KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI

COLLEGE OF HEALTH SCIENCES

SCHOOL OF PUBLIC HEALTH

DEPARTMENT OF HEALTH PROMOTION AND EDUCATION

ASSESSING THE ENVIRONMENTAL AND HEALTH IMPACT OF SMALL-SCALE MINING IN THE AMANSIE WEST DISTRICTOF ASHANTI REGION, GHANA

BY

LAWRENCIA ABIGAIL DONKOR (BSC NURSING)

NOVEMBER, 2015

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A THESIS SUBMITTED TO THE DEPARTMENT OF HEALTH PROMOTION AND EDUCATION, COLLEGE OF HEALTH SCIENCES, SCHOOL OF PUBLIC HEALTH, IN PARTIAL FULFILMENT OF REQUIREMENTS FOR THE DEGREE OF MASTER OF PUBLIC HEALTH IN HEALTH EDUCATION AND PROMOTION.

NOVEMBER, 2015

DECLARATION

I Lawrencia Abigail Donkor, hereby declare that, this is the result of my own hand work and that no previous submission for a degree has been done here or elsewhere. Also the work of others, which served as reference has been duly acknowledged.

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ABSTRACT

Small-scale mining activities (both legally and illegally) continue to be sighted in mineral prone communities in Ghana. Little is known of the health consequences of such activities in a relatively new and heavy mining area of Amansie West District. This study used both qualitative and quantitative data analysis to follow the footprint of both the environmental and health impacts of small-scale mining activities in the Amansie West District of the Ashanti Region. A total of nineteen (19) soil samples were purposively collected from twelve (12) mining communities in the Amansie West District, prepared and analysed at the Ghana Atomic Energy Commission for Arsenic (As) and Mercury (Hg) heavy metals. A further 424 questionnaires were randomly administered in the twelve mining communities from October to November 2014 to assess the environmental and health impacts of small-scale mining activities in the District. Analysis of the results showed mean concentrations of Hg in both soil and water were respectively higher than optimal regulatory limits of the Dutch Environmental standards of 0.30ppm and 0.05ppm, with mean concentrations of As in both soils and water from the sampling sites lower than the optimal regulatory limit of the Dutch Environmental standard of 29ppm and 10ppm in soil and water respectively. The results indicated a significantly negative correlation between Arsenic and Mercury in soil but a weak correlation between same in water samples. The degree of contamination assessment showed six zones among the areas considered as very highly contaminated sites. Destruction of forest and farm lands alongside water pollution were reported as the main environmental impacts experienced by respondents while malaria, respiratory and skin diseases were reported by respondents as the main health concerns of the people in these studied communities. Government, both national and local, community leaders, public health workers and the miners need to play their respective roles of enforcing regulation, promoting public health education and practicing environmentally sound small-scale mining activities so as to reduce the health and social risks and the rising concerns of environmental degradation from small-scale mining.

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DEDICATION

I dedicate this work to my children Ephraim, David and Abigail who had to endure my absence from home during the period of my study, and my dad who passed away during the course of my study.

TABLE OF CONTENTS

List of Figures

LIST OF TABLES

1 INTRODUCTION

The Ghanaian Small-scale Mining (SSM) industry is well over 2,000 years old with relics of alluvial gold extraction and winning activities that date as far back as the sixth century (Hilson 2001). Despite the exploration and mining of rich mineral resources by large multinational companies spanning for over 100 years, small-scale mining activities in Ghana continue to be on the ascendency. Small-scale mining in Ghana, as in most developing countries, has for decades been treated as an informal industrial sector, employing thousands of people but using largely rudimentary, unmonitored and uncontrolled practices. According to Botchway(2011), the small-scale mining segment of the industry has been the focus of governments in recent times with plans to formalize the sector after identifying the potential earnings in the industry as revenues in the sector are lost due to illegal trading and smuggling.

The World Bank(1995), estimates indicated two-thirds of Ghana's small-scale miners are engaged in the extraction of gold.According to Appiah(1998), there no precise small-scale mining employment figures can be found in Ghana, it is estimated some 200,000 are involved directly in the extraction of gold and diamonds with majority of them being illegal miners also called *galamsey operators.* A regional employment assessment estimates 6,000 illegal and 117 registered artisanal gold mines are found in Tarkwa alone (Agyapong 1998).

With increasing activities of both legal and illegal small-scale mining in Ghana, thePMMC(2001) indicated significant revenues have been generated by the sector, contributing over US$117 million worth of gold and $98 million worth of diamond since 1989. It is apparent that small-scale resource exploitation is a source of livelihoods to a significant number of people in Ghana (Hilson 2002). Despite, the contribution to the national economy, support to livelihoods and employment opportunities created by the sector, the environmental and health impacts as a result of the unconventional, primitive and crude methods employed by illegal and some legal small-scale miners in less known mining communities, towns and districts have not been looked at. Several studiesHilson (2001); Hilson and Pardie (2006); Asante et al. (2007); Hilson et al. (2007)and Yeboah(2008) in the Obuasi and Tarkwa municipalities of Ghana have revealed increased environmental complications and effects – namely, mercury (and other toxic chemical) pollution, land degradation, air pollution surface and ground water contamination from these well-known mining communities in Ghana. Resulting from these complicated environmental impacts are health effects such as respiratory diseases and injuries. This study examines the environmental and health impacts of small-scale gold mining in the Amansie West District of the Ashanti Region, a less known mining district in Ghana and seek to prescribe recommendations for improving environmental performance in the industry

1.1 Problem Statement

The handling and management of small-scale mining activities are vital for government and environmental managers in Ghana for they pose huge environmental and health hazard for present and future generations in host communities and the country. The recent increased activities of illegal small-scale mining in Ghana, despite the inauguration of a number of presidential taskforce to control and check the impacts of illegal mining activities; Ghana has not generated an effective infrastructure, policy and goodwill to control the environmental and health impacts as a result of small-scale mining. Activities and procedures associated with many small-scale mining in Ghana leads to the destruction and degradation of the environment while also exposing the vulnerable in society to other health risk, the non-compliance of appropriate small-scale mining regulation to handle the environmental and health effects have compounded the challenges posed by their management.

Studies by Mireku-Gyimah and Suglo(1993); Akabzaa and Darimani(2001); Hilson(2002); Hilson and Pardie(2006); Asante et al. (2007); Hilson et al. (2007); Yeboah(2008) have paid attention on small-scale mining issues in two main districts of mining in Ghana.Mireku-Gyimah and Suglo (1993) gave an overview of the state of Gold mining in Ghana, showing the involvement of small-scale mining players in the exploitation Ghana's gold resource. Akabzaa and Darimani(2001) conducted anin depth impact assessment of investment into the mining sector in the Tarkwa Mining area revealed economic, social and health as broader impacts from mining within Tarkwa.

Furthermore, Hilson(2002), examined the environmental impacts of small-scale gold mining in Ghana and suggested among other things a concerted effort be made to prospect for deposits suitable for small-scale gold mining as a key to preventing unnecessary exploration. Further studies by Hilson and Pardie(2006)in examining mercury asan agent of poverty in Ghana's small-scale gold-mining sector revealed lack of appropriate safeguards and alternatives to amalgamation, are preventing gold miners from improving their practices and livelihoods.Asante et al (2007), focused on assessing the state of contamination of arsenic and other trace metals in the drinking waters of residents within the mining areas of Tarkwa while Kumi-Boateng(2007) also assessed the spatial distribution of arsenic from gold mining in Obuasi.

In spite of the several studies done in Ghana on mining with much focus within the Tarkwa and Obuasidistricts, no or little research is known about the environmental and health impact of small-scale mining in the less known mining communities like the Amansie West District in Ghana. This research will seek to understand the environmental and health impacts of mining by answering the questions, what are the levels of mercury and arsenic pollution? What are the environmental and health effects of mining activities in the district?

1.2 Research Objectives

The main objective of this research will be to examine the environmental and health impacts of small-scale mining activities in the Amansie West District.

1.2.1 Specific Objectives

i. To determine the level of mercury and arsenic in soil and water within the Amansie West District.

ii. Document and observe health and environmental effects of small-scale mining within the Amansie West District.

iii. Identify the factors contributing toaggravating environmental and health impacts from small-scale mining in Amansie West District.

1.3 Conceptual Framework

The conceptual framework of this study explains the mechanics of the essential factors that are influencing problem of small-scale mining in the Amansie West District of Ashanti Region and attempt to establish the relationships among them. Figure 1.1 below shows the conceptual framework adopted for this study.

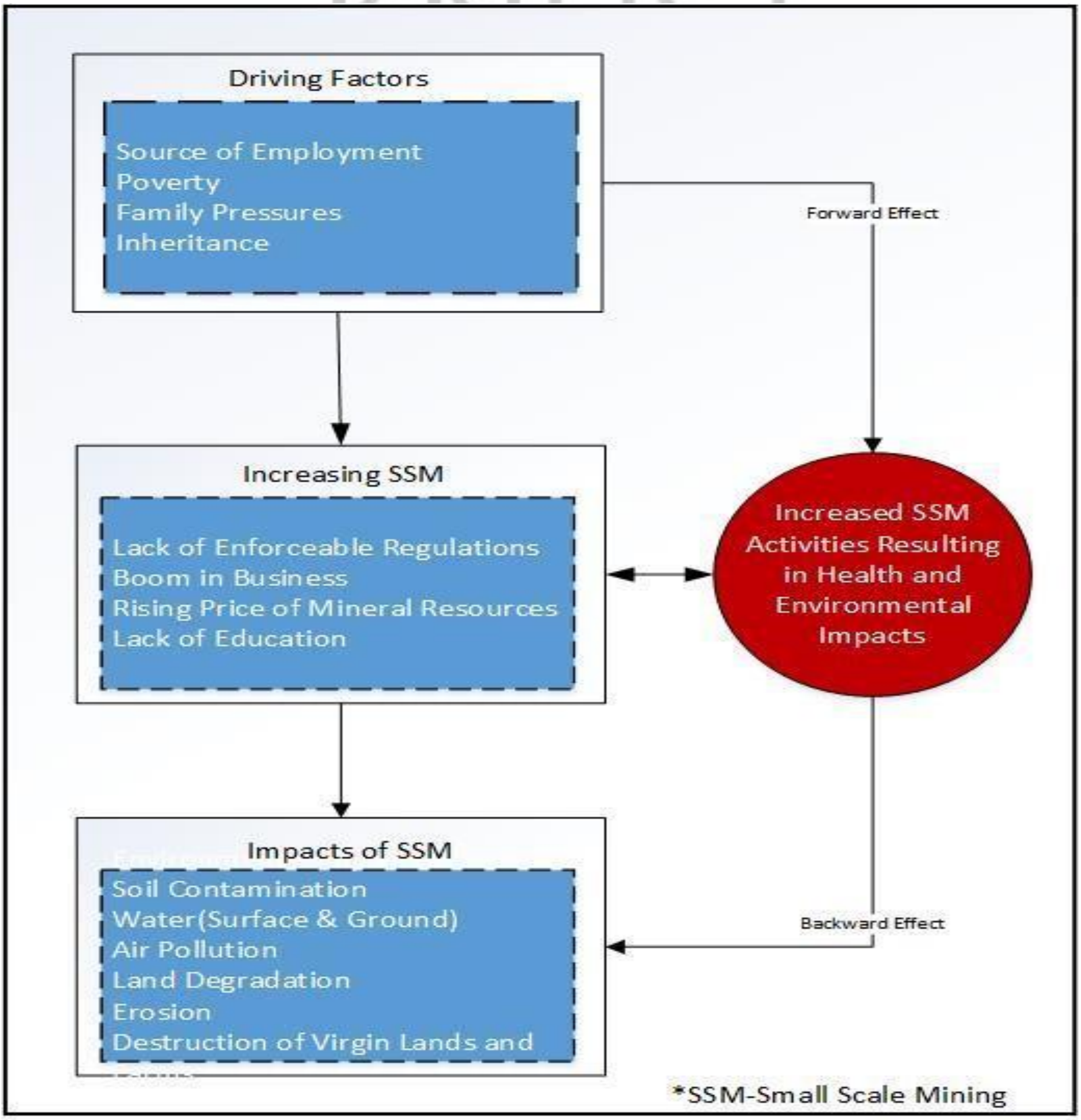


Figure 1.1: Conceptual Framework of study

1.4 Research Questions

The following research questions will be answered in order to achieve the above research objectives.

i. What is the level of mercury and arsenic concentrations in soil and water within the Amansie West District?
ii. What are the effects or impacts of small-scale mining activities on the environment and health of people within the Amansie West District?
iii. What factors contribute to the environmental and health impacts from smallscale mining in the Amansie West District?

1.5 Rationale and Justification of Research

In Ghana, there have been a number of studies on the activities of small-scale mining with much focused on the very well-known mining communities of Obuasi and Tarkwa to the neglect of less known mining areas in Ghana. With no or very little known about the impacts of small-scale mining activities within these less known mining communities, this research employed experimental and observational study to assess small-scale mining impacts in the Amansie West District of the Ashanti Region. The research did not only measure and document the impacts of small-scale mining activities, it among other thing sought to provide valuable information for governments, environmental managers and other decision makers or stakeholders on the state and impacts of small-scale mining activities in these less known mining communities.

1.6 Expected outcomes

The following outcomes were set to be achieved at the end of the research:

1. Knowledge on the levelsof arsenic and mercury within the Amansie West District
2. Documented and observed environmental and health impacts of small-scale mining in Amansie West District.
3. Records of factors contributing to the health and environmental impacts of small-scale mining within the Amansie West District.

4. Documented knowledge level of small-scale miners of their activities on health and environment.

2 LITERATURE REVIEW

2.1 The Mining Industry

According to Thrush (1968), mining is the process of digging into the earth to extract naturally occurring minerals . It is the second oldest important industry to agriculture and currently the 5th largest industry in the world which forms substantial part of international trade (Madeley 1999). The mining industry across the globe has been key to the development of civilisation. In 2001 alone, the industry produced over 6 million tons of raw materials valued at several trillions of dollars. According to Hentschel et al., (2002) downstream beneficiation and mineral processing of these raw materials and the product that are created serve all aspects of industry and commerce worldwide.

The mining sector in Ghana has over the years and continues to play a significant role in the country's socioeconomic development. The industry is one of the major driving forces for the country and produces different kind of metals including gold, bauxite and aluminum. The mining sector's contribution to gross foreign exchange particularly gold historically has been paralleled with cocoa, which has been the largest foreign exchange earner. Two types of mining are practice in Ghana, surface and underground mining. Surface mining is also known as open pit or strip mining and is normally employed the extraction or mining of minerals and metals which are near the surface of the earth. According to Bermudez-Lugo (2010), this type of mining though can be inexpensive and relatively safe method of mining the much needed mineral resources, the damage caused to the environment and human health cannot be under estimated. Pollution of surface and ground water, sediment clogged streams, landslides, soil contamination and unstable grounds are some of the problems associated with surface mining. Underground mining is also practiced in Ghana mostly by large multi-national companies and this technique is however used to extract or mine ores and valuable minerals in the ground by digging beneath the earth surface. This procedure is considered efficient but very expensive as it requires a lot of resources and logistics in order to safely execute. Also associated to underground mining is the collapse in mining, explosion, assortment of other health, environmental and safety risks.

Ghana's mining sector using both underground and surface mining has a long tradition of gold mining with an estimated 80 million ounces produced between 1493 and 1997 and

this accounted for 36% of the world gold output within the period (Kesse 1985; Tsikata 1997). The mining sector in Ghana is largely controlled or owned foreign companies that is about 85% with the rest controlled by the state with small-scale miners; both legal and illegal miners also known as galamsey operators (Hilson 2002). The use of primitive, crude and out-dated methods by illegal small-scale miners also known as galamsey in the mining and processing of mineral resources is shown by several studies to impact negatively on human health and the environment of the communities in which they are situated (Agyapong 1998; Hilson 2001; Aryee et al.
2003; Babut et al. 2003).

2.1.1 Benefits of Mining in Ghana

Proponents of mining argue that mining leads to economic expansion and decrease poverty as high income tax is accrued to the state which can be used to improve service, create employment and subsequently improve standard of living. Further, the income tax accrued to the state also helps in the provision of health care, road construction, education, provision of electricity infrastructure and other social amenities. According to Amponsah-Tawiah and Dartey-Baah (2011), mining does not only create jobs or employment but it also has a rippling effect on economic growth as these mining companies on the own accord provide some infrastructure development to the local communities where they operate as a form of social responsibility which are without recourse to their own tax obligation. Amponsah-Tawiah and Dartey-Baah (2011) further explains mining also helps catalyze other private investment at the local, regional and national level as the activities of mining possess a significant demonstrational effect. The injection of Foreign Direct Investment (FDI) can also not be overlooked. The earnings from the sale of gold and other mined mineral resources also provide the country significant amount of the much needed foreign exchange.

Despite the accompanying benefits of mining, there are also negative impacts that can also not be grossed over. According to Hilson, (2002) &Tunhumaa et al. (2007), depletion of resources rather than reuse of resources is promoted. Again, both underground and surface mining impact negatively on the environment and human life as well as pollution of surface and ground water, contamination of soil, danger of explosion, black-lung diseases, asbetosis, silicosis and radiation sickness.

2.1.2 Mining Policies in Ghana

In spite of the significant progress and clear benefits of mining the Ghana, the sector faces many challenges which require the attention of stakeholders. According to Babut et al. (2003), to position the mining industry to remain internationally competitive while at the same time ensuring that the expected benefits due the state, communities and investors are realized and in a more environmentally sustainable manner, there is the need for policy to address the challenges concerning environmental issues, minimizing social conflicts, improving the availability & sufficiency of geological data, ensure environmentally sound and sustainable small-scale mining in Ghana and enhancing the capacity of the mining sector and related institutions.

On the backdrop of these needs have various legislations and policies been introduced to regulate, improve and direct the activities of the mining industry in Ghana. Currently, in its draft stages is the National Mining Policy of Ghana which is aimed at providing a written declaration of the framework of principles and policies that will guide government in the management of mining and mineral sector. Further, the policy also seeks to establish a comprehensive and forward looking framework for mining that catalyses sustainable development. The legislative framework for the mineral sector in Ghana is provided by the Minerals and Mining Act (703) of 2006. In addition to the mining act (703) of 2006 is the Mineral commission act of 1993 (Act 450) which is responsible for the day to day administration of the mining industry and also grant mineral right.

2.2 The Structure of Mining Industry in Ghana

According to Akabzaa and Darimani (2001), with about 85 % ownership, the mining industry in Ghana is largely by foreigners while the rest are owned by the state and operated largely by legal and illegal small-scale miners. The ministry of lands and Natural

Resources, through the Geological Survey Department, the Minerals Commission and the Precious Mineral Marketing Company oversees all activities of the mining industry in Ghana. Bermudez-Lugo (2010) reports the Geological Survey Department is responsible for the provision of reliable and up to date geologic information and also serve as the repository of the country's geo-scientific data, while the Mineral Commission is responsible for regulating and managing the use of Ghana's Mineral Resources and also coordinate related government policies. Through the inspectorate of the Ghana's Mineral Commission together with other related institutions such as the Environmental Protection Agency regulate and ensures environmental, health and safety standard in the mining industries and the communities they are located are adhered to. The Precious Mineral Marketing Companies is also responsible for marketing the country's precious minerals. The structure and responsibilities of the mining industry is depicted in Figure 2.

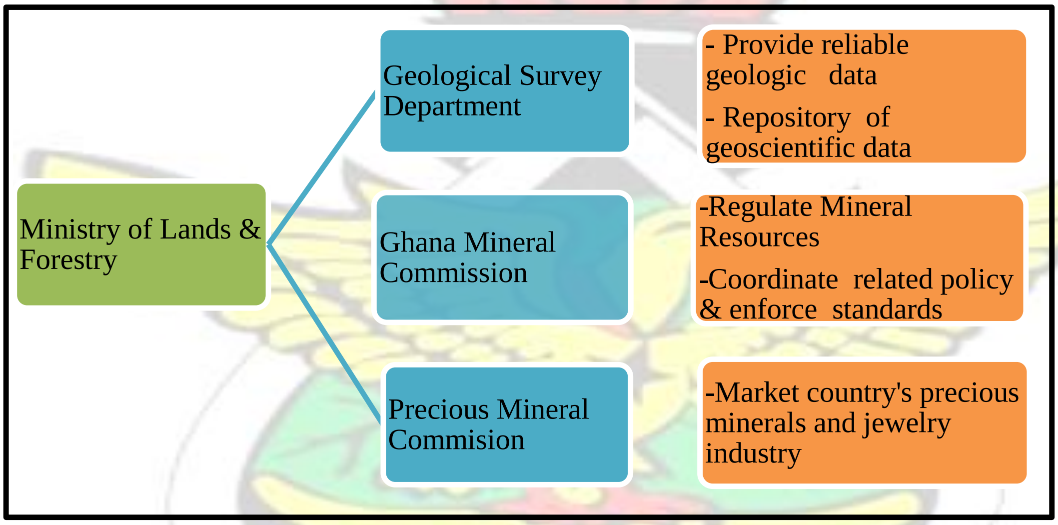


Figure 2.1: Structure & responsibilities of the mining industry

2.2.1 Small-scale Mining in Ghana

The definition of small-scale mining has always differed from country to country and as yet there is no universal definition for small-scale mining. Countries, researchers and organizations however, define small-scale mining on the basis or criteria ranging from investment costs, labour requirements, ore production capacity and the size of concession. In Ghana, the criteria used to classify Small-scale Mining include; size of concession and the duration of license. Small-scale mining operations can be found in precious minerals (gold and diamonds) and industrial minerals including construction materials. Generating of employment for rural folk thereby reducing the incidence of rural-urban drift and contributing to the production of precious minerals, gold and diamonds, and generating substantial foreign exchange are significant contribution from small-scale mining. Small-scale mining in Ghana is made of both legal and illegal miners and within the licensed operational areas, the incidence of child labour, drug abuse etc are very minimal, the same however, the same cannot be said of the illegal small-scale miners (Agyemang 2010). Estimates by Mireku-Gyimah and Suglo (1993) indicates small-scale miners in the informal system are deemed to be more than those in the formal sector and that over one million people benefiting from small-scale mining.

In spite of various interventions and very clear responsibilities of institutions regulating small-scale miners in Ghana over the years, the sub-sector is still plagued with a lot of challenges which border on inadequate delineation and definition of mineral potential areas suitable for Small-scale mining exploitation, inadequate provision of human and material resources to governmental institutions to manage the Small-scale mining subsector, insufficient legislative provisions in the Small-scale mining licensing, the difficulty in formalising the informal and more importantly illegal small-scale miners and also lack of viable and sustainable financing credit schemes for small-scale mining (Aryee et al. 2003). Further, Aryee et al. (2003) also outlined limited provision of appropriate technology transfer to increase productivity and reduced mercury use in the processing and extraction of mineral resources. Also critical and very challenging in the activities of small-scale miners especially illegal small-scale miners is the threat their activities and undertakings pose to health, safety and environmental. Hilson (2002) also indicates increased exposure of small-scale miners to mercury, dust and other chemicals, and vulnerability to the effects of noise, vibration, poor ventilation, overexertion and other respiratory diseases as significant and detrimental threat to human life in the small-scale mining sector. Furthermore, the direct discharge of tailings and effluents into rivers, water bodies and streams, does not only result in siltation of these water bodies or pose health threat to human and aquatic life but the general or larger ecosystem. Deforestation and landscape destruction have also been cited by a number of researches (Akabzaa and Darimani 2001; Hilson 2002; Tunhumaa et al. 2007) as other challenges brought about by uncontrolled and unregulated small-scale miners. (See fig 4.2, some challenges left behind or posed by small-scale miners in Ghana)

2.3 Mining and the Environment

Despite the economic importance of mining to a country and especially Ghana, the effects of mining on the environment can however not be ignored. The methods, process and activities executed by both small and large scale miners cause irreversible damage to trees, birds and animals. Processes such as hydraulic mining techniques, blasting at the banks of the river and separation of sediment and mercury from the gold-yielding gravel deposits employed by small-scale miners who are less equipped than industrial miners and also does not comply to minimum operating standard set out by the regulating institution, end up releasing of mercury and other toxic substances into the river and the surrounding environment as a whole. According to Singh et al. (2007), this toxic substance enters the food chain through aquatic animals and their predators. Other highly poisonous compound cyanide is also used to separate gold from sediment and rock, also has the potential of escaping into the surrounding environment in fish which can be subsequently be transferred to humans through the meat or food intake. In the following subsection, the effect of small-scale mining on soil, water and air are reviewed.

2.3.1 Effect of Mining on Land and Soil Degradation

Aryee et al. (2003), explained that the primary impact from small-scale mining is land degradation which is a common phenomenon at many uncontrolled, unmonitored smallscale mining sites. Aryee et al. (2003) further narrated that, miners leave behind "moonlike" landscapes consisting of unstable piles of waste, abandoned excavations and vast stretches of barren land. Typically, also left behind are unfilled and abandoned excavated pits that become receptacles for water and subsequently become breeding grounds for mosquitoes and potential dangers to both humans and animals. Again, large tracts of agricultural lands are also destroyed as a result of excessive vegetation removal and disturbance of soil structure.

Another effect of mining on environment is that growth supporting topsoil is usually removed during mining, and the land is rendered virtually incapable of supporting plant growth, in addition to being left exposed to erosion. Yet another conundrum or issue associated with small-scale mining and the environment is Deforestation. Mining requires large areas land to be cleared in order that miners can dig for these mineral resources and this imply large-scale deforestation is required to be carried out in the areas where mining has to be done. Besides clearing the mining area, vegetation in the adjoining areas also needs to be cut in order to construct roads and residential facilities for the mine workers. Again, the human population, that mining activities brings along with also harm the environment. For example, various activities at coal mines release dust and gas into the air. Also resulting from land degradation and deforestation is the loss of biodiversity.

According to Akabzaa and Darimani (2001), the forests that are cleared for mining purposes are home to a large number of organisms and as such indiscriminate clearing of the forests leads to loss of habitat of a large number of animals. This Allan (1995), explains puts the survival of a large number of animal species at stake. Also, the cutting down of trees in itself is a big threat to a number of plants, trees, birds and animals that dwell in the forests. In addition, unregulated, uncontrolled and primitive methods applied in small-scale mining exposes the large environment to soil and land pollution. Despite measures and safety standards outlined by regulatory institutions chemical waste and other toxic substances are released into the nearby rivers through pipes, a large amount of chemicals still leaks out onto the land.

2.3.2 Effect of Mining on Water Bodies

With chemicals such as mercury, cyanide, sulfuric acid, arsenic and methyl mercury used in various stages of mining being toxic, its improper discharge or release in the environment especially in water bodies does not only pollute the immediate environment or water bodies but ripple effect on plant, animals and the larger human population who depends on the water course. Most of the chemicals are released into nearby water bodies, and are responsible for water pollution and when these chemicals leak into water bodies slowly percolate through the layers of the earth and reach the groundwater and also pollute this reservoir of water in the earth's crust. The release of toxic substances from mining activities into water courses is obviously harmful for flora and fauna of water bodies. The withdrawal of water for washing by miners reduces the water content of the river bodies and hence organisms do not get enough water for their survival. Also the method of dredging adopted by small-scale miners also disrupts the natural flow of river which might cause fish and other living organisms in these rivers to die.

A number of studies have shown that mining activities both small-scale and industrial mining activities impact negatively on water bodies. Tiwary (2001), in assessing the environmental impact of mining on water regime in India indicated that impact of mining activities degrade the quality of water by lowering the pH of surrounding sources of water and also increase the level of suspended solids and heavy metals. In Mexico, Razo et al. (2004) arsenic and heavy metal contamination assessment in soil and water showed significantly high concentration of arsenic measured from mining sites in pluvial water storage ponds. Further, impacting on water resources from mining activities are other heavy metals. Reza and Singh (2010) in India identified other heavy metals deposits from river bodies within mining areas and these metals included Cadmium, Copper, Cobalt, Chromium, Iron, Manganese, Nickel, Lead, Mercury and Zinc. Reza and Singh (2010), further explained the amount or levels of heavy metals measured in drinking water were significantly higher than Indian national standards. In addition, studies in Canada by Allan (1995), also confirmed the deposits of heavy metal contaminant in water bodies within mining sites. According to Allan (1995), the heavy metal contaminants measured in the study were located in wastelands and are the source of acid and metal-rich runoff from land sited tailing or waste rock heaps that subsequently pollute the rivers, lakes and coastal areas. Researches related to effects of mining have been concentrated in well-known mining communities (mostly in Obuasi and Tarkwa) in Ghana Akabzaa and Darimani(2001); Hilson(2001); Asante et al. (2007); Kumi-Boateng(2007) and

Yeboah(2008), not very much is known about effects of mining on water bodies in less known mining communities such as the communities in the Amasie West District of the Ashanti Region. This research will seek to identify some of the effects of mining on waterbodies in these communities.

2.3.3 Noise, Vibration & Air Pollution from Mining

Mining activities of both small and industrial together with their mining support companies release particulate matter into the ambient air (Akabzaa and Darimani, 2001). The concerns of the affected communities on air quality have been the airborne particulate matter, emissions of black smoke, noise and vibration. Airborne particulates of major concern within the mining communities include respiratory dust, sulphur dioxide (SO_2), nitrogen dioxide (NO_2), Carbon monoxide (CO) and black smoke. According to Akabzaa and Darimani (2001), the activities that generate this particulate matter include site clearance and road building, open-pit drilling and blasting, loading and haulage, vehicular movement, ore and waste rock handling as well as heap leach crushing by companies doing heap leach processing. The release of airborne particulate matter into the environment particularly minute dust particles of less than 10 microns poses health threats to people within mining areas. Fine dust or particulate matter at a high level of exposure has the potential to cause respiratory diseases and disorders and can worsen the condition of people with asthma and arthritis. Dust arising from gold mining operations has high silica content which has been responsible for silicosis and silico-tuberculosis within mining areas. Results by Akabzaa and Darimani (2001) of air quality monitoring for dust showed values far above acceptable, detectable limits for health safety.

In addition to the release of fine dust or fine particulate matter from mining sites is the source of noise in the area from mobile equipment, air blasts and also vibration from blasting and other machinery. The likely effect of high pitched and other noises is known to include damage to the auditory system, cracks in buildings, stress and discomfort. These noises can also frighten animals, interfere with their mating processes and also cause abortions, therefore adversely affecting the animal population. There is widespread and deafening noise from operations of all the surface mines in the area. In some mining areas in Ghana, there are proposals to include the introduction of several delays during blasting in order to reduce the vibration effects, the reduction in the frequency of major blasts and of blasting in the daytime. According to AmponsahTawiah&Dartey-Baah (2011), this proposal is to reduce the noise level and vibration impact since most people would be busy outdoors. Although, these measures have not adequately addressed the problem of noise pollution and vibration in the area, it however minimizes the impact of these activities. In other areas despite the measures blast related noise remains high. In fact, blasting noise levels measured by Akabzaa and Darimani (2001) at one of the mines suggest that all the values obtained far exceed the

EPA's highest permissible noise level for heavy industry for both day and night.

2.3.4 Arsenic in the Environment

Arsenic (As) is a natural element which behaves like a metal. It is a ubiquitous element found in soil, rock, natural water, atmosphere and in organisms. Arsenic appears in three allotropic forms; yellow, black and grey with the stable form being silver-gray, brittle crystalline solid. Arsenic tarnishes rapidly in air while at high temperatures burns forming a white cloud of arsenic trioxide. Arsenic combines readily with many elements. Arsenic is released into the environment naturally through the weathering and erosion of sulphide minerals. These sulphide minerals can form soils with very high concentrations of arsenic, and can dissolve in water. Beside these natural occurring sources of arsenic in the environment is from tailings and other anthropogenic activities. According to Taylor et al. (2005), most environmental problems associated with arsenic are as result of mobilization under natural condition but man has an important impact through mining activities and also combustion of fossil fuels. According to Singh et al. (2007), human population is mostly exposed to arsenic through ingestion, inhalation and dermal contact. Ingestion of arsenic contaminated water, foods, drugs, wines, smoke of cigarette and fossil fuels are the various routes of arsenic exposure to the population both acute and chronically. In occupational exposure, the workers are exposed to airborne arsenic from the industries of smelting and refining metals, mining, producing and using arsenic-containing chemicals, manufacturing of glass, semiconductors and various pharmaceutical substances.

Despite the notoriety of arsenic as a deadly poison, inorganic arsenic is an essential trace element for some animals, and even for humans, although the necessary intake may be as low as 0.01 mg/day. The intake ofarsenic through food is fairly low, but levels of arsenic in fish and seafood may be high, because fish absorb arsenic from the water they live in. According to Singh et al. (2007), arsenic exposure may be higher for people that work with arsenic, for people that live in houses that contain conserved wood of any kind and for those who live on farmlands where arsenic-containing pesticides have been applied in the past. Exposure to inorganic arsenic can cause various health effects, such as irritation of the stomach and intestines, decreased production of red and white blood cells, skin changes and lung irritation (Razo et al. 2004). It is suggested that the uptake of significant amounts of inorganic arsenic can intensify the chances of cancer development, especially the chances of development of skin cancer, lung cancer, liver cancer and lymphatic cancer. Again, very high exposure to inorganic arsenic can cause infertility and miscarriages with women, and it can cause skin disturbances, declined resistance to infections, heart disruptions and brain damage with both men and women. Finally, inorganic arsenic can damage DNA.

Singh et al(2007) explains the arsenic cycle has broadened as a consequence of human interference and due to this, large amounts of arsenic end up in the environment and in living organisms. Arsenic is mainly emitted by the copper producing industries, but also during mining and processing of ore. Arsenic once it has entered the environment cannot be destroyed the amount in the environment can spread and cause health effects to humans and animals on many locations on earth. Plants absorb arsenic fairly easily, so that high-ranking concentrations may be present in food. In Ghana, levels of arsenic and pictures of oranges showing symptoms of arsenic induced oranges in Obuasi. The concentrations of the dangerous inorganic arsenics that are currently present in surface waters enhance the chances of alteration of genetic materials of fish. This is mainly caused by accumulation of arsenic in the bodies of plant-eating freshwater organisms. Birds eat the fish that already contain eminent amounts of arsenic and will die as a result of arsenic poisoning as the fish is decomposed in their bodies.

2.3.5 Mercury in the Environment

Mercury is the only common metal liquid at ordinary temperatures. It is a rather poor conductor of heat compared with other metals but it is a fair conductor of electricity. It alloys easily with many metals, such as gold, silver, and tin. Mercury can be found naturally in the environment and can also be found in metal form, as mercury salts or as organic mercury compounds. Again, mercury also enters the environment as a result of normal breakdown of minerals in rocks and soil through exposure to wind and water. According to Lacerda (1997), there is a seemingly increasing concentration of mercury in the environment and this has been ascribed largely to human activity. It is argued that most of the mercury released from human activities is released into air, through fossil fuel combustion, mining, smelting and solid waste combustion. Some other forms of human activity release mercury directly into soil or water, for instance the application of agricultural fertilizers and industrial wastewater disposal. All mercury that is released in the environment will eventually end up in soils or surface waters. Although, mercury is not naturally found in foodstuffs, but it may turn up in food as it can be spread within food chains by small organisms that are consumed by humans, for instance through fish.

According to Ikingura and Akagi (1996), mercury concentrations in fish usually greatly exceed the concentrations in the water they live in. Again, Ikingura and Akagi (1996)indicated that Mercury might not commonly be found in plant products, but it can enter human bodies through vegetables and other crops grown in areas contaminated with mercury. Mercury has been found to impact negatively on humans by the disruption of the nervous system, damage the brain functions. In addition, mercury can damage DNA, provoke allergic reactions which result in skin rashes, tiredness, headaches and also negatively affect reproduction by causing sperm damage, miscarriages and birth defects. Mercury in human is also known to damage brain functions and can cause degradation of learning abilities, personality changes.

According to Pfeiffer et al. (1993) large quantities of mercury are released into the waters, air and soil, which impact negatively to the entire environment. Mercury contamination has been reported in most mining areas by a number of researchers (Ikingura and Akagi 1996; Lacerda 1997; Hilson 2002; Taylor et al. 2005; Spiegel

2009). Once mercury has reached surface waters or soils microorganisms can convert it to methyl mercury, a substance that can be absorbed quickly by most organisms and is known to cause nerve damage. Fish are organisms that absorb great amounts of methyl mercury from surface waters every day. As a consequence, methyl mercury can accumulate in fish and in the food chains that they are part of. The effects that mercury has on animals are kidneys damage, stomach disruption, damage to intestines, reproductive failure and DNA alteration.

2.4 Mining and Health

According to Akabzaa and Darimani (2001) resulting from the consequences of the major adverse environmental impact of mining is the generation of diseases due to pollutants and accidents at mines with some of the effects of these pollutants manifesting themselves immediately. Although some of these pollutants such as cyanide manifest immediately while others such as mercury take a long time to show. In most mining areas, the extraction and processing of mineral resources has given rise to various environmental related diseases and accidents. Studies by Akabzaa and Darimani (2001) revealed vector-borne diseases such as malaria, schistosomiasis and onchocerciasis, respiratory tract diseases, especially pulmonary tuberculosis and silicosis, skin diseases, eye diseases, especially acute conjunctivitis, accidents resulting from galamsey activities, and mental cases as mining related diseases in some mining areas in Ghana. Akabzaa and Darimani (2001), further reported malaria, diarrhoea, upper respiratory diseases, skin diseases, acute conjunctivitis and accidents form the top ten diseases in the mining area of Tarkwa with also an increasing trend for respiratory diseases in the area.

Also reported or prevalent in mining communities are the cases of skin diseases. Again, Akabzaa and Darimani (2001) in their studies reported skin rashes as very common among the population with children being the hard hit by this condition and also rashes was allergic reaction affecting users of one of the hand dug wells provided by one of the mining companies. These reports of rashes and allergic reaction are believed to be as a result of cyanide and mercury pollution from the processing of mineral resources especially gold (Akagi et al. 2000; Akabzaa and Darimani 2001; Castilhos et al. 2006;

Bose-O'Reilly et al. 2008; Tomicic et al. 2011). Other mining and environment related diseases are reported to be on the increase in mining areas also included diarrhoea and sexually transmitted diseases (STDs) such as HIV (Akabzaa and Darimani 2001). These reported cases are also confirmed by Eisler (2003) in his assessment of health Risks of Gold Miners. Eisler (2003) assessment indicated health problems of gold miners to include decreased life expectancy; increased frequency of cancer of the trachea, bronchus, lung, stomach, and liver; increased frequency of pulmonary tuberculosis (PTB), silicosis, and pleural diseases; increased frequency of insect-borne diseases, such as malaria and dengue fever; noise-induced hearing loss; increased prevalence of certain bacterial and viral diseases; and diseases of the blood, skin, and musculoskeletal system. Eisler (2003) mentioned HIV infection or excessive alcohol and tobacco consumption as tending to exacerbate existing health problems confirming Akabzaa and Darimani (2001) report in Ghana.

2.4.1 Health Effects of Heavy Metal in Mining Areas

Active and abandoned mining areas around the world have been characterized by one form of pollution or the other. Common in most of these active or abandoned mining areas is pollution from heavy metals. Bryan and Gibbs (1983); Clevenger (1990); Miller (1997); Brooks (1998); Pruvot et al. (2006); Yu et al. (2006); Bernard and Duker(2007) in their various studies have indicated deposits of heavy metals from mining areas. The heavy metals measured in these studies are dependent on the type of mineral being mined and the processing procedures and the metals ranges from Cadmium (Cd), Cobalt (Co), Mercury (Hg), Lead (Pb), Zinc (Zn), Arsenic (As) and a host of others. Mostly identified and measured in small-scale mining areas in Ghana are As and Hg heavy metals although Pb, Zn and Cu have also been measured in soil and drinking water from these areas (Adetunde et al. 2014). Areas contaminated with deposits of these heavy metals can be uptake by plant, surface water, groundwater and through dermal, ingestion or inhalation by individuals exposed to them. Studies by Bernard and Duker(2007) measured As heavy metal in water resource and foodstuff from small-scale mining areas in Obuasi. Again, using neutron activation process, Hayford et al (2009) identified Hg heavy metals in two main staple food of cassava and plantain from mining communities in the Tarkwa Districts above the recommended limits by the Food and Agriculture Organization (FAO). With the characteristics of heavy metal to accumulate and being toxic it present current and future danger to human health and the environment. These heavy metals have neurological, developmental, and carcinogenic effects on humans. Table 2.1 gives an overview of some of these heavy metals and their effect on humans. With Hg and As extensively used in the processing of minerals from small-scale mining activities, this research focused on these two heavy metals of As and Hg to ascertain their extent of contamination to soil and impact on human health and the environment in the mining areas of the Amansie West District.

Table 2.1: Health Effects of Heavy Metals

Heavy Metal	Health & Environment Effects
Lead	-Affect the kidneys and can damage nervous system of children -Cause blood and brain disorders
Mercury	-Bio-accumulates causing brain and liver damage if ingested or inhaled.
Chromium	-It can cause irritation to the eyes, skin and mucous membranes. -It can cause permanent eye injury damage to DNA
Cadmium	-Cause flu-like symptoms of weakness, fever and muscular pain while. Long term exposure causes lung cancer and kidney damage.
Arsenic	-Exposure can cause nausea and vomiting, decrease blood cells and damage to blood vessels. Ingestion of very high levels can possibly result in death while long-term low level exposure can darken skin

Zinc	-Can cause stomach cramps, skin irritations, vomiting, nausea and anaemia. Very high levels of zinc can damage the pancreas and disturb the protein metabolism, and cause arteriosclerosis. Extensive exposure to zinc chloride can cause respiratory disorders.
Copper	Long-term exposure to copper can cause irritation of the nose, mouth and eyes and it causes headaches, stomachaches, dizziness, vomiting and diarrhea. High uptakes of copper may cause liver and kidney damage and even death

(Source: World Health Organization 1980; Khan et al. 2008)

3 MATERIALS AND METHODS

3.1 Study Area

The Amansie West District was chosen for this study. The area though predominantly a farming district, has in recent times seen increasing activities in both legal and illegal small-scale mining because of increasing demand for employment and immigration of Asians to the area to mine. More also the youth in the area obtain a gainful employment, this serves as a potential of high profit and good source of income. The district is within the Ashanti Region. (See Figure 3.1). The subsequent section gives a description of the study area by highlighting its location, size, climate condition, vegetation of the area as well its economy and Agricultural potential.

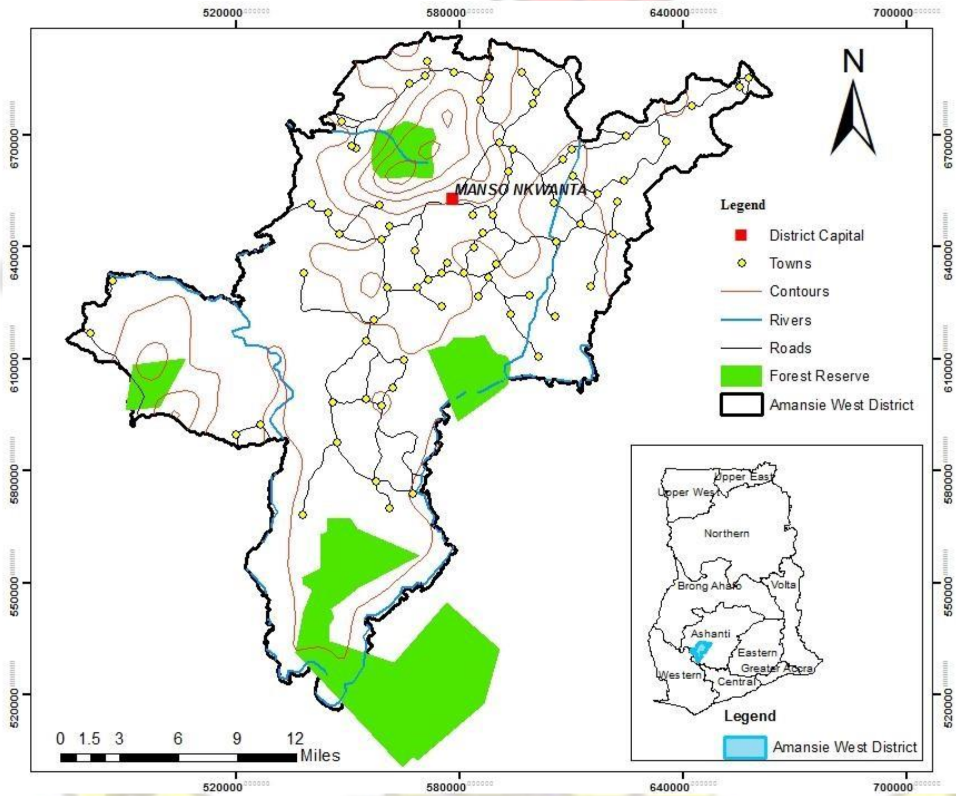


Figure 3.1: Study area of Amansie West District

3.1.1 Location, Size, Climate & Vegetation

The study area (Amansie West District) falls within latitudes 6º 35 and 6º 51 North and Longitudes 1º 40 and 2º 05. It is located in the south-western part of Ashanti Region in the forest zone of Ghana *(Fig 3.1)*. It shares boundaries with the Amansie East District in the west, Atwima Mponua District in the east, AtwimaNwabiagya District in the north and Amansie Central in the South. It has as its capital as Manso Nkwanta, some of the towns in the district are Pakyi 1 and Pakyi 2, Moseaso, Esaase, Datano, Antoakrom, Ankama, Ahwerewa, Agroyesum. With Abore and Mpatua being the main mining centers. The District covers an area of about 1,364 sq. km and forms about 5.4 percent of the total land area of the Ashanti Region (AWDP, 2005). The district has a population of about 108,726 people. The district lies entirely in the rainforest belt. It exhibits most semi-deciduous characteristics. The district is very rich in forest resources, such as timber, herbs of medicinal value and fuel wood. It also abounds in different species of tropical hardwood, notably Odum, Mahogany and Sapale. There are four main forest reserves in the district. These are: Oda River Forest Reserve, Apamprama Forest Reserve, Gyeni River Forest Reserve and Jimira Forest Reserve. The dominant soil type in the district is the ochrosols soils that are suitable for a number of crops such as plantain, cocoyam, cassava, maize, legumes, oil palm, cocoa, coffee, citrus and pear. The district covers an area of 136,400 square kilometers. The year 2000 Population and Housing census puts the estimated population of the district at 108,273 with a population density of 62.8 persons per square kilometer. The district can be classified as predominantly rural. It has about 310 settlements fairly distributed within the district. Of the 310 settlements, only 19 have populations above 1000 and shows a large proportion constituting the small settlement of farming communities.

3.1.2 Topology & drainage

The topography of the district is generally undulating with an elevation of 210m above sea level. The most prominent feature is the range of hills, which stretches across the north-western part of the district, especially around Manso-Nkwanta and Abore. These hills have an elevation of between 560m and 630m. The district is drained in the north by the Offin and Oda rivers and their tributaries such as Jeni, Pumpin and Emuna.

3.1.3 Economy and Agriculture

Agriculture is the mainstay of the people in the district in terms of output, employment and income as the bulk of the economically active population are involved in it. The District is endowed with large tracts of fertile and arable lands for Agricultural investment. Food crops such as Yam, Plantain, Cocoyam, Cassava, Maize, Legumes and Vegetable are widely grown in the District. Plantation crops such as Cocoa, Coffee, Citrus and Pear are also produced in the District, The District has two rainy seasons, which makes all year round farming possible. The major season is between March and July whilst the minor season is between September and November. The mean monthly temperature is 26"c and the mean annual rainfall ranges between 160 - 180mm.

3.2 Research Approach

The research was conducted in four phases and Figure 1 shows the steps and approach used in the study.

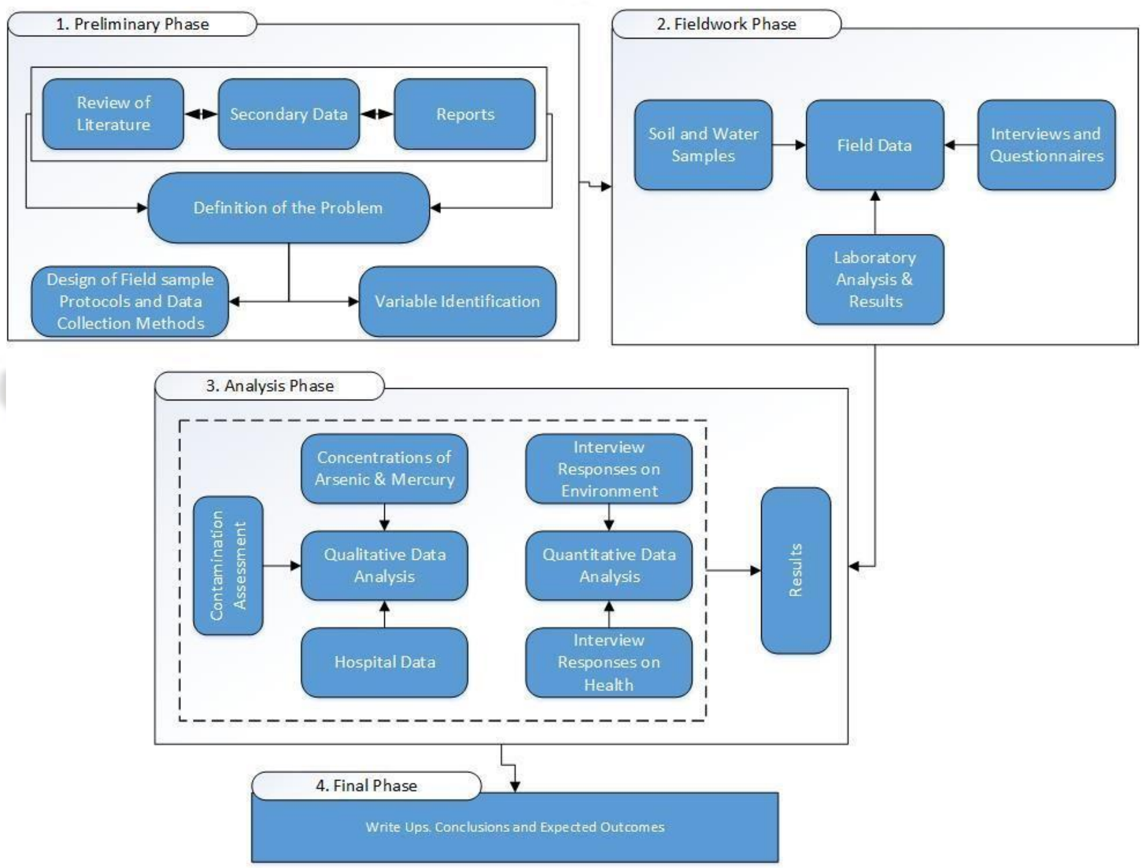


Figure 3.2: Research Approach

3.2.1 Preliminary Phase

This was the first phase of the research and it looked at review of literature, shopped for secondary data and observed the activities and actors in the small scaling mining industry. Extensive review of research, policy and legislative documents were also conducted under this phase. From these activities, the design of field samples and variables to be measured were done.

3.2.2 Fieldwork Phase

The fieldwork phase was the second phase of the research where measurements of variables in the study were conducted. Collection of soil samples from the twelve mining communities in the Amansie West District of Ashanti Region. Residents and workers in the small-scale mining industry were also interviewed. Laboratory analysis were performed to identify two heavy metals of arsenic and mercury in soil samples collected from the study area.

3.2.3 The Analysis Phase

Analysis of data was done in the third phase of the research. Both qualitative and quantitative analysis were done on the measured variable. Responses from interviews were also analyzed. Environmental and human health effects as a result of small-scale mining activities which were also assessed and documented and were also done under this phase of the research.

3.2.4 Final Phase

This phase of the research was made up of final write up, general assessment of smallscale mining in the Amansie West District of the Ashanti Region and on these bases draw recommendation and implications for future policy. This phase also considered the submission and defense of the research

3.3 Materials

The materials used to assess the environmental and health impact of small-scale mining in the Amansie West District of Ashanti region, of Ghana are discuss in the following subsections.

3.3.1 Data Used

In order to assess the environmental and health impacts as a result of small-scale mining activities in mining communities of the Amansie West District,the data as listed in Table 3.1 were used.

Table 3.1: Data Used

Data	Source
Hospital Annual Health Review 2012-2014	Agroyesum Hospital
District Mid-Year Health Review 2012-2014	District Health Directorate
Ghana Small-scale Mining Regulation	Ghana Mineral Commission

3.3.2 Equipment Used

Table 3.2 also gives a summary of the equipment used in the research.

Table 3.2: Equipment Used

No	Equipment	Use
1	X-Ray Fluorescence	Used to perform the elemental analysis for heavy metals from the soil samples collected
2	Ziplog Bags	These were served as containers for the collected soil samples
3	Plastic Spoon	The spoons were used in collecting the surface soil samples
4	100µm Mesh Sieve	The mesh was used during the sample preparation phase to fine the soil to their required particle size

3.3.3 Software Used

Data preparation and arrangement was done using Microsoft Excel. Exploratory statistical analysis was done using Stata 13. Zotero was used as the reference manager while Microsoft Word was used for the compilation of this research write up.

3.4 Laboratory Methods

3.4.1 Determination of Arsenic and Mercury Contamination

Soil and Water Sampling

Mainly a purposive sampling approach was adopted in the collection of soil and water sample data. A total of nineteen soil and water samples were collected from the twelve mining communities within the Amansie West District. The samples were collected in areas where small-scale mining activities are taking place and in areas where the activities had previously taken place. New plastic spoons were used at each location so as to avoid cross contamination of other sites.

Sampling Preparation and Laboratory Analysis

The collected soil samples were air dried at room temperature, and then sieved using a 100µm mesh. The samples were pulverized into a 2.5cm diameter thick pellet which were compressed using a 10-ton hydraulic press. Using acid tone or Nitric acid HNO_3 and wool the equipment was clean after each procedure so as to avoid cross contamination. The analysis of the two heavy metal (Arsenic (As) and Mercury (Hg)) concentrations in the prepared samples were done using the X-Ray Fluorescence (XRF) spectrometer at a maximum power of 3000W (60Kv and 50mA). The pelleted samples were placed in a disk and then placed on the excitation source of the XRF for a tenminute irradiation using Silicon Lithium Si(Li) detector with a resolution of 16V with Mn and Kα peak used throughout the procedure. To validate procedure and ensure quality control, International Atomic Energy Agency (IAEA) Standard Reference IAEA Soil 7 was irradiated five time and average values compared with recommended values before analysis of prepared samples.

Statistical Analysis of Arsenic and Mercury

The study using Stata 13 conducted statistical analysis including descriptive statistics to describe the measured variables of Arsenic and Mercury concentrations. The mean, standard deviation, median, coefficient of variation and the range were analysed to assess the normality and identify outliers in the study variables. The correlation, relationships and significance between variables were also performed. The descriptive statistics were also compared with Soil Quality and Guidance Values of the Dutch Environmental Protection Agency.

Contamination Assessment

To examine the health and environmental impacts of small-scale mining activities in these mining communities within the Amansie West District the extent of contamination based on the contamination factor of the two heavy metals and the degree of contamination which is the sum of the contamination factors of the two heavy metals at a location. The Contamination Factor and the Degree of Contamination have been used over the years to assess or ascertain the extent of contamination of heavy metals in soil (Loska et al. 1997; Loska et al. 2004; Liu et al. 2005; Atiemo et al. 2012). The contamination factor as defined by Hakanson (1980)is expressed as:

$$C_f^i = \frac{C_{0-1}^i}{C_n^i}$$ **Equation 3.1**

Where $C_f{}^i$is the contamination factor of the element of interest; $C_0{}^i{}_{-1}$ is the concentration of the element in the sample; $C_n^i$is the background concentration or the continental crustal average as was used by (Taylor and McLennan 1985). The Contamination factor is defined according to four categories (See Table 3.3).

Table 3.3: Classification of Contamination Factor

Contamination Factor	Extent of Contamination
< 1	Low CF
1< CF ≤ 3	Moderate CF
3< CF ≤ 6	Considerable CF
CF>6	Very high CF

Although the Contamination Factor is used to evaluate the pollution of the environment by single substances it is complimented by the degree of contamination which is the sum of contamination factors and describes the contamination of the environment by all examined substances. The Degree of Contamination defines the quality of the environment and is expressed as:

$$C_{deg} = \sum C_f^i$$ **Equation 3.2**

The Degree of Contamination was useful in this study as it gives a comprehensive assessment of contamination by summing up contamination factors of all elements measured and the possibility of utilizing background concentration. The degree of Contamination is useful to identify hot spots within the sampling location. The Degree of Contamination is also categorized into four (see Table 3.4)

Table 3.4: Categories of Degree of Contamination

Degree of Contamination (Cdeg)	Extent of Contamination
Cdeg < 8	Low degree of contamination
8 ≤ Cdeg < 16	Moderate degree of contamination
16 ≤ Cdeg < 32	Considerable degree of contamination
Cdeg ≥ 32	Very high degree of contamination

3.4.2 Examination of Environmental and Health Impacts

Study Type and Design

A community-based descriptive cross-sectional survey was conducted to help assess and describe the mining activities being carried out in the district and to identify the effect on the health of the people and the impact on the community.

Sampling

Due to the location of small-scale (both legal and illegal (galamsey)) mining, distance of artisans from small-scale mining sites and objective of the study, two sampling techniques were adopted for the study. Since not all the communities in the Amansie West district are involved in small-scale mining, purposive sampling technique was used in selecting twelve mining communities where small-scale mining activities are on-going. The selection of the communities was based on the criteria of a community having small-scale mining activity, the size and the proximity of people working in this area and the extent of observed environmental and health impacts as a result of smallscale mining in the district. After the selection of the communities, simple random sampling was used in the selection of interviewees from the selected communities for questionnaires to be administered to them.

Data Collection

The data type used in this study was solely based on primary data that were collected by the researcher. Questionnaires administered covered the general background of the respondent, a check list of possible diseases associated mining, possible health status, and their awareness on issues of small-scale mining.

Data Collection Technique

To ascertain, document and observe the effects of small-scale mining as well as examine the factors contributing to the increasing activities of small-scale mining and accompanied environmental and human health impacts within the Amansie West District of the Ashanti Region closed ended questionnaire mixed with open ended ones (see Appendix A) were administered in the district during data collection. Review of literature from current journal, conference proceedings and credible reports will also be done.

Sample size estimation

Power and Precision software was used to calculate the minimum sample size required with level of significance set at 5% for a 95% confidence interval. The sample size required for effective analysis (385), the calculated sample size was extrapolated to four hundred and twenty-four (424) by a ten per cent (10%) non-response rate.

Population

Four hundred and twenty-four (424) artisans and residents were selected and interviewed during this phase of the study with a ten per cent (10%) non-response rate. The population included people working in the small-scale mining areas and families or people living within the mining areas.

Pretest of Questionnaires

Twenty small-scale miners from Abore were purposefully selected for pre-testing of the questionnaire before administering it for the large scale study. Options obtained for the questionnaires were used to re-structure unclear and ambiguous questions in the questionnaire and to prompt respondents during the main stream study. The pretesting also served as pre-training for the research assistants who will be conducting and administering the questionnaires.

3.5 Data Analysis

The qualitative data was analyzed with SPSS version 20 by displaying their frequency distribution. The association or relationship between the studied nominal or categorical variables were assessed using Chi-Square and the Likelihood Ratio Tests at a p-value significance less or equal to 0.05. The Chi-Square Test was used when the overall expected count is less than 20% of the observed account. The Likelihood Ratio Test is applied the expected count of less than 20% is violated. The test of significance or strength of relationship between variables were also assessed using the Cramer's V

Test. The strength or significance of the relationship (Cramer's V) is categorized and described in Table 3.5

Table 3.5: Strength of Relationship Using Cramer's V

Cramer's V	Verbal Description
0.00 to 0.15	Very Weak
0.16 to 0.20	Weak
0.21 to 0.25	Moderate
0.26 to 0.30	Moderately Strong

0.31 to 0.35	Strong
0.36 to 0.40	Very Strong
0.41 to 0.50	Worrisomely Strong
0.51 to 0.99	Redundant
1.00	Perfect Relationship.

3.6 Ethical Considerations

Ethical clearance for the study was also obtained from Institutional Review Board (IRB) of College of Health Science of the Kwame Nkrumah University of Science and technology. Written consent was also obtained from respondents to ensure their willingness to participate in the study. Participants were assured that at any point during the study they are free to withdraw from the study. The research team also ensured confidentiality of the data collected.

3.7 Limitations of Study

During the study of the health and environmental impacts of small-scale mining in the Amansie West District, the following limitations were encountered:

i. The application of purposive sampling for the collection of soil samples could introduce bias and make the data not representative for the conclusion drawn for the study area.

ii. Accessibility to the sampling areas was also limited by the terrain and mining operations or activities in the study areas. The mining areas were very muddy and waterlog and the danger to slip or fall limited the researcher and research assistants' ability to navigate the areas for soil sample collection which again raises the issue of representativeness of the soil samples collected.

iii. Again, the use of structured questionnaires also placed possible limitation as indepth understanding and expression were restricted by the fixed responses provided in the questionnaires.

4 RESULTS

4.1 Demographic Characteristics

The demographic characteristics are presented in Table 4.1, Table 4.2 and Table 4.3. Responses were obtained from a total of 12 mining communities within the Amansie West District of the Ashanti Region. The responses from the twelve communities in Table 4.1 shows a fairly equal distribution with Abodom and Aponapong showing 10.2% while Kensere and Mpatasie recorded the least responses with 6.9% each. The other communities recorded responses within the range of 7.2% and 9.3%.

Table 4.1: Communities Involved in the Study

No	Community	Frequency	Percent
1	Abodom	34	10.2
2	Adwumamum	24	7.2
3	Agroyesum	31	9.3
4	Aponapong	34	10.2
5	Brofroyedu	25	7.5
6	Kensere	23	6.9
7	Kwankyeabo	32	9.6
8	Mem	32	9.6
9	Mpatasie	23	6.9
10	Nweneso	25	7.5
11	Odumasi	24	7.2
12	Yawkrom	25	7.5
	Total	**332**	**100.0**

Further, the gender distribution showed skewness towards males with 68.4 % of the respondents while the female population recorded 31.6% (see Table 4.2). Again, Table 4.2 shows majority of the respondents representing 61.7% were within the age range of 18-29 with 6.3% representing respondents above 40 years being in the minority. Also worth noticing is the 12.3% of the respondents under the age of 18 years.

Table 4.2: Gender and Age Distribution of Respondents

Variable	Frequency	Percent
Gender		
Female	105	31.6
Male	227	68.4
Age Range		
Below 18	41	12.3
18 -29	205	61.7
30 – 40	65	19.6
Above 40 years	21	6.4

Again, Table 4.3 revealed majority of the respondents representing 48.8% had primary education as their highest education level and 29.8% have no formal education while 2.1% had education up to the tertiary level. Furthermore, the demographic analysis on occupation showed 50% of respondents as miner and 28.3% as farmers. Artisans were 3.3% of the respondents while 7.8% of the respondents were students.

Table 4.3: Educational and Occupational Background of Respondents

Variable	Frequency	Percent
Education		
No Formal Education	99	29.8
Primary	162	48.8
Secondary	64	19.3
Tertiary	7	2.1
Occupation		
Artisan	11	3.3
Farmer	94	28.3
Miner	167	50.3
Student	26	7.9

Teacher	11	3.3
Trader	23	6.9

4.2 Levels and Contamination of Arsenic and Mercury

The results from soil and water samples analysis to ascertain the levels and contamination of arsenic and mercury are presented in this section.

4.2.1 Arsenic and Mercury Levels in Soil and Water

Table 4.4 shows the summary statistics of arsenic and mercury levels in soil and water from the 12 mining communities in the Amansie West District.

Table 4.4: Summary Statistics of As and Hg in Soil and Water

Statistic	Soil Samples		Water Samples	
	As	Hg	As	Hg
Mean	28.57	2.33	3.27	0.16
Median	23.09	0.11	2.63	0.03
S.D	14.64	3.35	2.38	0.39
Minimum	7.50	0.01	0.25	0.01
Maximum	52.31	11.20	8.02	1.34
C.V	0.51	1.44	0.73	2.48
Skewness	0.23	1.62	0.75	3.25
Kurtosis	-1.28	2.09	-0.30	10.68
No of Obs	19	18	18	11
SQGV (Dutch)				
Optimal	29.00	0.30	10.00	0.05
Action Required	55.00	10.00	60.00	0.30

A total of nineteen samples were collected from the twelve communities. Out of the 19 soil samples collected As were observed and detected in all the 19 soil samples while Hg was observed and detected in 18 out of the 19 soil samples (see Appendix B). With respect to the water As was detected in 18 of the water samples while Hg was detected in 11 water samples (as shown in Appendix C). Table 4.4 shows mean concentrations of Hg in both soil and water samples were significantly higher than the optimal or minimum concentrations of Hg expected to be in soils but the measured mean concentrations were however lower than that of action required limits of Hg in soil and water when compared the Dutch SQGV. Mean concentrations of As both in soil and water however were lower than the optimal and action required values of the Dutch Soil Quality and Guidance standards. Again, the differences between the mean and median of the elements in the two medium indicates the data was not normally distributed. The non-normality of the data is also seen in the values of skewness and kurtosis. The skewness shows all the dataset are positively skewed with As in soil and water showing characteristics of normally distributed data when compared with Hg dataset in soil and water. Hg in water and soil showed greater variation with a high coefficient of variation of 2.48 and 1.44 of Hg in water and soil respectively. As in soil also showed lower variation with a variation coefficient of 0.51 and in water with 0.73 coefficient of variation.

4.2.2 Relationship Between As and Hg in Soil and Water

The correlation coefficient matrix of As and Hg in both soil and water was done to assess the relationship between the two variables under investigation. Table 4.5 shows the correlation matrix. The matrix shows a weak positive correlation of As (Soil) at 0.097 with As levels in water and showed a weak negative correlation with Hg (Water). Hg (Water) showed a weak negative correlation with As (Soil), Hg (Soil) and As (Water) at -0.195, -0.247 and -0.147 respectively. The matrix as shown in Table 4.5 however showed a strong negative correlation of As (Soil) with Hg (Soil) at -0.640 with a p-value of 0.008 implying a significant relationship between As and Hg in soil.

Table 4.5: Correlation Coefficient Matrix of As and Hg in Soil and Water

Variable	As (Soil)	Hg (Soil)	As (Water)	Hg (Water)
As (Soil)	1			
Hg (Soil)	-0.640*	1		
As (Water)	0.097	0.185	1	
Hg (Water)	-0.195	-0.247	-0.147	1

*Significant at p<0.05

4.2.3 Contamination Assessment of As and Hg in Soil

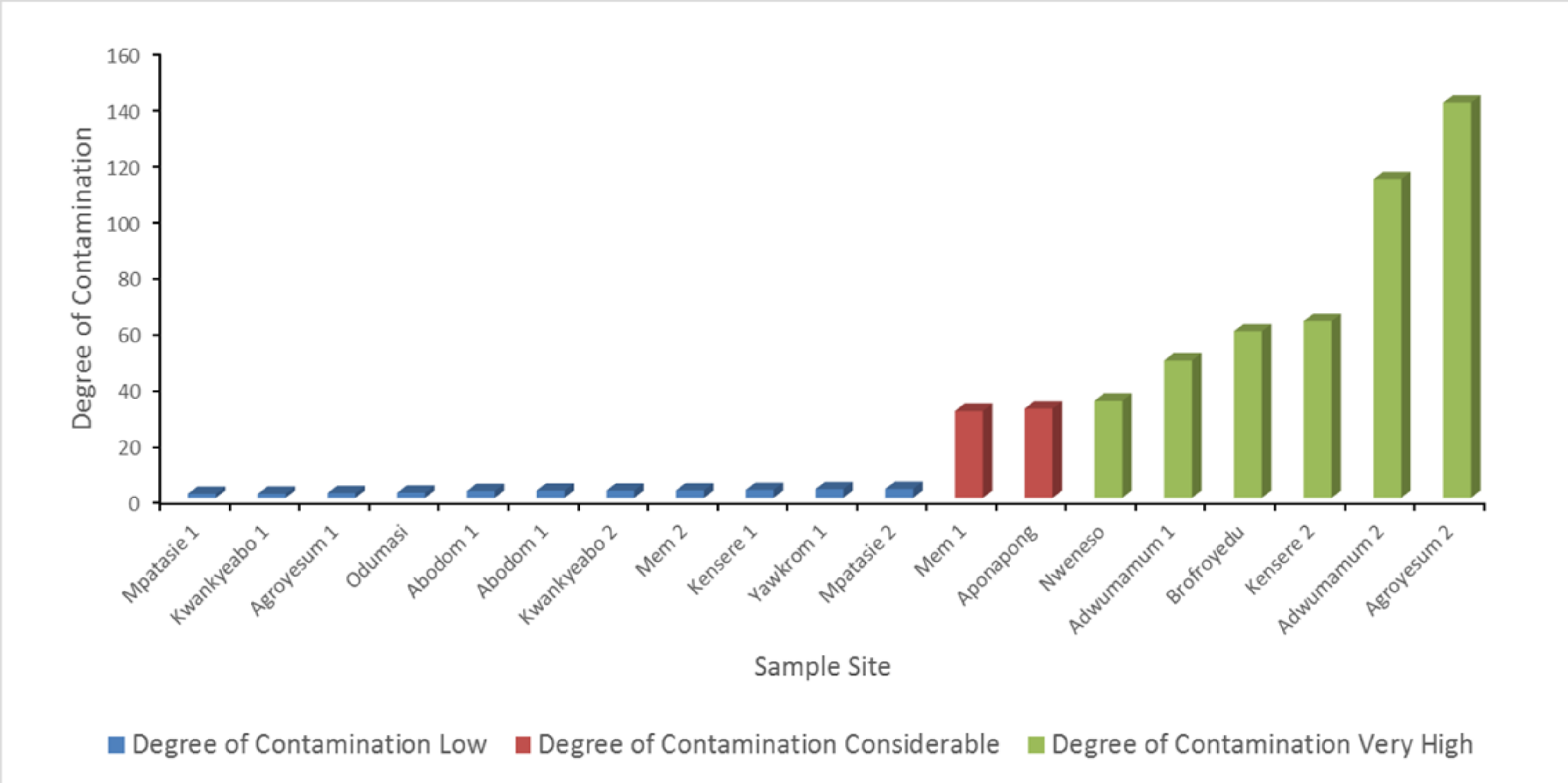


Figure 4.1: Degree of Contamination at Sample Sites

Table

Figure 4.1 shows the degree of contamination from the sample sites. Site in blue were graded as low degree of contamination as the degree of contamination values of these sites were below 8 and within the classification of low degree of contamination. Two small-scale mining sites of Mem 1 and Aponapongwere graded with considerable degree of contamination with their degree of contamination values between 16 and 32. Nwenso, Adwumamum 1, Brofroyedu, Kensere, Adwumamum 2 and Agroyesum had degree of contamination values 34.62, 49.03,59.38, 63.01 and 140.87 respectively and as such classified as very high degree of contamination as their values exceeded 32.

4.3 Environmental and Health Impacts of Small-scale Mining

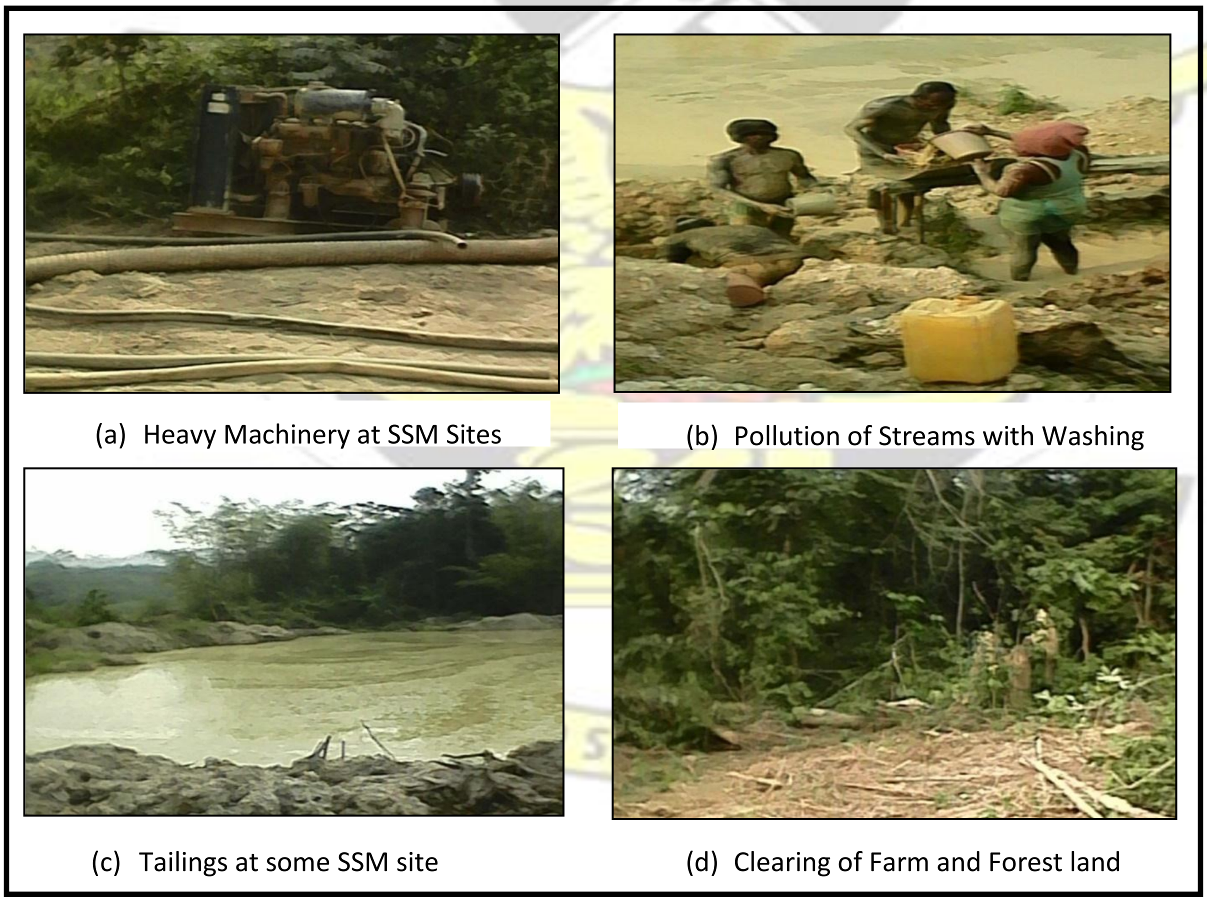
This section presents the results of health and environmental impacts of small-scale mining in the Amansie West District.

4.3.1 Environmental Impacts of Small-scale Mining

Table 4.6 and Figure 4.2 show responses and observed environmental impacts as a result of small-scale mining in the communities where the study was conducted. 94.9% of the respondents pointed out the activities of small-scale mining have effects on the environment with 5.1% indicating that small-scale mining activities have no effect on the environment. Five (5) environmental impacts were identified (Table 5), with 43.4%, 34.9% and 12.0% of the respondents indicating destruction of forests & farm lands, water pollution and erosion as some environmental impacts from small-scale mining activities in these communities. Noise and air pollution recorded the least responses with 3.3% and 1.2% respectively as other environmental impacts from small-scale mining.

4.6: Observed Environmental Impacts by Respondents

Variable	Frequency	Percent
Opinion on Environmental Impact		
No	17	5.1
Yes	315	94.9
Environmental Impact		
Air Pollution	4	1.2
Destruction of Forest & Farmlands	144	43.4
Erosion	40	12.0
No Response	17	5.1
Noise	11	3.3
Water Pollution	116	34.9
Total	**332**	**100.0**



(a) Heavy Machinery at SSM Sites

(b) Pollution of Streams with Washing

(c) Tailings at some SSM site

(d) Clearing of Farm and Forest land

Figure 4.2: Some Environmental Impacts Observed during Fieldwork

Table

4.3.2 Relationship between Demographics and Environmental Impacts

The Likelihood Ratio Test (LRT) for association and the Cramer's V test for the size or effect or significance of the association are given in Table 4.8. The test of association or relationship showed Gender has no evidence of significant association with environmental impacts from small-scale mining with a LRT of 11.144 at p>0.05. There is however evidence of a relationship between the demographic characteristics (Age, Education, Occupation, Marital Status and length of stay) and environmental impacts at p<0.05. A further test to assess the strength of these associations showed Education and Length of stay as not having a strong association or relationship with environmental impacts with Cramer's V of 0.169 and 0.160 respectively at p<0.05 (See Table 4.7).

Table 4.7: Demographic Characteristics and Environmental Impacts

Relationship (Demographics& Environmental Impacts)		LRT	Cramer's V	Asymp Sig (p-value)
Environmental Impact	Gender	11.144	0.184	0.082
	Age	53.457	0.204	0.001*
	Education	36.415	0.169	0.006**(0.057***)
	Occupation	94.051	0.261	0.001*
	Marrital Status	31.708	0.176	0.024*
	Length of Stay	29.764	0.16	0.040**(0.113***)

*Significant at both LRT and Cramer's V: **Significant at only LRT: ***Not significant at Cramer's V

4.3.3 Environmental Interventions

On interventions being put in place to curtail some of the impacts as a result of the small-scale activities, 48% of the respondents were of the opinion that No Visible Intervention is or are taken place, with 18.7%, 16.9%, 8.7% and 5.7% (Table 4.8) of the respondents revealing Proper Maintenance, Reforestation, Resettlement and construction of Gutters respectively as some interventions put in place by operators of these small-scale mining to minimize the impacts from small-scale mining. It is also worth noting that 1.8% of the respondents saw variation on the operation times as an intervention to minimize the impacts from small-scale mining.

4.8: Observed Environmental Intervention by Small-scale Miners

Intervention	**Frequency**	**Percent**
Construction of gutters to channel waste water	19	5.7
No Visible Intervention	160	48.2
Proper Maintenance of tailings	62	18.7
Reforestation	56	16.9
Resettlement to avoid impacts	29	8.7
Varying operations timings	6	1.8
Total	**332**	**100.0**

4.3.4 Environmental Interventions and Demographic Characteristics

An examination to assess the relationship and the strength of relationship between environmental interventions and demographics from the study showed four (Gender, Age, Education and Marital status) had no evidence of relationship. There is however strong evidence of relationship or association between two demographic characteristics (Occupation and Length of Stay) and environmental interventions. A further assessment for the strength the association using Phi and Cramer's V showed moderate association between the environmental interventions and occupation with a Cramer's V of 0.234 at a p-value ≤ 0.05 (Table 4.9). In addition, from Table 4.9, Length of Stay also showed evidence of an association with environmental interventions and indicated strength of the association as weak with a Cramer's V of 0.165 at p-value ≤ 0.05.

Table 4.9: Environmental Interventions and Demographic Characteristics

	Relationship	Chi-Sq^{c}/LRT^{L}	Phi^{p}/Cramer's V	P-value
Environmental Interventions	Gender	7.046^{c}	0.146	0.113
	Age	18.134^{L}	0.218	0.204
	Education	15.842^{L}	0.111	0.430
	Occupation	81.125^{L}	0.234	0.001*
	Marital Status	16.786^{L}	0.127	0.190

Table

Length of Stay	27.279[c]	0.165	0.007*

*Evidence of relationship and significant at p-value<0.05

4.3.5 Health Impacts from Small-scale Mining Activities

From Table 4.10, a total of eight diseases were reported by respondents as some of the health issues which is or are either on the increase or identified as a result of increasing small-scale mining activities in these communities. 31% of the respondents indicated malaria as one of the health issues resulting from the small-scale mining activities while Skin Diseases and Respiratory Disease were reported by 27.1% and 13.6% of the respondents. 2.7% of the respondents also indicated Onchocerciasis as another health issues respondent are having to cope with.

Table 4.10: Respondents Reported Health Impacts

No	Disease	Frequency	Percent
1	Eye Diseases	30	9.0
2	Malaria	103	31.0
3	No response	16	4.8
4	Respiratory Diseases	45	13.6
5	Schistosomiasis	23	6.9
6	Skin Diseases	90	27.1
7	Wounds	25	7.5
	Total	332	100

Further, the results on health impacts as reported by the respondents during the studies follows a similar trend of the top ten diseases record by the district hospital from 2012 to 2014 (Table 4.11). A comparison of diseases reported as health impacts per respondents (Table 4.10) and the hospital records (Table 4.11) shows that all the diseases as reported by the respondents are among the top ten diseases reported hospital.

4.11: Hospital recorded data from 2012 - 2014

SN	DISEASES	2012	2013	2014
1	Malaria	15684	18633	20505
2	Acute eye infection	3311	4592	3992
3	A.R.T.I	3177	2414	2425
4	Rheumatism & joint pains	1930	3469	3675
5	Skin diseases & ulcers	1706	1789	1822
6	Anaemia	793	1062	1226
7	Intestinal worms	1493	1027	1181
8	UTI	924	742	827
9	Gynaecological conditions	888	555	721
10	Diarrhoea	694	520	316

4.3.6 Health Impacts and Demographic Characteristics

Worth noting from Table 4.12is that all the demographic characteristics showed strong evidence of a relationship with health impacts from small-scale mining activities in the studied communities. With a Cramer's V of 0.246, age and education showed a moderate relationship or association with observed health impacts at p-value of 0.001 while length of stay in these community showed a moderately strong association with a Cramer's V of 0.297 at p-value of 0.001. Gender, Occupation and Marital status however showed strong relationship with health impacts from small-scale mining activities.

Table 4.12: Health Impacts and Demographic Characteristics

Relationship	LRT	Cramer's V	P-value

Table

Health Impacts	Gender	45.021	0.334	0.001
	Age	63.758	0.246	0.002
	Education	65.063	0.247	0.001
	Occupation	153.384	0.302	0.001
	Marital Status	85.504	0.311	0.001
	Length of Stay	100.362	0.297	0.001

4.4 Factors affecting Small-scale Mining

From the data analyzed four factors were found to affect small-scale mining activities in the Amansie West District of the Ashanti Region (Table 4.13). From Table 4.13, 30.1% of the respondents indicated non-enforcement of existing small-scale mining regulations, 27.1% indicated lack of regulation, 25.6% were also of the opinion that miners lack awareness on the threats of their activities on the environment and health while 15.4% of the respondent also indicated lack of punitive measures to offenders or miners who do not adhere to existing operating standards as the factors affecting small-scale mining within the study area.

Table 4.13: Factors affecting Small-scale mining in Ghana

Factors affecting SSM	Frequency	Percent
Lack of awareness of miners	85	25.6
Lack of Regulation	90	27.1
No punitive Measures	51	15.4
No Response	6	1.8
Non enforcement of existing regulations	100	30.1
Total	332	100.0

Relationship between Factors affecting SSM and DemographicsAn assessment of the relationship between demographic characteristics and factor affecting small-scale mining within the Amansie West District showed Gender, Age, Education and Marital status had no relationship with the factors affecting small-scale mining activities as they showed a likelihood ratio test which is a measure of relationship or association of 7.225, 18.134, 15.842 and 16.787 respectively at p-value > 0.05 (Table 4.14). Occupation and length of stay of respondent however showed moderate and weak existence of a relationship with factors affecting small scale mining of a likelihood ratio test of 81.125 and 29.449 at p-value < 0.05 (See Table 4.14).

.

4.14: Factors affecting SSM and Demographic Characteristics

	Relationship	LRT	Cramer's V	P-value
Factors affecting SSM	Gender	7.225	0.146	0.133
	Age	18.134	0.126	0.204
	Education	15.842	0.111	0.43
	Marital Status	16.787	0.127	0.19
	Occupation	81.125	0.234	0.008
	Length of Stay	29.449	0.165	0.007

5 DISCUSSIONS

5.1 Levels of As and Hg in Soil and Water

This study revealed the following key findings, mean concentrations of Hg measured in soil and water were significantly higher than the optimal limit but lower than the action required limits of the Dutch Soil Quality and Guidance Values and eight out of the nineteen sample zones were all considered to be higher contaminated with As and Hg. The results of As and Hg in soil and water are in Appendix A. The levels of As in soil ranged from 7.50 to 52.31, Hg in soil ranged between 0.01 and 11.20, in water As ranged between 0.25 and 8.02 while Hg ranged between 0.01 and 1.34 as shown in Table 4.1. Although, the minimum and maximum values of As in water were below the optimal and action values according to the Dutch Soil Guidance and Quality values, the low values of As in water could be due to the fact that there is less usage of As in the processing of mined minerals by the small-scale miners or may be due to the fact that the sites visited were new areas being operated by small-scale miners as such not much processing have been done in these areas. Similarly, studies by Adetunde et al(2014) also confirmed acceptable limits of As in water from mining areas in the Obuasi Municipality. The levels of As in soil however was lower than those measured in old and active small-scale mining areas in Obuasi(Asante et al. 2007; Bernard and Duker 2007) and in Tarkwa (Asante et al. 2007).

The extremely high values of the maximum and mean values of Hg above the optimal and actions values of the Dutch SGQV be from the usage of Hg in the washing and processing of mined minerals. The extremely high values of Hg were measured in Kensere and Agroyesum which have a very active small-scale mining sites operated by a sizable number of indigenous and foreign miners. In a similar studies by Donkor et al (2006)and Babut et al(2003)measured Hg heavy metals in stream nearby small-scale mining areas but however did not only attributed the levels of Hg to the operations of small-scale mining but also to river line sediment of the terrestrial origin as a result of methyl mercury (Hg) found in the aqueous phase.

Further, seven (7) out of the nineteen (19) sites (Appendix B) for the soil sampling recorded Hg values above the optimally required levels in soil could also be due to the fact that there is or are an active and intense small-scale mining activity or activities using Hg in the processing or discharges from the tailings of these small-scale mining sites which sips into nearby soils. Furthermore, the considerable and very high degree of contamination from Mem 1, Aponapong, Nweneso, Adwumamum 1, Brofroyedu, Kensere and Agroyesum can also be attributed to the very active and large small-scale mining activities in these areas.

5.1.1 Degree of Contamination of As and Hg

The degree of contamination gave the extent to which both heavy metals measured from the small-scale mining communities pollutes the sample locations. With eight of the sample locations showing considerable to high degree of contamination, there is the likelihood of people living in the areas getting exposed to these heavy metals through plant uptake, water bodies and dermal contact. Several studies Atiemo et al (2012) and Itai et al (2014) have indicated areas contaminated with heavy metals could present current and future health risk to people living in these areas. These results and conclusions by Atiemo et al (2012) and Itai et al (2014) give indication that business as usual scenarios in these mining areas could have health implications for people living in these mining communities.

5.1.2 Relationship between As and Hg

As showed in the table 4.5 a significantly negative correlation with Hg in soil at an adjusted r square of 64% at a p-value less than 0.05. The significant but negative correlation between As and Hg in soil could be attributed to the high in demand operational use of Hg and the less usage of As in the processing of mined minerals. It is also worth noting that the significantly negative correlation between As and Hg in soil does not imply cause and effect relationship of these two heavy metals. The significantly negative correlation between As and Hg in soil could also be explained by anthropogenic factors in the use of mercury for processing mined mineral and naturally occurring As levels identified in mining areas (Wickre et al. 2004). Again, despite the measured amount of Hg in water, has a property of easily vaporization in water can account for it low levels measured in water and the subsequently weak correlation between the two heavy metals.

5.2 Environmental and Health Impacts of Small-scale Mining

5.2.1 Environmental Impacts

The results from the interviews on environmental impacts showed destruction of forest and farmlands as the top environmental issue reported by respondents. With a number of the residents being farmers before the activities of small-scale mining, the clearing of lands for mining activities would not only be an impact on the environment but also a threat to their livelihood as most of them depend on these farms and forests for their daily source of livelihood. Furthermore, the clearing of their farmland, forest and threat to their livelihood is compounded by the pollution of their source of water that serves as their source for irrigation of their farm and other household chores.

The expected low response from respondents on air pollution and noise which were 1.2% and 3.3% respectively could be as a result of the location of these small-scale mining sites from residential areas of the people in the mining communities. The responses on the environmental impacts from small-scale mining areas collaborate with earlier findings of Hilson (2001); Hilson (2002) and Yeboah (2008)where the issues of air pollution, destruction of forests and farmlands, water pollution and Noise cut across in all these studies as environmental impacts from smallscale mining.

5.2.2 Environmental Interventions

Contrary to the visible intervention of borehole construction identified by Bernard and Duker(2007), majority of the respondents of this study revealed of no visible intervention in these less known mining areas of the Amansie West District of the Ashanti Region. The invisibility of intervention in the less known mining communities could be attributed to the lack of enforcement and implementation of policy and legislation in these community. Again, this also raises question of whether the operation of small-scale mining activities in the area receives some form of monitoring or not. Besides the majority response of no visible intervention in the mining communities, resettlement of farmer, time variations in the operations of small-scale miners reflects the findings of Yeboah(2008).

5.2.3 Demographics, Environmental Impacts and Interventions

Of the six demographic characteristics age, occupation and marital status showed strong and significant relationship with environmental impacts. Surprisingly, despite the evidence of a relationship between education and environmental impacts, the relationship is not significantly strong confirming studies by Yeboah(2008) and this could be attributed to respondents bias with a cumulative total of over 70% have no formal education and up to primary school education. Similar inference was also drawn for the relationship between gender and environmental impact, which also showed similar bias in the respondents' gender of 68.4% males.

Furthermore, two demographic characteristics of occupation and length of stay out of the six demographic characteristics indicated strong relationship with intervention put in place to reduce the environmental impacts from small-scale mining. The non-existence of relations between environmental and the four other demographic characteristics could also be attributed to bias in either of the two variables been compared.

5.2.4 Health Impacts

The expected high responses to malaria which recorded 31% could be due to the increasing number of stagnant water points serving as tailing and breeding ground for mosquitoes which cause malaria. Further, the high number of respondents' choice of skin diseases may also stem from the fact of high degree of contamination of these areas with As and Hg which has the potential to irritate the skin causing skin disease and with the potential to even cause cancers. Respiratory diseases which were the third highest health impacts reported by respondent could possibly be due to the fact that most of the workers in the small-scale mining sites work unprotected and without any protective gear (See Figure 4.2) during work and such inhale a lot of dust and other possible toxicant with the ability to cause respiratory diseases. The reported responses also confirm reports from community health centres and annual municipal health reports of 2013 and 2014. Also seen and reported by small number of the respondents was schistosomiasis which is river and water related diseases with farmers, workers and other daily users of infected stream and waterbodies at risk. Lastly, the similar trend shown between the respondents reported health impacts (Table 4.10) and data reported by the hospital (Table 4.11) also confirmed earlier research by Akabzaa and

Darimani (2001)that also recorded diseases such as malaria, respiratory tract infection, skin diseases, acute conjunctivitis and wounds as the top ten diseases reported in other mining communities.

5.2.5 Demographic and Health Impacts

All the demographic characteristics of gender, age, education, occupation, marital status and length of stay showed strong significant relationship with health impacts from small-scale mining. The significantly strong relationship of all characteristics and health impacts could imply bias in age, gender and other demographic variable distribution did not affect the relationship between these variables. This implies respondents' appreciation of mining effect on health positively and strongly correlated with all the demographic variable. Findings from Akabzaa and Darimani(2001); Hilson(2002) and Yeboah(2008) confirm results in this research which showed significantly strong relationship between demographic characteristics and health impacts from small-scale mining activities.

5.3 Factors Affecting Small Scale Mining

There was a normal distribution of responses on the factors affecting small-scale mining activities, this indicates representativeness of the samples while the factors of lack of awareness, lack of functional regulation, no punitive measures for violators of existing standards also confirms earlier work by Akagi et al.(2000); Babut et al. (2003); Taylor et al. (2005). The nonsignificance and non-existence of relationship or association within Gender, Age, Education and Marital status with the factors affecting small-scale mining could be as a result of bias in these demographic characteristics during data collection. The indication of association between occupation, length of stay and factors affecting small scale mining follows similar reasons as shown in sections 5.2.3 and 5.2.5.

5.4 Implications of the Study

The implication of the research and its findings are outlined under this section. The indication of pollution of mining areas in the Amansie West District with As and Hg from mining activities if business as usual scenarios should continue and persist in the long term will have health implications such as nausea, decrease blood cells, damage to blood vessels, darken skin and cause brain and liver damage (See Table 2.1) when people in these mining areas are exposed to As and Hg. Again, the continuous release of these contaminants of As and Hg into the environment could also contaminate soil, water bodies, plants and other aquatic species within the areas of mining activities.

In addition, continuous activities of small-scale mining if nothing is done will intensify the health and environmental impacts of small-scale mining. Further there is a clear indication from the findings that the relationship between demographic characteristics and health impacts could imply health impacts from small-scale mining is independent of biases of the demographic characteristics from the study areas.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Based on the results and discussions of the result, the following conclusions were drawn for this study:

- The revelation of a negative significant correlation between As and Hg in soil but weak correlation between the two in water could imply As and Hg mobilized by the streams or waterbodies seep and stay in the soil medium.

- Although majority of the sample sites were below degree of contamination targets, seven out of the nineteen study sites with a very active small-scale mining activities showed considerable and very high degrees of contamination.

- From the analysis of the contamination factors of both heavy metals, that is As and Hg, Hg contributed significantly to the high degrees of contamination in these six sites.

- There is a clear and obvious pollution of water bodies, destruction of farms, air pollution erosion and noise as some environmental impacts with its possible health implications for respiratory diseases, malaria, wounds and skin diseases from small-scale mining activities, the interventions reported however by workers of these mining to mitigate these impacts seem not to be visible to majority of respondents in the study.

6.2 Recommendation

Based on the work done the following recommendation are suggested for the attention of all stakeholders in the small-scale mining activities.

- There is the need for government both national and local and subsequently related agencies to ensure formulation, implementation and enforcement of policies that can help curb and reduce the impacts small-scale mining.

- Again there is the need to ensure collaboration between regulating agencies and public health workers so as to ensure enforcement of working standards and also promote educational awareness on the impacts of small-scale mining on health and environment.

- With As and Hg contributing greatly to the degree of contamination, alternative to the use of As and Hg dependent processing of mined minerals should be great interest to environmental managers, researchers and policy makers.

- Monitoring agencies such as the Environmental Protection Agency must ensure engineered construction of tailings dams which are the recipient of discharges from processed mined minerals should be done to help prevent or reduce sipping of contaminated substances in soil and plants

- Community leaders and operators of small-scale should also endeavor to ensure workers wear protective clothes during operations so as to reduce the direct impact of their activities on themselves and their immediate surroundings.

- Further, since entrusted community lands used for small scale mining activities are acquired from chiefs and community leaders, this research recommend chiefs and community rulers should regulate or avoid the indiscriminate sale of lands for small scale mining activities.

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APPENDICES

Appendix A: Questionnaire

Assessment of Environmental and Health impact of small-scale mining in the Amansie West District of Ashanti Region, Ghana General

Questions

1. Residence: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
2. Sex of Respondent
   a) Male b) Female
3. Age of Respondent
   a) Below 18 years c) 30 - 40 years
   b) 18 - 29 years d) Above 40 years
4. Level of Education
   a) No Formal Education
   b) Primary/JHS
   c) Secondary (SHS/Vocational/Technical)
   d) Tertiary (Training College/Polytechnique/University)
5. Marital Status
   a) Single c) Divorced
   b) Married d) Widowed
6. Occupation of respondents
   a) Farmer d) Nurse
   b) Miner e) Business/Trader
   c) Teacher f) Others, Specify: _ _ _ _ _
7. Since when have you been leaving here?
   a) Under a year
   b) 1 - 5 years
   c) 6 - 10 years
   d) Over 10 years

Impact of Mining on the environment within the Amansie West District

8. Are you involved in any mining activities in the community?
    a) Yes   b) No
9. In which mining sector or mining activity are you involved in?
    a) Industrial Mining
    b) Small-scale Mining
    c) Others, Specify
10. If you are involved in small-scale mining, is your mining work registered?
    a) Yes   c) I don't know
    b) No
11. Are you aware of any environmental impacts as a result of the mining activity?
    a) Yes   b) No
12. If yes, what are some of the environmental impacts as a result of these mining activities?
    a) Erosion
    b) Destruction of farmlands
    c) Pollution of water/river bodies
    d) Destruction of Forest
    e) Air Pollution
    f) Noise
    g) Others, Specify
13. What could be the cause of the environmental impacts mentioned above?
    a) Disposal of mining waste, tailings
    b) Use of Heavy machines
    c) The process of extraction/washing
    d) Clearing of virgin lands
    e) Others, Specify
14. Are there measures undertaken to reduce the impact on the environment?
    a) Yes   b) No
15. What factors contribute to the impacts from small-scale mining on the environment and human health?
    a) Lack of Regulation
    b) Non enforcement of existing Regulation

c) No punitive measures for Offenders

d) Lack of awareness on the part of miners

16. If yes, what measures do you put in place to reduce or minimize the impacts?

a) Reforestation

b) Vary the timing of operation

c) Re-settlement to avoid impact

d) Proper maintenance of tailings

e) Construction of Gutters to channel waste water

f) How effective are these measure over the period?

Mining Impacts on human health within the Amansie West District

17. Do you think or see small-scale miners and mining companies are doing something to reduce the impact of their activities?

a) Yes b) No

18. If yes, what are they doing to reduce the impacts?

a) Varying their time of operations

b) Provide Personal Protection Equipment

c) Provision Medical Assistance

d) Financing Health Insurance Schemes for community

e) Others

19. Are there some diseases or sickness or health impacts as a result of the mining? a) Yes

b) No

20. From the checklist of these diseases which of the following do you report of?

a) Malaria
b) Skin Diseases
c) Headaches and Cold
d) Respiratory Diseases
e) Asthma
f) Schistomiasis
g) Onchocerciasis
h) Respiratory tract diseases
i) Pulmonary tuberculosis and silicosis
j) Eye diseases (acute conjunctivitis)
k) Wounds
l) Diarrhoea
m) Others, Specify

Location	As (µg/l)	Hg (µg/l)
Kensere 1	2.81	1.34
Nweneso	6.02	0.03
Brofroyedu 2	0.52	ND
Adwumamum 1	4.62	0.07
Kensere 2	1.02	0.01
Adwumamum 2	8.02	0.06

Kwankyeabo 1	2.45	ND

Appendix B: Levels of As and Hg and the Degree of soil contamination

Location	As (mg/kg)	CFAs	Hg (mg/kg)	CFHg	Cdeg
Kensere 1	25.01	1.25	0.13	1.63	2.88
Nweneso	42.23	2.11	2.60	32.50	34.61
Brofroyedu 2	7.50	0.38	4.72	59.00	59.38
Adwumamum 1	23.09	1.15	3.83	47.88	49.03
Kensere 2	10.22	0.51	5.00	62.50	63.01
Adwumamum 2	8.34	0.42	9.05	113.13	113.54
Kwankyeabo 1	20.70	1.04	0.04	0.44	1.47
Agroyesum 2	17.30	0.87	11.20	140.00	140.87
Abodom 1	43.79	2.19	0.02	0.30	2.49
Mem 2	48.50	2.43	0.02	0.30	2.73
Mpatasie 1	22.57	1.13	0.03	0.33	1.45
Agroyesum 1	33.91	1.70	ND	0.00	1.70
Abodom 2	50.33	2.52	0.01	0.13	2.64
Kwankyeabo 2	37.90	1.90	0.06	0.75	2.65
Yawkrom 1	41.01	2.05	0.09	1.11	3.16
Mpatasie 2	52.31	2.62	0.05	0.63	3.24
Mem 1	16.01	0.80	2.42	30.25	31.05
Aponapong	22.52	1.13	2.46	30.75	31.88
Odumasi	19.36	0.97	0.07	0.88	1.84

Appendix C: Levels of As and Hg in water samples

Agroyesum 2	ND	0.01
Abodom 1	1.87	ND
Mem 2	4.6	ND
Mpatasie 1	2.07	0.01
Agroyesum 1	0.9	0.15

Abodom 2	1.76	ND
Kwankyeabo 2	7.9	0.02
Yawkrom 1	0.25	0.03
Mpatasie 2	5.23	0.02
Mem 1	3.65	ND
Aponapong	1.56	ND
Odumasi	3.61	ND