Distribution of Arsenic level in water against A. Sore throat B. skinrash and C. itchy eyes

The boxplots in **figure 5** above shows the distributions of the categorized health symptoms versus water arsenic levels of the participants. The distribution looked at the

burden of health symptoms likely to be experienced against levels of arsenic in drinking water. Most of the health symptoms were not statistically significant when compared with water arsenic levels except for the phlegm production which is found under the category of respiratory health symptoms with mean(lower and upper quartile) of 5.6 (4.43-6.54) and (p=0.05)

Table 4.5: Association between proximity to mines and self-reported health symptoms (n=106)

	Proximity to the mines			
Health symptoms	**≤ 250 m n(%)**	**> 250 meters n(%)**	**chi-square**	**P-value**
GASTROINTESTINAL SYMPTOMS				
Diarrhoea			0.3934	0.531
Always/sometimes	32 (34.04)	3 (25)		
Never	62 (65.96)	9 (75)		
Vomiting			0.8459	0.358
Always/sometimes	27 (28.72)	5 (41.67)		
RESPIRATORY SYMPTOMS				
Never	67 (71.28)	7 (58.33)		
Phlegm			4.4689	0.035
Always/sometimes	61 (64.89)	4 (33.33)		
Never	33 (35.11)	8 (66.67)		
Wheezing			1.5191	0.218
Always/sometimes	41 (43.62)	3 (25)		
Never	53 (56.38)	9 (75)		
NEUROLOGICAL SYMPTOMS				
Change in vision/ hearing			0.6091	0.435
Always/sometimes	58 (61.7)	6 (50)		
Never	36 (38.3)	6 (50)		
Headache			3.1758	0.075
Always/sometimes	76 (80.85)	7 (58.33)		
Never	18 (19.15)	5 (41.67)		
Memory loss			0.4995	0.48
Always/sometimes	57 (60.64)	6 (50)		
Never	37 (39.36)	6 (50)		
Sleeplessness				1.00
Always/sometimes	51 (54.26)	3 (25)		
Never	43 (45.74)	9 (75)		
OTHERS SYMPTOMS				
Sore throat			1.3969	0.237
Always/sometimes	38 (40.43)	7 (58.33)		
Never	56 (59.57)	5 (41.67)		
Skin rashes			0.0147	0.903
Always/sometimes	61 (64.89)	8 (66.67)		
Never	33 (35.11)	4 (33.33)		
Itchy eye			4.2886	0.038
Always/sometimes	73 (77.66)	6 (50)		
Never	21 (22.34)	6 (50)		

The above **table 4.5** was looking at the association between proximity to the mine (<250 m and > 250 m) and the health symptoms that they were predisposed to. Only itchy eye (p=0.038) and phlegm production (p= 0.035) had statistically significant associations with proximity to the mine. These could be due to other factors as a result of blasting of rocks that releases dust into the atmosphere.

CHAPTER FIVE

DISCUSSION

5.1 Summary of the Main Findings

The mean age of the study participants was 40.2 years. Most (83.96%) of the participants were aware that their drinking water source was polluted by mining activities and 83.01% were also certain that the pollution could lead to certain health problems in the future. Headache (83%), excessive phlegm production (65%), Itchy eyes (70%) and skin rash (69%) were common among study participants. Mean level of arsenic in drinking (W_As) was 5.63µg/L and that in urine (U_As) was 6.36µg/L. There was a significant association between U_As and memory (p=0.04) but not for the other health outcomes. Again, W_As was associated with excessive phlegm production (p=0.05). Living within 250m of a mining activity was associated with excessive phlegm production (p=0.035) and itching eye (0.038).

5.2 Methodological validity

This study sought out to look at the burden certain health symptoms that the participants were predisposed to as a result of the presence of a heavy metal(Arsenic) in their drinking water and to confirm its presence in their bodies by analyzing their Urine samples. The indicators of exposure to arsenic considered in the study were levels of urine arsenic, water arsenic and living within 250m of the mine. The only hurdle was the inability to confirm the reported health outcomes through any clinical evaluation. A major limitation of this study may be the small sub sample size of samples (50) which may prevent forecasting for a larger population. However the strength of the study was its ability to objectively confirm that there were concentrations of arsenic in the urine and water of the participants even though the health symptoms were self-reported.

5.3 comparing study results with previous findings

Natives of this community were described mainly as farmers but from the details gathered by this study showed they are gradually shifting to other businesses which could be as a result of the degradation, sale or acquisition of their farm lands for mining activities. Effluents from these legal and illegal miners have contaminated the drinking water of this community to which (97%) of the participants have confirmed to be positive, a fact supported by(Fatawu & Allan, 2014) and (Jaishankar, Tseten, Anbalagan, Mathew, & Beeregowda, 2014). which recorded (95%) of their study participants also confirming pollution of their drinking water. Most (86.7%) of the participants who lived less than 250 meters from the mines tested positive for levels of Arsenic in their urine an assertion which is consistent with a report by (Bortey-Sam et al., 2015) of increased level of Arsenic in drinking water close to the mine. Participant close to the mine were aware of the pollution of their water and this was so in the study as (83.9%) were affirmative just like in a study by (Dogaru et al., 2009) also recording (82.5%) affirmation.

According to (Jaishankar et al., 2014) arsenic contaminated water predisposes an individual to certain health symptoms that may lead to diseases. Participants of this study also confirmed some health symptoms such as headache (83%), skin rash (69%), phlegm production (65%) and Itchy eyes (79%). There may be increased risk to certain health symptoms amongst individuals who have levels of arsenic in their urine. This predisposition is emphasized in a study by (Mahurpawar, 2015). There is therefore the need to educate the community on the various health symptoms that they may be exposed to when they continue to use the known drinking water.

The mean level of arsenic in the urine of the subsample participants(n=50) was (6.36µg/L) which was above that reported by (Navas-Acien et al., 2009) who recorded (3.4µg/L) in a study in chile that spanned 10 years. Even though arsenic levels in Urine and drinking

water against most of the various health symptoms did not have any significant association, however phlegm production and level of arsenic in drinking water was significant when comparing participants who responded to always or sometimes producing excessive phlegm's to those that responded to have never had excessive phlegm production with (p= 0.0476)**,** similarly, level of arsenic in urine against memory loss was significant when comparing participants that confirmed they always or sometimes experience memory loss and participant that said they never experienced memory loss (p= 0.0375). In comparing and contrasting the level of Arsenic in drinking water and Urine, there was a moderate correlation. The levels of arsenic in the subsample (n=50) of drinking water provided by the community that was analyzed ranged from (3.11—7.47 µg/L) but were also below the WHO guideline of 10 µg/L. However, this does not mean pollution of water by mining companies should be neglected. The need to prevent the contamination of the water bodies that exist in these communities should be upheld.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

In conclusion, this study confirmed the presence of the heavy metal Arsenic in the drinking water and urine of the participants as well as confirming the burden of certain neurological, gastrointestinal, respiratory and other physiological health symptoms due to exposure to arsenic. However, there was no significant association between level of arsenic in drinking water or Urine and some of the categorized health symptoms (gastrointestinal and respiratory) while there was a significant association between Arsenic level in urine and neurological symptoms but when the health symptoms were compared singularly, there was an association between level of arsenic in drinking water and phlegm production as well as level of arsenic in Urine and memory loss. The level of Arsenic in drinking water moderately correlated with level of arsenic in urine. Living close to a mine should be discouraged as it may predispose an individual to certain health symptoms if care is not taken even though other factors may contribute to experiencing a particular self-reported health symptom. The level of arsenic in water (3.11—7.47 µg/L) was within the WHO guideline of 10µg/l whereas that of Urine Arsenic ranged from (3.107—7.635µg/L). Exposure to arsenic has been a worldwide health problem and steps to mitigate its effects on humans must be advocated.

6.2 Recommendation

1. So long as the nation earns huge income from mining activities, it is clear that this problem will continue but there is the need educate the communities about the exposures that are possible when they live close to a mine.

2. The legal regulations regarding activities of mining companies must be enforced to prevent continuous contamination of the environment that will predispose communities around the mines to certain types of self-reported health symptoms.
3. It will be important to design a research that will look at the association between the heavy metal Arsenic and high blood pressure in this same community as it was reported by majority of the participants.

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APPENDICES

Appendix 1: Questionnaire

General Information

1. Can you please tell us about yourself? Age ……..
2. What is your Gender? 1. Male 2. Female ☐
3. What is your current Marital Status? 1. Single ☐ 2.Married ☐ 3. Cohabiting ☐
4. What is your highest level of education? 1. No formal education ☐ 2. Primary ☐ 3.JSS ☐ 4.Secondary ☐ 5. Poly/university/tertiary ☐

The next set of questions is about your residence, drinking water source and work.

5. How long have you lived in this community? 1. 6mths- 1yr ☐ 2. 2-3yrs ☐ 3. 4-5yrs ☐ 4. >5yrs ☐

5a. How close are you to the mine? 1. < 250 m ☐ 2. >250 -1km ☐

5b. Is there pollution in your environment? 1. Yes ☐ 2. No ☐

5c. Does this pollution affect your source of drinking water? ? 1. Yes ☐ 2. No ☐

5d.What is your main source of drinking water? 1. Well/Borehole ☐ 2.Stream ☐ 3. Sachet water ☐

5e. How long have you been drinking from this source? 1. 6mths- 1yr ☐ 2. 2-3yrs ☐ 3. 4-5yrs ☐ 4. >5yrs ☐

5f. Can your water harm your health in anyway? 1. Yes ☐ 2. No ☐ 3. Don't Know ☐

6a.What is your occupation? 1. Farmer ☐ 2.Small scale miner ☐ 3. Other ☐

6b. If other, please specify. ……

6c. Do you use any chemical at your work place? 1. Yes ☐ 2. No ☐

6d. If yes, please name it. …… .

6e. Do you wear any protective clothing while using the chemical? 1. Yes ☐ 2. No ☐

6f. How long have you been using the chemical? 1. 6mths- 1yr ☐ 2. 2-3yrs ☐

6g. Can the chemical at work harm your health in anyway? 1. Yes ☐ 2. No ☐ 3.Don't know ☐

This set of questions is about your health in relation to your Drinking water source and Work

7a. Do you have any illness you know about? 1. Yes ☐ 2. No ☐

7b. Have you had any health attacks? ? 1. Yes ☐ 2. No ☐

7c. If Yes please specify. ……

8. Do you experience any of the following?

Symptoms	Always(1)	Sometimes (2)	Never (3)
Diarrhea			
Vomiting			
Skin rashes			
Itching eyes			
Change in vision or hearing			
Headaches			
Phlegm production			
Sore throat			
Wheezing			
Memory loss			
Sleeplessness			
Non healing wounds			

The next set of questions is about your habit or lifestyle

9. Do you smoke cigarette? 1. Yes ☐ 2. No ☐ 3. In the past ☐

9b. If yes, how many sticks do you smoke per day? 1. < 5 sticks ☐ 2. 5– 10 sticks ☐ 3. >10 sticks ☐

9c. How long have you been smoking? 1. 1- 5yrs ☐ 2. 6- 10 ☐ 3. >10yrs ☐

10. Do you take alcohol? 1. Yes ☐ 2. No ☐ 3.In the past ☐

10b. how long have been taking alcohol? 1. 1- 5yrs ☐ 2. 6- 10 ☐ 3. >10yrs ☐

10c. Which type of alcohol do you take? Please tick (√) as appropriate.

1. ☐ Local bitters 2. ☐ Beers 3.1. ☐ Spirits

Appendix 2: Participant Consent Form

School of Public Health

University of Ghana

Project Topic

Exposure to Arsenic in drinking water and health symptoms in Tamso, Tarkwa.

Background

Dear Participant,

I wish to invite you to participate in this study of mine. My name is Tetteh Leon Michael, a student of the school of public health, University of Ghana.

I am undertaking a research on the topic exposure to heavy metals in Drinking water and health symptoms in Tamso, Tarkwa. The object is to assess the quality of your drinking by testing it for some arsenic and mercury and its possible health symptoms you may experience because of the mining processes especially waste effluent discharge, accidental spilling of mining chemicals and natural weathering of rocks releases heavy metals into the environment.

The study is purely an academic research which forms part of my work towards the award of a Master Degree in Public Health.

Possible risk of Discomfort

There are no major risks associated with participating in this study. The procedures involved in this study are non-invasive and will not cause any discomfort to the participant.

Description of level of research burden

Study participants will be asked to answer a questionnaire, and provide urine and drinking water for laboratory analysis for heavy metals.

Possible benefits

There will be no direct benefits to the participants. However, the information given will guide government and other relevant agencies for any future interventions on the effects and release of heavy metals into the environment.

Right to refuse

Participation in this study is voluntary and you can choose to not to partake. You are at liberty to withdraw from the study at any time and this will not come with any consequences. However your participation is key.

Clients Consent

I, ……., declare that the purpose, procedures as well as risks and benefits of this study have been thoroughly explained to me and I have understood them. I hereby agree to take a part in this study.

Signature/ thumbprint of participant ……..

Date ……/……../……..

If the volunteer is a minor or cannot read form themselves, a witness must sign here:

I was present whiles 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/Mark 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/ Marks of persons who obtained consent

You may contact these numbers if you have any concerns.

GHS-ERC administrators contact , Tel 0243235225/0302681109/0302679323,

Email: hanna.frimpong@gmail.com

Micheal Leon Tetteh

School of Public Health, University of Ghana, Legon

Mobile number: 0209338649

Email. Leont90@gmail.com

Interviewer's statement

I, the undersigned, have given a copy and explained this consent form to the subject in simple language that she/he understands, clarified the purpose of the study, procedures to

be followed as well as risks and benefits involved. The subject has freely agreed to participate in the study.

……. ……...

Signature of interviewer **Date**