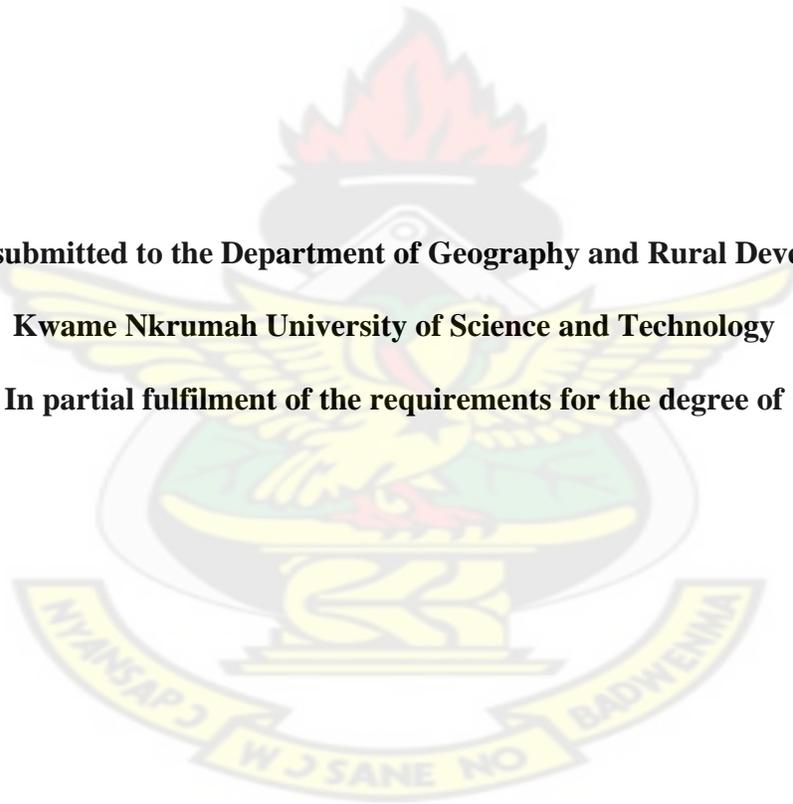


**ENVIRONMENTAL AND HEALTH IMPACT OF MINING ON SURROUNDING
COMMUNITIES: A CASE STUDY OF ANGLOGOLD ASHANTI IN OBUASI**

by

Joseph Yaw Yeboah B. A. (Hons.)

**A Thesis submitted to the Department of Geography and Rural Development,
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In partial fulfilment of the requirements for the degree of**



**MASTER OF ARTS
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DECLARATION

I hereby declare that this submission is my own work towards the MA and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

KNUST

Joseph Yaw Yeboah (PG8752505)
(Student & ID) Signature Date

Certified by:

PROF. DR. DR. DANIEL BUOR
(Lead Supervisor) Signature Date

DR. CHARLOTTE MENSAH
(Second Supervisor) Signature Date

Certified by:

DR. EVA TAGOE-DARKO
(Head of Department) Signature Date

ABSTRACT

Mining is viewed as one of the important economic activities which have the potential of contributing to the development of economies. At the same time, the environmental and health impacts of mining on surrounding communities have been a major concern to governments, the general public and stakeholder organizations and individuals. While the contributions of mining activities to economic development of Ghana is well acknowledged, others contend that the gains from the mining sector to the economy is achieved at significant environmental, health and social costs to the country.

The research examines the environmental and health impacts of AngloGold Ashanti's mining activities on the people of Obuasi and other surrounding communities. Five communities within the Obuasi Municipal area were covered for the data needed for the research. A total of 300 respondents were contacted for relevant information through questionnaire administration and interviews. In addition, institutions and organizations that hold stake in the mining and related environmental and health issues were contacted for relevant data. Data collection problems included respondents' bias and reluctance to answer certain questions. These were tackled through segmentation of the target population and verifications from field observations. Quantitative methods such as chi-square as well as other qualitative methods were employed to analyze findings of the problem investigated.

The research revealed that mining activities have resulted in land degradation leading to limited land available for local food production and other agricultural purposes in the Obuasi municipality. In addition, there is pollution which has affected mainly water resources in the area with major streams like Kwabrafo, Pompo, Nyam, San and Akapori

being polluted. Air and noise pollution are also evident in the area. The hypothesis that residents' appreciation of mining effects on the environments is affected by their years of stay in the communities was validated.

The combined effects of environmental problems have culminated into health problems with high prevalence of diseases such as malaria, respiratory tract infections and skin diseases. The hypothesis that infection of malaria and respiratory infections among residents is inversely related to distance from the mines was validated.

The findings of the research have demonstrated vividly that mining effects on health of residents in the communities is a function of distance from active mine sites. This is a valuable contribution to existing knowledge.

In view of efforts at restoration and intervention measures by AngloGold Ashanti Company in the form of re-forestation, review of methods of operation and provision of alternative sources of drinking water to the affected communities, it has been recommended that the company revise its environmental management policy in the area to ensure that environmental effects of mining activities in the area are reduced to the barest minimum. In addition, it is recommended that the government, through the Obuasi Municipal Assembly, build additional health centres, principally in all the villages close to the mining containment points to ensure adequate accessibility to health facilities. It is further recommended that the government of Ghana make conscious efforts to reduce the rate at which concessions are granted to mining companies in the country. All these measures should be fully integrated into the mining policy of the country.

DEDICATION

I humbly dedicate this work to God Almighty, and Mary, the ever Blessed Virgin who have made this endeavour fruitful.

To my beloved mother, Mrs Margaret Osei who has been my source of hope and inspiration in all these years. To my brothers, John K.Baafi, Peter Boakye, Joseph Osei Kofi, and my sisters, Grace Yeboah, Theresa Birago, and Christiana Boadu for their moral and financial support throughout my education.



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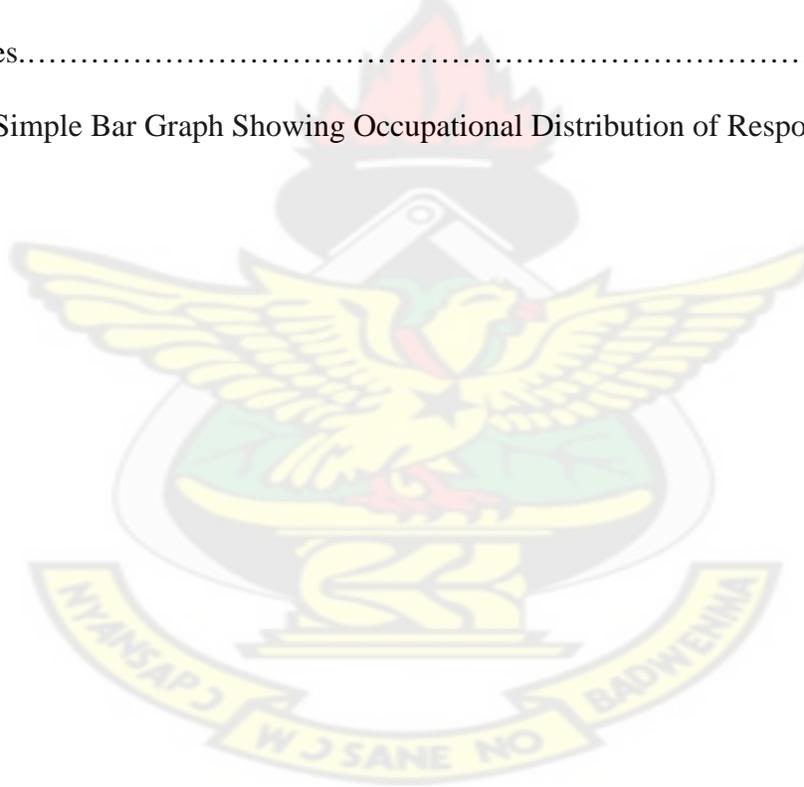
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LIST OF ACRONYMS

AGA - AngloGold Ashanti

AGC - Ashanti Goldfields Company

AGL – Abosso Goldfields Limited

AIDS - Acquired Immune Deficiency Syndrome

ARP - Arsenic Recovery Plant

BIOX - Biological Oxidation

CBUD - Centre for Biodiversity and Utilization Development

EC - European Commission

EIA - Environmental Impact Assessment

EPA - Environmental Protection Agency

FDI - Foreign Direct Investment

FOE - Friends of the Earth

GAG – Ghana Australian Goldfields

GCD - Ghana Consolidated Diamonds

GDP - Gross Domestic Product

GGL – Ghana Gold Mines Limited

GMC - Ghana Minerals Commission

HIV - Human Immuno-Deficiency Virus

IMF - International Monetary Fund

ISSER - Institute of Statistical, Social and Economic Research

KMA - Kumasi Metropolitan Assembly

KNUST - Kwame Nkrumah University of Science and Technology

LI - Legislative Instrument

LTD -Limited

MCH/FPU – Maternal and Child Health/ Family Planning Unit

MLTIFR - Malaria Lost-Time Frequency Rate

NGO – Non Governmental Organization

NHIS - National Health Insurance Scheme

OMAMTDP – Obuasi Municipal Assembly Medium Term Development Plan

OPD – Out Patient Department

PUO – Pyrexia of Unknown Origin

PTP – Pompola Treatment Plant

SALP – Sustainable Alternative Livelihood Programme

SPSS – Statistical Package for Social Scientists

STP – Sulphide Treatment Plant

TB – Tuberculosis

TGL – Teberebie Goldfields Limited

UN – United Nations

UNIDO – United Nations Industrial Development Organisation

URTI – Upper Respiratory Tract Infection

USA – United States of America

VRA – Volta River Authority

WHO – World Health Organisation

CHAPTER ONE

1.0 BACKGROUND TO THE STUDY

1.1 INTRODUCTION

To achieve rapid economic development, many countries resort to various activities to exploit natural resources. One of such activities is mining. Consequently, mining is an important economic activity which has the potential of contributing to the development of areas endowed with the resource.

In North America, raw mineral production in 1998 was valued at approximately US\$ 70 billion. The industry employs approximately 1 million people (Mbendi Profile, 2005).

In Peru, the mining sector accounts for 50% of the country's annual export earnings. During 1993, the mining industry's contribution to the Peruvian economy was represented by \$240m paid in taxes; \$400m spent on local purchases; \$280m in imported goods and accounted for over 11% of GDP (Acheampong, 2003). In South Africa, where gold is the largest mineral foreign income earner, gold mining alone contributes 27.4% in mineral revenues. The gold industry is also responsible for 56% of South Africa's mine labour force (Mbendi Profile, 2005).

In Ghana, the sector plays a vital role in the development of the economy. In 2000, minerals accounted for 38.96% of total export earnings, followed by cocoa (22.51%) and

timber (9.03%) (ISSER, 2001). The mining sector now contributes 41% to the country's foreign exchange and is the leading foreign exchange earner. Of the \$612.9 million in total mineral export income in 1997, gold, the most important mineral, accounted for \$579.2 million, or 94.5%, while the remaining 5.4% came from diamonds, bauxite and manganese (ISSER, 1998).

Gold now earns over U\$600 million and accounts for almost 90% of the mineral output and has therefore, replaced cocoa as the chief foreign exchange earner (Awudi, 2002). As a result of this, the main focus of Ghana's mining and minerals development industry remains focused on gold. Ghana is Africa's 2nd largest gold producer, producing 70 tons in 2003. Production is dominated by homegrown Ashanti Gold Fields, which produced nearly half of Ghana's total gold output (that is 37 tons) from its five mining operations in 2003 (Mbendi Profiles, 2004).

Ghana's economic geology is centered around Proterozoic rocktypes, notably the Birimian and Tarkwaian systems. The Proterozoic Birimian belt in West Africa hosts nearly all of the known gold deposits in Ghana, Burkina Faso and Cote d'Ivoire (Grubaugh, 2002). Realizing the enormous economic potential of Ghana's mining sector, the government took steps under the Economic Recovery Programme to revive the sector that had declined prior to the period. The government also instituted new mining laws and introduced a generous investment code including a 35% retention programme for the export sector (Acheampong, 2004).

To this effect, over the past fifteen years, Ghana has been successful in attracting investors into its mining sector. By 1990, there were over sixty (60) mining companies

engaged in mineral exploration including twenty (20) foreign companies (Barning, 1990: cited in Acheampong, 2003:2). Now, there are about 50 of which 25 are large mining companies operating in the country. Currently, with the exception of Ashanti Goldfields Company's Obuasi mine and the Prestea Gold Resources Limited, all other mines are surface operations (Aawaar, 2006).

The main minerals produced by large-scale companies are gold, diamond, bauxite and manganese, while industrial minerals such as kaolin, limestone, silica and sand are mainly produced by small-scale operators (Aryee, 2001). While foreigners are the main owners of the large mining companies, the government and private Ghanaian investors account for less than 15 per cent of the shares in these mines. Small-scale mining activity is statutorily restricted to Ghanaians (Aryee, 2001). According to Akabzaa and Darimani (2001), "both foreign and local companies are actively involved in exploration of minerals. By October 2000, 224 local and foreign companies held mineral rights for gold exploration and exploitation, while over 600 registered small-scale miners, along with an estimated 200,000 informal miners, popularly called "galamsey operators", were scattered on prospecting grounds throughout the country".

Mining activities have lots of environmental and health impacts. This has emanated from the methods of operation by the mining companies, its effects on the natural environment as well as the people in the surrounding communities. The health cost of mining operations sometimes outweighs the benefits gained. In view of this, Awudi (2002) has maintained that, "despite these positive indicators, the role of the mining industry in the

economic development of Ghana is a suspect. Despite the over US\$2 billion Foreign Direct Investment (FDI) in mineral exploration and mine development during the last decade indicating over 56% of total FDI flows to the country, (with the attendant increase in mineral export) the sector is yet to make any meaningful impact on the country's overall economy".

The gains from the sector in the form of increased investment are being achieved at great environmental, health and social costs to the people, recording series of public outcry against the mining companies operating in Ghana who themselves are yet to explicitly concede that their investments are inherently a major pollutant and a source of social conflicts around (Awudi, 2002).

1.2 STATEMENT OF THE PROBLEM

Ghana has a variety of mineral resources and mining dates back well into the pre-colonial times. However, since the inception of the World Bank/IMF-led Mineral Sector Reforms in Ghana in the mid-1980's there has been a considerable increase in mining activities, particularly gold (Awudi, 2002). Production of gold is dominated by homegrown Ashanti Gold Fields, which produced nearly half of Ghana's total gold output (that is 37 tons) from its five mining operations in 2003 (Mbendi Profiles, 2004). The Obuasi Goldmines is an affiliate of the AngloGold Ashanti Limited. It is both surface and underground mine which began its operations in 2004 (following the merger by Ashanti Goldfields of Ghana and AngloGold Limited of South Africa). The surface mining method involves

removing the top soil up to the bedrock, which bears the gold. Heavy machines are used for this purpose. Concessions are therefore made bare and devoid of vegetation. The use of heavy machines and chemicals underground do not only cause instability within the earth crust but also underground water which serves as source of water to various waterbodies in the area are affected by infiltration of toxic materials.

In addition, dynamite is used to blast the large rocks to aid excavation of the area where gold is extracted. The loud noise and the vibrations from the blasts have affected people within the surrounding communities very much. Buildings of the indigenes have cracked whereas those very close to the mining sites suffer much from breaking of glasses and other glasswares in their homes. Added to this is the shock being experienced by the inhabitants. Cyanide (potassium cyanide), a poisonous chemical, is used to recover gold from the ore, and in the process some spillages occur resulting in drainage (of cyanide) into the nearby streams. This causes aquatic life loss, as these chemicals are highly toxic. It also seeps down into the soil causing plant roots to die. For instance, there was a tailing treatment dam failure at Kokoteasua in 2005 alledged to have been caused by illegal activities of 'galamseyers' two years ago. This resulted in the spillage of tailings materials into the external environment, thereby, affecting surrounding downstream communities of Kokoteasua, Abompekrom and Nkamprom (Obuasi Mine Report, 2005).

Undoubtedly, it is evident that streams and rivers where these chemicals and toxic materials drain into serve the villages and towns along them. Consequently, their drinking water is poisoned, causing morbidity and mortality conditions among residents.

During 2005, according to the annual report of the company, 17,460 cases of malaria were reported amongst its employees, reflecting a malaria lost-time injury frequency rate (MLTIFR) of 721.7 per million man-hours (Obuasi Mine Report, 2005). This was one of the indirect effects of the mining activities.

These environmental and health effects of mining activities have been attracting attention recently, hence, need to be addressed. Although, the mining company is believed to have made steps to improve health conditions of residents within the surrounding communities, however, the extent to which these efforts are reducing the negative environmental and health impacts is yet to be established. For instance, the Obuasi mines claim to have put in place an effective environmental policy and strategy which is overseen by the Board Committee on Safety, Health and Sustainable Development. In addition, there is the cyanide management policy that is being implemented in line with the provisions of the International Cyanide Management Code (Obuasi Goldmines report, 2005). As required by law, the Environmental Protection Agency examines the Environmental Impact Assessment (EIA) of the company as well as its Environmental Management Plan (E.P.A., 2005). Notwithstanding these, the public is yet to acknowledge the extent to which these stakeholder organisations are contributing to the reduction of adverse health effects of mining. Environmental and health issues relating to mining activities are matters of concern within the public domain.

A conference organized by the Centre for Biodiversity and Utilization Development (CBUD) of the Kwame Nkrumah University of Science and Technology (KNUST) on 2nd

August 2006 dubbed “The mines corporate social responsibility towards sustainable alternative livelihood to affected communities in Ghana mines sector” was partly in response to the health problems arising from mining activities in the country. The Chamber of Mines, on its part has therefore, sought to order all of its members to embark on Sustainable Alternative Livelihood Programme (S.A.L.P.) (Ghana Chamber of Mines, 2006).

In spite of the above, a thorough research into the current environmental and health impacts (both positive and negative) of Obuasi Goldmines, one of the main areas of operation by the AngloGold Ashanti Company Limited, on the surrounding communities, is therefore a necessity.

1.3 OBJECTIVES OF THE STUDY

In line with the problems outlined above, some key research questions to which answers would be sought are:

- a.** What methods of mining and ore extraction are employed by AngloGold Ashanti in the Obuasi area?
- b.** What are the effects of these methods on the environment?
- c.** What are the effects on farming activities (food production) in the Obuasi area?
- d.** What are the health effects of mining on the people living in the Obuasi area?
- e.** What measures have been put in place by AngloGold Ashanti to reduce or curtail the environmental and health effects of mining activities on the people?

Accordingly, the main objective of the study was to ascertain the environmental and health impacts of Obuasi Goldmines on the surrounding communities.

The specific objectives were to:

1.3.1 Examine the methods of mining operations and their effects on the environment.

1.3.2 Determine the diseases prevalent in the surrounding communities resulting from the mining activities.

1.3.3. Find out the effects of mining on farming (food production) activities within the Obuasi Municipality.

1.3.4. Determine and examine the interventional measures of Obuasi Goldmines in ensuring the safety of residents in the surrounding communities.

1.3.5 Assess the role of the Chamber of Mines, Ghana Minerals Commission and the Environmental Protection Agency in regulating the activities of the Mining Company.

1.3.6. Make recommendations and point out policy directives which can be implemented to ensure better health conditions for residents in the surrounding communities.

1.4 HYPOTHESES

1.4.1. Appreciation of mining effects on the environment by residents is related to their number of years of stay in the communities.

1.4.2 Knowledge of mining effects on health is positively related to years of schooling (education).

1.4.3 The rate of infection of malaria and respiratory tract infections among residents is inversely related to distance from the mines

1.5 JUSTIFICATION AND SIGNIFICANCE OF THE STUDY

Mining activities are indispensable in the economic development of any country endowed with mineral resources. This is due to the economic benefits that are made available to countries that are involved in the extraction of mineral resources, both internal and external. Internally, there is the creation of employment and revenue generation. Externally, a substantial foreign exchange is available to such countries.

Acknowledging the economic contributions of mining, however, several economies lost sight of environmental and health effects associated with mining activities. Researches that have been undertaken lately to look into the environmental and health effects of mining have found mining activities to be more hazardous to economic development than a blessing. Accordingly, several mining companies in the country claim to have responded to this by instituting and implementing several measures to reduce the negative environmental and health effects of their activities on the people. Whether some of these measures have or are capable of reducing the negative health impacts of mining on the environment and surrounding communities is a matter of great concern.

The significance of this research work lies in the fact that it seeks to undertake a thorough and broader outlook into the environmental and health effects of mining on surrounding communities, both negative and positive, and recommend policy directives to improve the already instituted health policies by the Anglo-Gold Ashanti Company, as well as reducing the rate of hazardous health effects of the mining activities that may be

identified in Obuasi and other surrounding towns. Findings and recommendations will serve as guide to other mining companies in the country.

1.6.0 RESEARCH METHODOLOGY

1.6.1 Types of Data

The data collected included background data on respondents, awareness, perception and effects of mining within the surrounding communities, health status of residents in the surrounding communities, food security and the status of health facilities available to the residents in the surrounding communities of the mines.

In addition, data on the methods of Obuasi Goldmine operations as well as waste disposal activities were collected. Similarly, data on the effects of Obuasi mine operations on the environment were collected and analyzed.

Moreover, data on interventional measures by AGA such as those dealing with the environment as well as the safety health measures being put in place by the Company were collected and analyzed. Last but not the least, data on activities of agencies and organizations such as the Environmental Protection Agency (EPA), the Ghana Minerals Commission (GMC) and the Ghana Chamber of Mines in regulating mining activities in the country were collected.

1.5.2 Sources of Data and Methods of Data Collection

Data for this study were from primary and secondary sources. Primary data included administering of questionnaires in the field to residents of surrounding communities of Obuasi Goldmines and some mine workers of AngloGold Ashanti Company Limited.

In addition, there were interviews with officials of the Ashanti Goldfields Company Limited-Obuasi as well as officials of governmental agencies such as the Obuasi District Assembly, the Environmental Protection Agency (E.P.A), the Ministry of Lands, Forestry and Mines, Ghana Chamber of Mines and other NGOs operating in the area. Officials and workers of health centres within the locality were also contacted for relevant information.

There were formal interviews with the chiefs and other opinion leaders in the surrounding areas. Moreover, there were field observations to the mine sites and other areas to determine the effects of mining operations on the environment.

Secondary data were culled from books, relevant articles from journals and reports of researches conducted on the effects of mining operations on the surrounding communities. These were obtained from libraries of the University of Mines and Technology, Tarkwa, Institute of Renewable Natural Resources, KNUST, Department of Geological Engineering, KNUST, the Internet and other sources.

There were also collections from the Environmental Protection Agency, Ministry of Lands, Forestry and Mines, Ghana Chamber of Mines and other publications from NGOs relevant to this study. Data on mining related diseases reported at the various health centres within the surroundings of Obuasi Goldmines were also collected and analyzed.

1.6.3 Sampling Design

In this study, the method of sampling were a combination simple random, stratified and purposive sampling. The reason for this was that the data included different variables of the target population in terms of place of work, distance from the mines, socio-economic circumstances of the interviewees and differences in perception towards mining activities and its effects on the environment.

After purposively selecting the study communities based on their proximity to the mine sites, 300 people were randomly selected for the administration of a detailed questionnaire using the interview method to ensure a hundred percent completion rate.

The justification of the sample size lies in the fact that time and resources available to the researcher were not enough to cover the entire area with a population of about 195,000. In all, there are 52 communities in the municipality. This divides the total population into approximately, 3750 people per community. Five communities were chosen based on their relative proximity to mine sites or containment points (Table 1.1). Seventy (70) respondents were sampled for questionnaire administration at two communities each located 0.5-1.5km away from mine sites. Sixty (60) respondents were taken from one community located 0.5-1.5km away from mine site, with the fifty (50) respondents taken from two communities each located more distant from the mine containment points (that is 1.5-3km away). This was done to determine variations in responses regarding mining effects on the localities by distance from the mines. This distribution gives a total of three hundred (300). Since the five communities chosen for this survey were not concentrated at one area but were scattered across the municipality, the views gathered from the total

sample of three hundred (300) respondents effectively represented the views of the entire population. Table 1.1 gives details of the sample.

Table 1.1: Distribution of Sample

Community	Distance From The Mine Site	Number of Respondents	Percentage (%)
Sanso	0.5-1.5km	70	23.33
Anyinam	0.5-1.5km	70	23.33
Anyimadukrom	0.5-1.5km	60	20
Abompe	1.5-3km	50	16.67
Tutuka	1.5-3km	50	16.67
TOTAL		300	100

Source: Author's Field Sample Survey, 2007

It is evident from table 1.1 that larger samples were taken from Sanso (70), Anyinam (70) and Anyimadukrom (60). This was done purposely by the researcher because these towns/ villages are closer to the mine sites of AGA (ranging from 0.5-1.5km away) than Abompe and Tutuka, whose proximity to the mine sites of AGA ranges from 1.5 -3 kilometres. This was done to find out response variations from respondents regarding the effects of mining activities on their respective communities.

In addition, two (2) officials were interviewed each at the EPA, the Ghana Minerals Commission and the Ghana Chamber of Mines, with five (5) officials each at AngloGold Ashanti Company Ltd- Obuasi and the Obuasi Municipal Assembly. Five health workers from Obuasi Government Hospital were interviewed for relevant information.

Aside from these, a sample of twenty (20) mine workers from different departments of the mines were interviewed for specific information relating to their health conditions.

1.6.4 Data Analysis

Data collected were summarized and stored in statistical tables, graphs and maps. These included frequency distribution tables and bar charts and using SPSS software. Other relevant mathematical and statistical techniques such as chi square were used when appropriate for the analysis. Explanations of the analyses were done qualitatively and quantitatively.



CHAPTER TWO

2.0 LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.1 INTRODUCTION

Several researches have been conducted on mining and its effects as well as contributions to economic development of countries endowed with mineral resources. Whereas some researches highlight the benefits of mining to economic development, others focus on the negative impacts of mining on the overall development of such economies. This chapter reviews what has been documented regarding mining as a concept, processes involved in mining and the methods employed in ore extraction. The chapter also looks at the relationship between mining and economic development as well as its impact on the environment and health of the people living close to mining areas.

2.2 Definitions, Processes and Methods of Mining

Mining is the removal of minerals from the earth's crust in the service of man (Down and Stock, 1977 cited in Acheampong, 2004:1). The Encarta encyclopaedia also defines mining as the selective recovery of minerals and materials, other than recently formed organic materials from the crust of the earth (Encarta, 2005).

Mining has also been defined as the extraction of valuable minerals or other geological materials from the earth, usually (but not always) from an ore body, vein, or (coal) seam. Materials recovered by mining include bauxite, coal, diamonds, iron, precious metals, lead, limestone, nickel, phosphate, rock salt, tin, uranium, and molybdenum. Any

material that cannot be grown from agricultural processes must be mined. Mining in a wider sense can also include extraction of petroleum, natural gas, and even water (Wikipedia, 2006).

The oldest known mine in the archaeological record is the "Lion Cave" in Swaziland. Available literature indicates that basically, there are eight steps to mining process. These are as follows:

1. Prospecting to locate ore.
 2. Exploration to defining the extent and value of ore where it was located.
 3. Conduct resource estimate to mathematically estimate the extent and grade of the deposit.
 4. Conduct mine planning to evaluate the economically recoverable portion of the deposit.
 5. Conduct a feasibility study to evaluate the total project and make a decision as whether to develop or walk away from a proposed mine project. This includes a cradle to grave analysis of the possible mine, from the initial excavation all the way through to reclamation.
 6. Development to create access to an ore body.
 7. Exploitation to extract ore on a large scale.
 8. Reclamation to make land where a mine had been suitable for future use
- (Wikipedia, 2006).

Mining methods are of four basic types. Firstly, materials may be mined from surface mines, open pits, quarries, or other diggings open to the atmosphere. This group constitutes by far the greatest number of mines in the world. Secondly, there are underground mines, entered through shafts or tunnels. Thirdly, there is the recovery of minerals and fuels through boreholes. Finally, there is underwater mining or dredging, which is now extending to the potential mining of the deep oceans (Encarta, 2005).

2.3 Mining and Economic Development

The contributions of mining to economic development is immense. Mining has an essential foundation for human development through creation of wealth (Acheampong, 2004). The mining industry has been key to the development of civilisation, underpinning the iron and bronze ages, the industrial revolution and the infrastructure of today's information age. In 2001, the mining industry produced over 6 billion tons of raw product valued at several trillion dollars (Mbendi, 2004). Traditional mining countries such as the USA, Canada, Australia, South Africa and Chile dominate the global mining scene. These countries have become the traditional leaders in mining and exploration methods and technology (Mbendi, 2004).

The contributions of the mining sector for some selected countries can be evaluated. The mining industry in Peru accounts for 50% of the country's annual export earnings. In 1993 the mining industry's contribution to the Peruvian economy was represented by \$2400million paid in taxes, \$400million spent on local purchases and \$280million on imported goods. This accounted for over 11% of GDP (Down and Stock, 1995 cited in Acheampong, 2004:1).

North America is the major producer of gold and silver. Raw mineral production in 1998 was valued at approximately US\$ 70 billion. The industry employs approximately 1 million people. Gold, the largest mineral foreign income earner in South Africa alone contributes 27.4% in mineral revenues. The gold industry is also responsible for 56% of South Africa's mine labour force (Mbendi, 2002). However, the United Nations Industrial Development Organisation (UNIDO) considers joblessness and landlessness (resulting from large scale mining) to have forced people into small-scale gold mining, and UNIDO estimates that there are over a million people directly involved in small-scale gold mining operations in Latin America. If Africa and Asia are incorporated there could be as many as six million artisanal miners world-wide (UNIDO, 2001). For instance, there are no exact figures on the number of small-scale miners in Ghana, though it is estimated that approximately 100,000 Ghanaians are legally engaged in mining (Aryee, 2003). 'Galamseys' involved in illegal mining activities also create challenges for monitoring and regulating small-scale mining activities in the country. A UN study on artisanal mining and poverty reduction reports that there may be 50,000 – 80,000 people engaged in illegal small-scale mining activities in Ghana (Carnegie, et al, 2000).

In Ghana, the mining sector now accounts for 41% of the country's foreign exchange and is the leading foreign exchange earner. Gold, the most important mineral, which now earns over US\$600 million and constituting almost 90% of the mineral output, has replaced cocoa as the principal foreign exchange earner (Awudi, 2002)

“The most publicized benefits of the increased mining sector investments resulting from Ghana's economic reforms include the following:

- Mining is the chief earner of foreign exchange in the country
- Provides substantial government revenue
- Provides capital and social infrastructure to the general public
- Generates direct and indirect employment
- Contributes to community development in mining areas”(Akabzaa and Darimani, 2001).

“The industry generates revenue for the internal economy through the following sources:

- Salaries, wages and other payments made to workers and contractors
- Corporate income taxes, royalties, concession rents, services, customs and harbour duties
- Taxes on salaries of employees, and social security contributions from workers and their employers
- Dividends to shareholders
- Equipment and consumables purchased locally
- Import duty and purchase tax on vehicles
- Electricity and water charges
- Divestiture of state mining companies and sale of government shares” (Akabzaa and Darimani, 2001).

Furthermore, it can be noted that since mining projects are usually located in remote sites, mining companies have had to invest in considerable physical and social infrastructure such as roads, schools, hospitals, electricity and water supplies. Communities within mine locations have generally been beneficiaries of some of these facilities. Thus, while mining projects usually have weak links with the rest of a host national economy, they

can have a significant impact on the communities in which or near which the mines are located (Anyemedu, 1992 cited in Akabzaa and Darimani, 2001:35).

Awudi (2002) has, however, noted that despite the over US\$2 billion FDI attracted in mineral exploration and mine development during the last decade, accounting for over 56% of total FDI flows to the country, (with the attendant increase in mineral export) the sector is yet to make any meaningful impact on the country's general economy. The sectors' contribution to the country's GDP is a meagre average of 1.5% since 1993. There is lack of linkage between the mineral sector and the rest of the internal economy. The massive investment has not been translated into significant increase in employment. Labour-intensive underground gold mines have been replaced by surface mining, which is capital intensive and employs relatively few people. Large-scale surface mines only employ about 20,000 workers whilst over twice this number are involved in small-scale mining. State mines, now privatized, aim to maximize profits and have retrenched more than 50% of their workforce many of whom have moved to the informal sector.

2.4 Mining and Health

Health can be defined as a state of complete physical, mental and social well being of an individual, and not merely the absence of disease and infirmity (World Health Organisation, 2005). An alteration in the living cells of the body which jeopardizes survival in the environment results in diseases. Health problems arise from a variety of man's activities including industrialisation, farming, mining, migration and others.

Available literature examines the impact of mining on the health of both mine workers and the people within the surrounding communities of the mines. According to Stephens and Ahern (2001), mining remains one of the most perilous occupations in the world, both in terms of short term injuries and fatalities, but also due to long term impacts such as cancers and respiratory conditions such as silicosis, asbestosis and pneumoconiosis.

Studies of mining and health by type of mine process are divided into deep and open cast mines. Deep mines produce severe harms for employees in terms of their risks of high blood pressure; heat exhaustion; myocardial infarction and nervous system disorders. Studies of surface mining focus on coal, granite and rock mining and health risks related to dust breathing. In all levels of mining health risks occur with dust exposure (Stephens and Ahern, 2001).

Respiratory impacts are the most studied and problematic of health impacts for mine workers. Injuries have declined in importance but continue to be an important safety issue in mines. Long-term effects include cancers, mental health impacts and some proof of impacts on genetic integrity of workers. The heated discussion on the impact of the mining and minerals sector on both worker and community health is polarized. On the one hand the industry tends to underscore the supposed benefits of the sector, whilst on the other, community groups and NGOs suggest that the sector is injurious to health and sustainable development (Stephens and Ahern, 2001).

Further, the mining sector has been affected by the world-wide epidemic of HIV/AIDS, and this is apparent in the studies of South African mines. Several studies (Jochelson, Mothibeli et al. 1991; Campbell 1997; Williams and Campbell, 1998; Campbell and

Williams, 1999; Campbell 2000; Corbett, Churchyard et al. 2000) have focused on the condition of the gold mines of South Africa. Migrant labour plays a vital role in the mining sector of South Africa, and these migrants are believed to play an important role in the transmission of HIV/AIDS. In terms of how the mining industry has dealt with this problem one study (Williams and Campbell, 1998; Campbell and Williams, 1999) reports that “many mines made substantial efforts to establish HIV-prevention programmes relatively early on in the epidemic, (but) these appear to have had little impact”. Meanwhile, Corbett, Churchyard et al. (2000) investigated the combined effects of HIV infection and silicosis on mycobacterial disease in a South African gold mine, and concluded that the danger of silicosis and HIV infection combine in a multiplicative manner. This indicates that tuberculosis (TB) remains as much a silica-related occupational disease in HIV-positive as in HIV-negative miners, and HIV- positive silicotics have by far higher TB prevalence rates than those reported from other HIV- positive Africans. The increasing impact of HIV over time may indicate epidemic TB transmission with swift disease development in HIV-infected miners.

There were relatively few studies of policy initiatives by Stephens and Ahern (2001). According to them, health and safety improvements in mines have been developed over a long period of negotiation and struggle. Laws have come after union and management activities. Governments have supported organized labour in the improvements.

Moreover, Stephens and Ahern (2001) stress that scientific evaluation of long-term impacts has grown. Employees have been able to use scientific evidence for improved

“hazard visibility” and for shifts in health and safety legislation. However, much of the small-scale mining sector falls outside formal legislative shield or scientific analysis.

Companies have provided a range of community initiatives including vaccination programmes and health services. These have mixed results. Companies have seldom addressed the community claims for damage made against them internationally.

Communities have worked with scientists to understand some of the impacts associated with living near mines. Unions have scarcely played an overt role in support for community claims (Stephens and Ahern, 2001).

In Ghana, available literature on effects of mining on health are reviewed as follows.

Biostatistics obtained from Obuasi hospital in a survey by Friends of the Earth-Ghana (FOE-Ghana) showed a high prevalence of upper respiratory tract infection (URTI) in the area which medical experts linked to the mining activities and associated pollution (Awudi, 2002). Clinical symptoms similar to arsenic poisoning have been observed in patients in AGC hospital at Obuasi and have been associated with aerial pollution from mineral procession by the AGC (Awudi, 2002).

In the Tarkwa area, with the initiation of mining investment, mining impact related diseases such as malaria, diarrhoea, upper respiratory tract infections, skin disease, acute conjunctivitis and accidents constitute the top ten diseases in the area according to biostatistics, obtained by FOE – Ghana in Korle-Bu Hospital in a survey in 2001. The area has the highest incidence of malaria in the Western Region and the country as a whole. Skin rashes are widespread particularly among communities living along rivers

and streams which regularly receive leaked cyanide waste waters and other mining wastes within concessions (Akabzaa and Darimani, 2001).

2.5 Existing Initiatives To Reduce Risk And Maximise Mining Benefits in the communities

A number of studies (Ijsselmuiden, Padayachee et al. 1990; Jochelson, Mothibeli et al. 1991; Williams and Campbell, 1998; Campbell and Williams, 1999) that focused on the HIV/AIDS epidemic and in particular the associated problems on the gold mines of South Africa have been documented. These studies highlight the particular problems with the mines and their dependence on a substantial migrant labour force that is drawn from both within South Africa and from neighbouring states. There is recognition that earlier on in the HIV/AIDS crisis many mines made substantial efforts to establish HIV/AIDS prevention programmes but that these seem to have had little impact. One possible reason for this is the inability of the prevention programmes to take account of the psychosocial environment of the labour force, and especially those migrants from neighbouring states who spend unlimited periods away from their immediate family and friends. In one of the few studies of community health programmes associated with mining in Latin America, Foreit et al. (1991) described the costs and the benefits of implementing child survival services at a private mining company in Peru. Here, despite extensive outlays for medical services, few children under age 5 were vaccinated, and half of their illnesses went untreated. Children who were attended at the company clinic usually received unnecessary medication. As a result of the study, the company hired additional staff to provide integrated maternal-child preventive health care and family planning and

contracted for intensive training and periodic on-site supervision. In less than 2 years, vaccination coverage reached 75%, and virtually all children under age 1 were enrolled in growth monitoring. Prescriptions were reduced by 24%, including a 67% drop in anti-microbials.

In Ghana, health-related environmental monitoring mandated in mining areas by Ghana's National Environmental Policy include monitoring air, water, noise, emissions and food contamination (Minerals Commission and Environmental Protection Council, 1994).

Ghana Consolidated Diamonds Limited has a hospital on its company's grounds to serve the healthcare requirements of its company workers and their dependants, and the people of Akwatia, though it is sternly under resourced (GCD, 2001). The same can also be said of other major mining companies like Anglo Gold Ashanti, Goldfields Ghana Limited who do not only have hospitals and clinics to serve both workers and residents in the mining communities but also embark on other health education programmes.

From the findings of their research, Stephens and Ahern have called for the need for more openness and transparency within the mining sector, particularly in countries of Latin America, Asia and Africa. There is a further need for in-depth long-term evaluation of the impacts of mining on health of workers and communities. There is evidence of long-term impacts of mining on health of workers and communities. This implies that the sector's activities currently undermine the human objectives of sustainable development, which are to protect the health of current and future generations.

There is still a long way to go before mining becomes a healthy work or a healthy development activity to take place in a community. There is also a long way to go before the industry, the workers and the community agree over the real health impacts of the sector and the real responsibility of each of the actors in the sector (Stephens and Ahern, 2001).

2.6 Mining and the Environment

The adverse environmental impact of mining activities on the environment is well documented (Heath et al., 1993; Veiga and Beinhoff, 1997; Warhurst 1999; Warhurst, 1994). Particular attention has been directed towards the impacts of large scale and small-scale gold mining activities on environmental contamination. While the land degradation caused by the gold mining is pronounced, chemical contamination from the gold extraction process imposes a double burden on the environment, with harmful health implications for mining communities and people residing in close proximity to such activities (Yelpaala, 2004). For instance, due to the informal nature of gold-mining in the South (Africa and Latin America), most studies concentrate on mercury exposure and intoxication incurred in the extraction and processing stage of mining (Camara, Filhote et al. 1997; Malm, 1998; Harada et al. 1999; Tirado et al. 2000; van Straaten 2000a; Rojas, Drake et al. 2001). Results of studies indicate patterns of mercury intoxication during the gold amalgamation process (Camara, Filhote et al. 1997; Tirado, Garcia et al. 2000; van Straaten 2000a; Drasch, Bose- O'Reilly et al. 2001). Most studies involve small numbers and are thus susceptible to predisposition, but some attempt more

rigorous design. For example, in one site in the Philippines a study of 102 workers (occupationally Hg burdened ball-millers and amalgam- smelters), 63 other inhabitants (exposed from the environment), 100 persons living downstream of the mine, and 42 inhabitants of another site (serving as controls) was undertaken. Bio-monitors and medical scores for both workers and the surrounding communities were taken. The authors report that “By this method, 0% of the controls, 38% downstream, 27% from Mt. Diwata non-occupational exposed and 71.6% of the workers were classified as Hg intoxicated”(Drasch, Bose-O'Reilly et al. 2001). Another study in Tanzania with a similar design found lower levels of intoxication and a more complex mix of mining-related and environmental exposures to mercury through household items such as soap (Harada, Nakachi et al. 1999). One study in Ecuador reports higher levels of intoxication in children involved in “gold washing” (Harari, Forastiere et al. 1997). One study in Venezuela found no mercury intoxication, despite occupational and community exposures (Rojas, Drake et al. 2001)

In Ghana several studies in mining towns have revealed that environmental problems such as land degradation, pollution and others are associated with mining activities. Some of these are enumerated below.

2.6.1 Degradation of Land and Vegetation

According to Akabzaa and Darimani (2001), extensive areas of land and vegetation in Tarkwa have been cleared to make way for surface mining activities. Currently, open pit mining concessions have taken over 70% of the total land area of Tarkwa. It is estimated

that at the close of mining a company would have utilized 40-60% of its total concession space for activities such as siting of mines, heap leach facilities, tailings dump and open pits, mine camps, roads, and resettlement for displaced communities (Akabzaa and Darimani, 2001). This has momentous adverse impact on the land and vegetation, the main sources of livelihood of the people. There is already a scramble for farmlands in Atuabo and Dumasi.

In most parts of Tarkwa, the environment is undergoing rapid dreadful conditions and its immense economic value is dwindling from year to year, due mainly to the heavy concentration of mining activities in the area. Agricultural lands are not only generally degraded, but the loss of land for agricultural production has also led to a shortening of the fallow period from 10-15 years to 2-3 years. The traditional bush fallow system, which sufficiently recycled substantial amounts of nutrients and made the next cycle productive, can no longer be practised due to insufficiency of land. Large-scale mining activities generally continue to diminish the vegetation of the area to levels that are vicious to biological diversity (Akabzaa and Darimani, 2001).

The deforestation that has emanated from surface mining has long-term effects even when the soil is replaced and trees are planted after mine decommissioning. The new species that might be introduced have the potential to influence the composition of the topsoil and then determine soil fertility and fallow period for certain crops. In addition to erosion when surface vegetation is depleted, there is deterioration in the viability of the land for agricultural activities and loss of habitat for birds and other animals. This has degenerated into destruction of the luxuriant plant life, biodiversity, cultural sites and

water bodies (Akabzaa and Darimani, 2001). It is predictable that by the time the four companies - GAG, TGL, GGL, and AGL-would have mined out all their concessions, a total of 16 ridges ranging between 120m and 340m high would have been twisted into huge craters (Akabzaa and Darimani, 2001).

2.6.2 Water Pollution

Many mines have an active programme to reduce the water table or divert major watercourses away from the mines. This exercise has disruptive outcomes for the quality and availability of surface and ground water. The concentration of mining operations in Tarkwa has been a chief cause of both surface and groundwater pollution. Four main problems of water pollution have been identified in Tarkwa mining areas. These are chemical pollution of ground water and streams, siltation through increased sediment load, increased faecal matter and dewatering effects (Akabzaa and Darimani, 2001).

2.6.3 Air and Noise Pollution

Mining activities and mining support companies discharge particulate matter into the ambient air. The grievances 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 Tarkwa area include respirable dust, sulphur dioxide (SO₂), nitrogen dioxide (NO₂), carbon monoxide (CO) and black smoke. The activities that produce 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 during heap leach processing.

Others include fumes from the roasting of sulphide ores by assay laboratories and in refining processes. The discharge of airborne particulate matter into the environment -- principally minute dust particles of less than 10 microns -- poses health threats to the people of the Tarkwa area. All fine dust at a high level of exposure has the potential to cause respiratory diseases and disorders and can exacerbate the condition of people with asthma and arthritis. Dust from gold mining operations has a high silica content which has been responsible for silicosis and silico-tuberculosis in the area (Akabzaa and Darimani, 2001).

Unfortunately, the mining companies have not laid down adequate measures to prevent harmful emissions of dust into the ambient air. Measures to reduce dust emission are restricted to occasional spraying of roads within the premises of the mining concessions. This seems to be a misplaced effort because road dust does not appear to be the main source of dust pollution. Furthermore, the EPA acknowledged that dust suppression on the haulage roads is ineffective and the frequency of spraying is inadequate, particularly in the case of TGL¹². Black smoke from fuel burning, fumes from the assay laboratories and ore roasting at Prestea make up additional sources of airborne pollutants in the Tarkwa mining district. There were cases where the values recorded for smoke exceeded the acceptable and tolerable levels of the EC, WHO and EPA. The uppermost value recorded was 207 gm⁻³ as against the tolerable levels of 100 gm⁻³ for the EC, 85 gm⁻³ for the WHO and 40 gm⁻³ for EPA-Ghana (Akabzaa and Darimani, 2001).

2.6.4 Noise and Vibration

The sources of noise and vibration in the area comprise mobile equipment, air blasts and vibration from blasting and other machinery. The impact of high-pitched and other noises is known to include damage to the auditory system, cracks in buildings, stress and discomfort (Akabzaa and Darimani, 2001). These noises can also terrify animals, hinder their mating processes and also cause abortions, therefore adversely affecting the animal population. Communities within the concessions of GAG and TGL have lodged a number of complaints with the Wassa West District Assembly Environmental Management Committee on the noise aggravation (Akabzaa and Darimani, 2001). However, the measures being put in place by the mining companies have not sufficiently addressed the problem of noise pollution in the area.

A critical assessment of the literature under review showed that much of the negative environmental and health effects of mining activities have been documented. However, little do we know as to suggestions and policy directives needed to be implemented to redress hazardous health effects of mining. In addition, most of the literatures reviewed were focused mainly on mining and economic development. Hence, these presented less findings on environmental and health impacts of mining on surrounding communities.

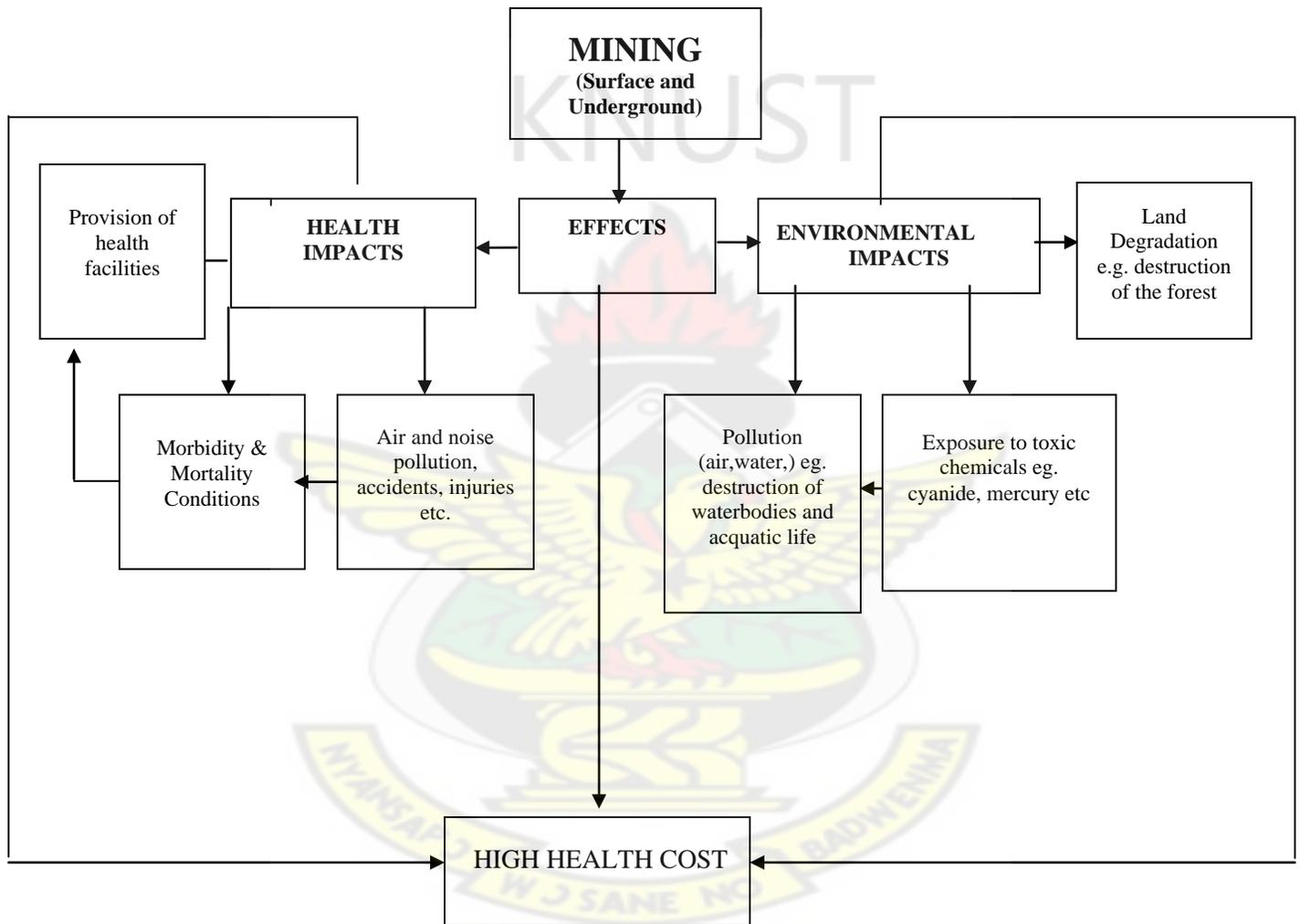
This research work therefore intends to undertake a thorough and broader outlook into the environmental and health implications of mining on surrounding communities, both negative and positive, and recommend policy directives to improve the already instituted health policies by the Ashanti Goldfields Company, as well as reducing the rate of hazardous health effects of the mining activities that may be identified in Obuasi and other surrounding towns.

2.7

CONCEPTUAL FRAMEWORK

The conceptual framework (Figure 2.1) used for the study shows the environmental and health impacts of mining activities.

Figure 2.1 Mining, Environmental and Health Impacts



Sources: Author's own construct, 2007.

The conceptual framework shows the impact of mining on the environment and the health of people. This is based on the review of the available literature. Mining methods on the land can either be underground (deep shaft) or surface mining. With any of these methods, there are environmental and health impacts.

The impact of mining activities on the environment is very remarkable. First of all, mining activities require acquisition of large tracts of land. Both deep and surface mining degrade the land surface since there is destruction of the entire forest. Consequently, land for farming and other agricultural purposes is lost.

Furthermore, spillages of chemicals such as cyanide, mercury and other toxic materials into the nearby streams cause water pollution, destroying water bodies and aquatic life. Exposures of such chemicals are also harmful to human health. Linked to this, gas and other forms of vapour produced from heavy machines and equipments used, as well as other chemicals are sources of air pollution to the environment.

On health, several health implications are associated with mining activities. Mining activities such as blasting of rocks lead to air and noise pollution that affect the people within the surrounding areas. These sometimes lead to incidence of upper respiratory tract infections such as cancer, cough or cold and asthma. There are also the incidence of malaria, diarrhoea, acute conjunctivitis and accidents all of which result in morbidity and mortality conditions in the mining areas. In response to these, mining companies usually seek to lay down health measures by providing health facilities such as clinics, hospitals, and health education of various forms. Notwithstanding this, the negative environmental and health impacts of mining activities are so immense that they call for urgent interventions.

According to the literature that was reviewed, the compounding environmental and health cost and damages of mining activities far outweigh their economic and social benefits, the magnitude of which cannot be quantified. There is therefore high health cost incurred as a result of mining activities.

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CHAPTER THREE

3.0 PROFILE OF THE OBUASI MUNICIPAL AREA AND ANGLOGOLD ASHANTI LIMITED-OBUASI

3.1 INTRODUCTION

This chapter looks broadly at the area under study as far as the topic of the research is concerned. It covers the background and profile of the Obuasi Municipal Assembly, that is, the local governmental authority responsible for the area (Obuasi) where the study is undertaken. It also looks at the profile of the Anglo Gold Ashanti Limited- Obuasi; the main company of concern for the purpose of the research or study.

3.2 THE OBUASI MUNICIPAL AREA

3.2.1 Location and Size

The Obuasi Municipality lies in the southern part of Ashanti Region of Ghana between latitudes 5°35'N and 5 °65'N, and longitudes 6°35'W and 6°90'W (Figures 3.1). It is the second largest political authority in the region after Kumasi Metropolitan Assembly (K.M.A.) and covers a land area of about 162.4 square km. It is bounded on the south by Upper Denkyira District of the Central Region, east by Adansi South, west by Amansie Central, and north by Adansi North. The municipal capital, Obuasi, is about 64km drive from Kumasi, the regional capital. At the moment, there are 52 communities in the

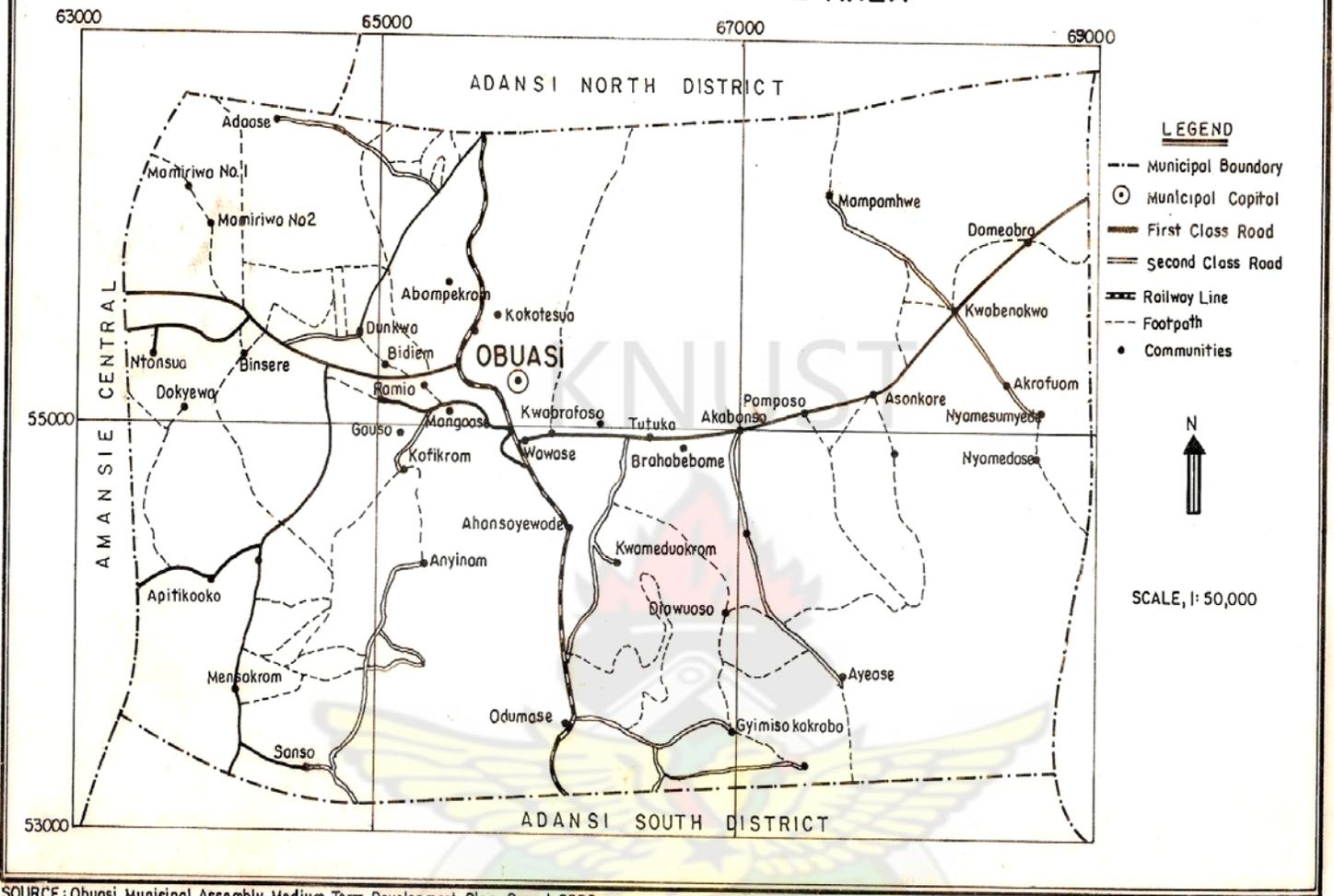
municipality with 30 Electoral Areas, and 1 Urban Council. A proposal has been submitted for the creation of additional 3 Zonal Councils in the municipality (Obuasi

Municipal Assembly Medium Term Development Plan (OMAMTDP), 2006).

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FIG.3.1 MAP OF OBUASI MUNICIPAL AREA



SOURCE: Obuasi Municipal Assembly Medium Term Development Plan Report 2006

3.2.2 PHYSICAL FEATURES

The Municipality experiences semi-equatorial climatic conditions with a double maximum rainfall regime. Mean annual rainfall ranges between 125 cm and 175 cm. Temperatures are uniformly high all year with the hottest month being March when 30^oC is usually recorded. Mean average annual temperature is 25.5^oC. Relative humidity is highest (75% - 80%) in the wet season (OMAMTDP, 2006). The vegetation is predominantly a degraded semi-deciduous forest. The forest consists of limited species of hard wood, which are harvested as timber. The AngloGold Ashanti has maintained large tracts of teak plantation as green belts covering 12.10km² within its concession.

Generally, the Municipality has an undulating terrain with more of the hills rising above 500 meters above sea level. The Municipality is drained by streams and rivers which include; Pompo, Nyame, Akapori, Wheaseammo and Kunka. All these rivers are almost polluted by mining and other human activities.

Soils in the municipality are predominantly forest ochrosols developed under forest vegetation with rainfall between 90cm and 165cm. They are rich in humus and suitable for both cash and food crops production. Crops grown include citrus, oil palm, cocoa, plantain, maize, cassava, vegetables etc. Table 3.1 shows land use in the Obuasi Municipality

Table 3.1: Land Use in the Obuasi Municipality

LAND USE	SIZE (km)
Agricultural Land Area	92.57km²
Land Under Cultivation	55.60km ²
Undeveloped Agricultural Land Area	36.97km ²
Land Under Forest	4.10km ²
Others (Settlements & Degraded Lands)	65.73km ²
Total Land Area	162.4km²

Source: OMAMTDP, 2006

Rocks in the Municipality are mostly of Tarkwaian (Pre-Cambrian) and Upper Birimian formation which are noted for their rich mineral bearing potentials. Areas around the contacts of the Birimian and Tarkwaian zones known as reefs are noted for gold deposits. The Obuasi mine (AngloGold Ashanti) which works on steeply dipping quartz veins over a strike length of 8km. has since 1898 produced over 600 tons (18 million ounces) of gold from ore averaging about 0.65 ounces per ton (OMAMTDP, 2006).

3.2.3 DEMOGRAPHIC CHARACTERISTICS

3.2.3.1 Population

According to the recent survey from statistical services and projections from the 2000 Population and Housing census, the population of the Municipality as at the end of 2005 was 195,000 (OMAMTDP, 2006). The population distribution of the Municipality shows that about 48% of the population is in dependent age groups, that is between 0-14 years

and 65 years and over and 52% constitute the potential labour force in the District. This gives age-dependency ratio of about 1:1 implying that every person in the working age group takes care of himself/herself and an additional person. There are more females than males. Male population constitutes 49.45% as against female population of 50.55% (Table 3.2).

Table 3.2: Age and Sex Distribution of the Population

AGE GROUP	MALE	FEMALE	TOTAL	PERCENTAGE
Under 1 year	3,901	3,899	7,800	4%
1-5 years	15,274	15,926	31,200	16%
6-14 years	26,170	26,480	52,650	27%
15-49 years	39,961	38,039	78,000	40%
50-60	7094	8,506	15,600	8%
60 +	4,035	5,715	9,750	5%
TOTAL	96,435	98,565	195000	100%

Source: OMAMTDP, 2006

The annual growth rate in the Municipality is about 4.0% resulting from migrants who are in search for jobs with the mining and other related companies. The population density of the area is 1,201 persons per square kilometres which is the second highest after Kumasi Metropolitan Area in Ashanti Region. This really puts a lot of pressure on socio-economic facilities and land for both housing and other economic activities.

3.2.3.2 Settlement Patterns

There are 52 communities which make up the municipality. Due to limited land area, 94% of the population in the Municipality is concentrated along the major roads which run in the valleys (Figure 3.2).

According to the 2000 Population and Housing Census, there are 24,729 households in the Municipality with average housing occupancy of 11.8 persons (OMAMTDP, 2006).

The composition and structure of household in the Municipality are a reflection of the social structure of the Ghanaian society.

From the settlement scalogram, there is no single community in the Municipality which heavily dominates the other communities. Based on the total centrality, there are five identified order of settlements. The first order settlements include three communities namely; Boete, Obuasi Central and Mangoase. The second order settlements are Wawase and Tutuka. A clear feature of the first to the fourth order settlements is that they are all along the major roads which also lie within a valley being flanked by high steep hills.

It can be said that facilities in the Municipality are relatively fairly distributed especially basic facilities like Clinics, Basic Schools, Water and sanitation, Communication, etc. It can be emphasized that location of settlements has been influenced by mining activities. Whereas some settlements have been relocated to pave way for gold extraction, others have been developed solely for the staff of AGA and their families.

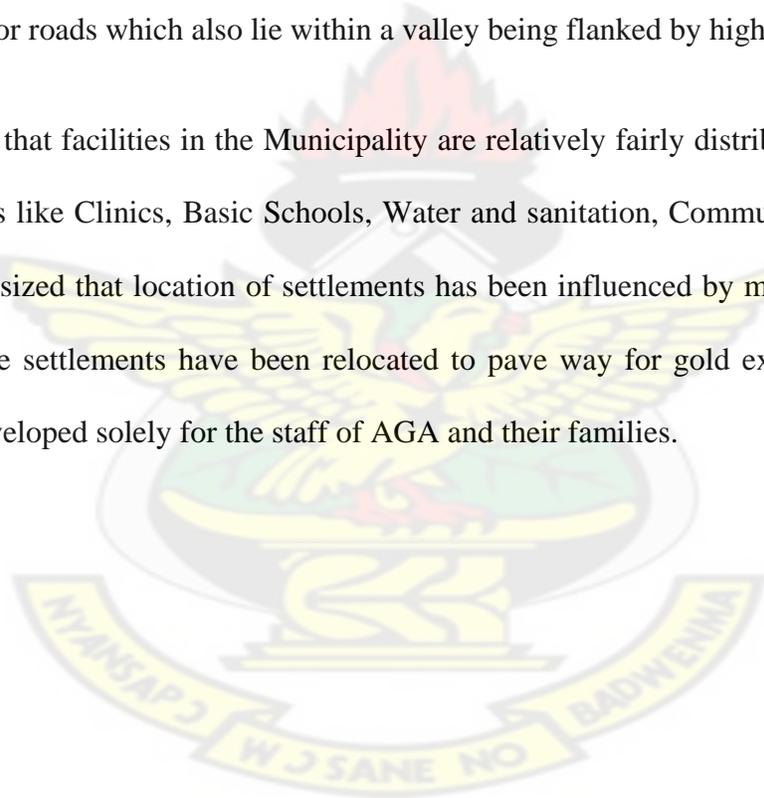
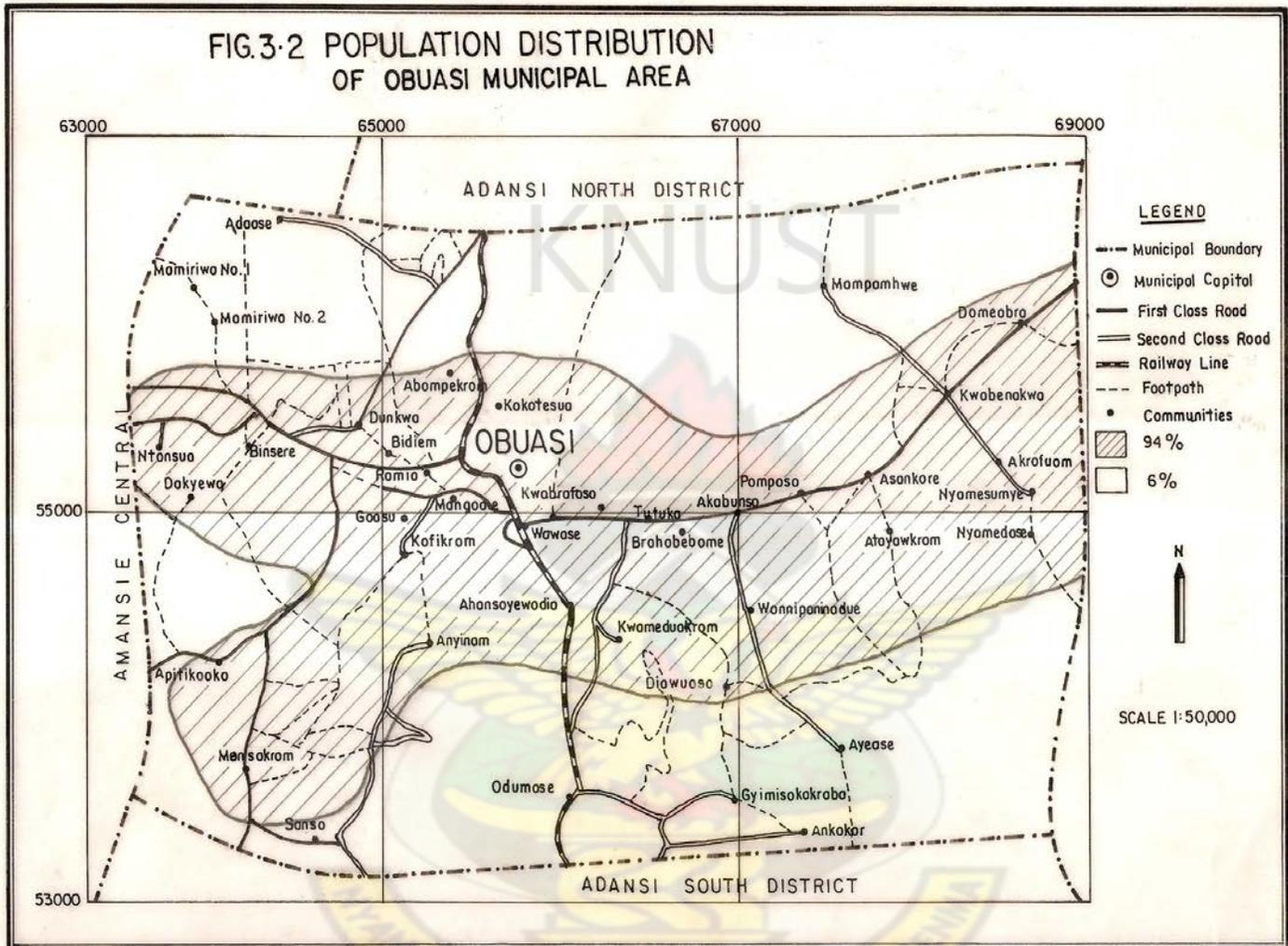


FIG.3.2 POPULATION DISTRIBUTION OF OBUASI MUNICIPAL AREA



SOURCE: Obuasi Municipal Assembly Medium Term Development Plan Report 2006

3.2.4 OCCUPATIONAL DISTRIBUTION

In the Municipality, the service and commerce sectors take the lead in terms of economic activities. This is followed by mining/industry and lastly, agriculture. The service sector which includes transport, telecommunication, banking, insurance, finance, trading and mining support activities engages about 55% of the working population while mining/industry employs about 35% and agriculture engaging 15% (OMAMTDP, 2006).

3.2.5 ADMINISTRATION AND POLITICAL STRUCTURES

3.2.5.1 Traditional Authority

The area is under the traditional authority of the King of Ashanti. The area has a Paramount Chief who supervises activities of various sub-chiefs of all the communities. The whole system is therefore a local form of decentralization. Such traditional set-up gives rise to popular participation and smooth development. Royalties are paid to the traditional authorities by the mining company (AGA) annually.

3.2.5.2 The Municipal Assembly

The Obuasi Municipal Assembly was established on 17th March, 2004 under the L.I. 1614 of 1995 to provide municipal services for its populace. The administrative and political structure within the municipality is not different from any other political and administrative structure in the country. The Assembly consists of 45 Assembly Members (36 males and 9 females) from 57 communities with the Municipal Chief Executive and

the Presiding Officer as the Heads of the Assembly. The Municipality consists of one (1) Constituency with one (1) Member of Parliament.

There are seven (7) sub-committees with different roles and responsibilities. These sub-committees include development planning, works, justice and security, finance and administration, social services, environmental and education. At the moment, there are 78 Unit Committees and one urban council. There is a proposal for the establishment of new Zonal Councils for Tutuka, Kunka and Akaporiso (OMAMTDP, 2006).

Royalties from the mines to the Municipal Assembly from 2002 to 2005 amounted to ₵7,004,241,712.00 (Old Ghana Cedis). This was used for the implementation of specific programmes and projects such as provision of health facilities and potable water.

3.2.6 MUNICIPAL ECONOMY

3.2.6.1 The Structure of the Local Economy

In the Municipality, the Service and Commerce sectors take the lead in terms of employment. This is followed by Mining/Industry and lastly, Agriculture. The service sector which includes transport, telecommunication, banking, insurance, finance, trading and mining-support activities engages about 55% of the working population while Mining/Industry employs about 35% and Agriculture engaging 15% (OMAMTDP, 2006).

3.2.6.2 Agriculture

Agriculture and its related activities, ranks third in the order of economic activities in the Obuasi Municipality, employing about 15% of the labour force. It can be emphasized that mining activities have deprived most farmers access to fertile lands hence agricultural activities are not that widespread in the municipality. Agriculture, is therefore, predominantly on small basis in the Municipality. About 90% of farm holdings are less than 2 hectares in size, although there are some large farms and plantations, particularly for citrus, oil palm and cocoa and to a lesser extent maize, cassava, vegetables and pineapple. Major tree cash crops cultivated are cocoa, citrus, oil palm and teak. Major food crops grown are cassava, maize, yam, rice and cocoyam. Vegetables like pepper, tomatoes, okra, cabbage and legumes, groundnut and cowpea are cultivated by farmers in the municipality. It can be emphasized that labour in the sector has experienced a sharp decline as quite a good number have shifted to the mining sector, hence, reducing annual production levels of crops produced.

3.2.6.3 Mining and Other Industrial Activities

Mining and its related activities is the mainstay of the Municipal economy. The municipality is rich in gold and the mining industry is operated by Anglo-Gold Ashanti. The mining sector's workforce of 10,000 in the early 1990s has now reduced to 6500 due to restructuring and retrenchment exercise currently going on. Some of the other major industrial activities in the municipality are forest/wood based and related industries, blacksmithing and metal based industries, construction and quarrying based industries, mining and allied industries and agro-based industries. Blacksmithing and metal-based

industries have sprung up in the municipality. Used metal scraps from the AngloGold Ashanti are salvaged by scrap dealers for the manufacturing of farm implements and equipments (OMAMTDP, 2006).

Agro-based industries, notably oil palm and palm kernel extraction and gari processing ventures can also be found in the municipality. Some of the natural resource deposits in the municipality are gold, sand, gravel, stones and forest.

3.2.6.4 Commerce and Financial Services

The sector which falls into the informal sector employs between 55% and 65% of the labour force in the Municipality. A broad spectrum of economic and financial services exists in the municipality to facilitate business activities. There are seven (7) reputable financial institutions, six (6) insurance companies and three (3) macro-credit institutions operating in the municipality.

3.2.6.5 Health Care Systems and Delivery in the Municipality

Environmental and health effects of mining activities call for special services such as health care to deal with health problems that arise from mining and other activities. Forms of medical systems in the municipality are discussed below.

There are both modern and traditional systems of health care in Obuasi Municipal Area. Medical care in the municipality is said to be pluralistic, consisting of three different sectors: home remedy, traditional medical sector and modern medical system.

The traditional medical system in the municipality is an integrated one. Many types of practitioners are available, each with a distinctive approach and diagnosis and therapy. They include secular healers who employ or apply herbal medicine prepared from selected leaves, roots or other parts of plants and animals. The actual number of traditional herbalist is not known, however, there are thirty six (36) of whom are registered and located in towns and villages such as New Nsuta, Brahabehome, Kwabena Fosu, Kunka and others. Other traditional medicine practitioners include priests and priestess of gods and deities who employ divination and ritual manipulation in their healing practices. They cure both organic and spiritually caused diseases. Other groups of such sacred healers are the faith healers who are usually the heads of the numerous spiritual churches in the municipality. They employ prayers, fasting, incantation, as well as substantial elements of occultism. It can be emphasized, however, that the traditional sector is gradually fading out within the municipality over the years. It now constitutes just about 20% of the overall health care delivery in the municipality.

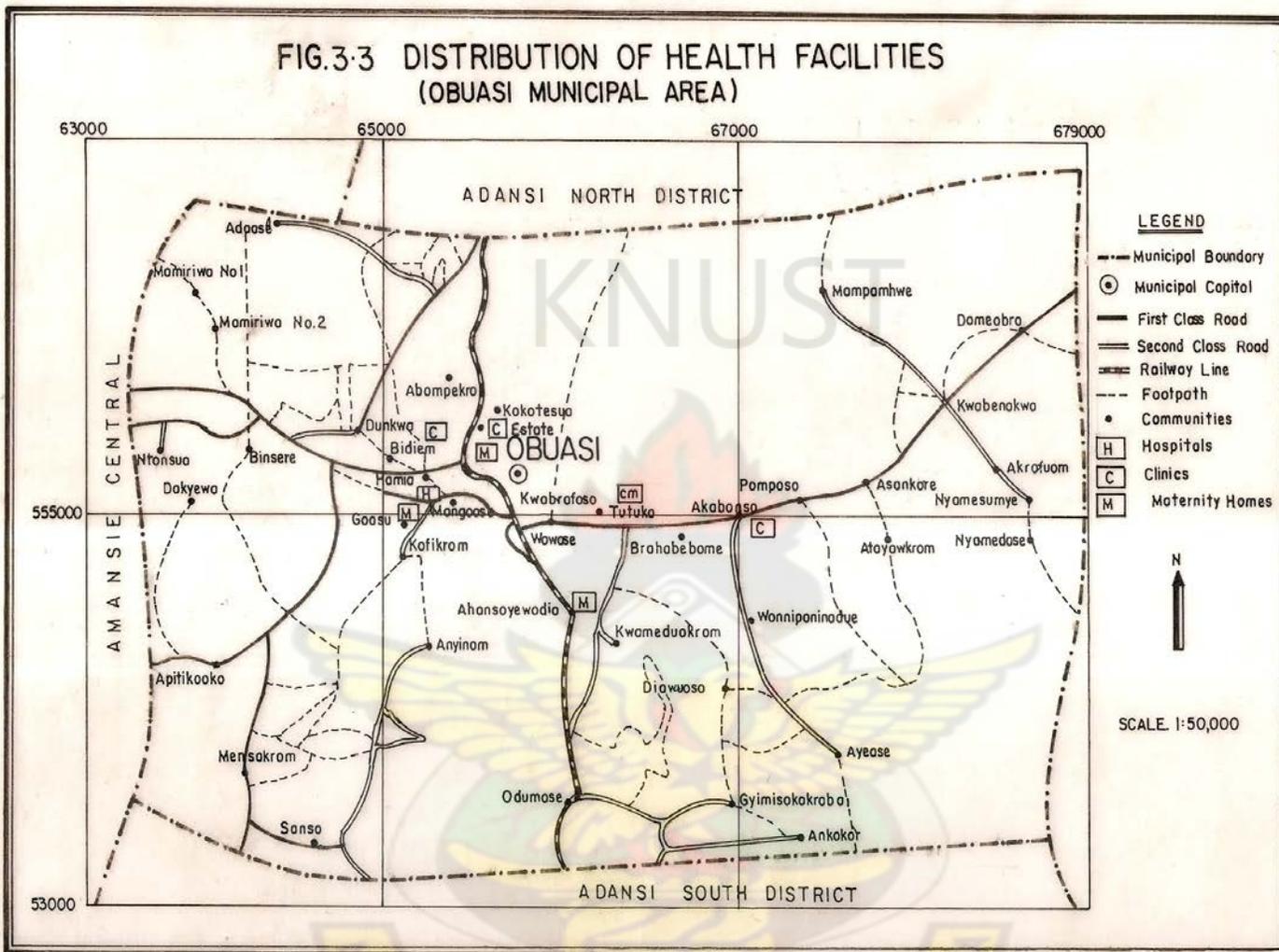
The modern sector is made up of various hospitals, clinics, Health Posts and Health Centres. It also includes the Maternal and Child Health/Family Planning Units as well as Private Maternity Homes. They provide both curative and preventive health care to the population within the municipality. They employ scientific methods or approaches in diagnosing and treating patients. It must be pointed out that where a particular health institution like a clinic, health post and a health centre is attached to M.C.H. /FP Unit, there tends to be specialization to some extent. The Clinics, Health Posts and Health Centres to which the M.C.H/FP are attached tend to concentrate on curative services

while M.C.H. /FP units focus primarily on preventive services. They carry out services such as health education, immunization, vaccination, weighing and other post natal and antenatal services. These modern health care systems are admittedly less equipped and understaffed resulting in less efficient health care delivery.

There are a total of 22 health centres within the Obuasi Municipal Area consisting of hospitals, clinics, health posts and maternity homes owned by the government, private entities and the churches. Figure 3.3 shows the location of health facilities within the municipality.



FIG.3.3 DISTRIBUTION OF HEALTH FACILITIES
(OBUASI MUNICIPAL AREA)



SOURCE: Obuasi Municipal Assembly Medium Term Development Plan Report 2006

There are four (4) hospitals within the municipality, namely; Obuasi Government Hospital, AngloGold Ashanti Hospital, Bryant Mission Hospital and St. Jude Hospital. These hospitals serve a number of the populace in the municipality. There are also 6 clinics, which complement the services of the Hospitals. The rest consist of health posts (predominantly located in the mines) and maternity homes. Table 3.3 gives a summary of health facilities and staff situation in the Municipality.

Table 3.3: Distribution of Health Facilities and Personnel in Obuasi Municipality

Type of Facility	Name of Facility	Location
Hospitals		
Government	1. Obuasi Government Hospital	Obuasi-Rhemia
Private	1. AngloGold Ashanti Hospital 2. Bryant Mission Hospital 3. St. Jude Hospital	Onyinase Boete Bedieso
Clinics		
Government	1.Kunka Clinic 2.Brahabebome Clinic	Kunka Brahabebome
Private	1. Neighbourhood Clinic 2. All Souls Clinic 3. Aril Keonghan Community Clinic 4. Amansan Clinic 5. Agyenkwa Clinic 6. Central Market Clinic	Abompekrom Akaporiso Akaporiso Tutuka Obuasi- Estate Obuasi
Staff Strengths and Ranks		
	Number	
Medical Doctors	11	
Nurses	138	
Paramedics	223	

Source: OMAMTDP, 2006.

Doctor patient ratio in the municipality is 1: 38,017 whereas doctor population ratio is 1: 16,785. Nurse patient ratio is 1: 3,030, with nurse population ratio of 1:1,338. This therefore implies that there is an urgent need for medical doctors to a greater extent, nurses and paramedics to a lesser extent.

Incidence of malaria continues to be the most common disease in the Municipality, followed by respiratory infections as shown on the list below:

Table 3.4: List of Ten Common Diseases in the Obuasi Municipality

No.	Disease
1	Malaria
2	Respiratory Infections
3	Diarrhoea
4	Rheumatism/Joint Pains
5	Hypertension
6	Anaemia
7	Acute Eye Problem
8	Skin Diseases
9	Intestinal Worms
10	Home/Occupational Injuries

Source: OMAMTDP, 2006

Maternal mortality rate is 160 per 100,000 women and child mortality rate stands at 0.7‰

The rate of utilization of modern health facilities is very high in the municipality since the sector alone contributes about 80% of the health care delivery. The introduction of the National Health Insurance about two years ago has contributed immensely to this. With the utilization of facilities, hospitals are at the highest level of hierarchy and by far more sophisticated and more equipped compared to the other types. Next to the clinics in the hierarchy are the clinics. The health posts, maternal and child health/family planning units are at the lowest level of the hierarchy. Precisely, because they are small and not equipped they only serve as first aid centres for communities in which they are located. The hospitals serve as referral centres for the other institutions at the lower level of the hierarchy. Due to this, the rate of utilization at the hospitals is higher than the clinics and other health centres especially, where NHIS is not operational. From the accessibility map it is evident that almost all the communities have relatively high access to Health

services. There are few communities that seem to have problem due to bad nature of their roads, namely: Mampahwe, Asratoase, Anikokor, Nyamesomyede and others.

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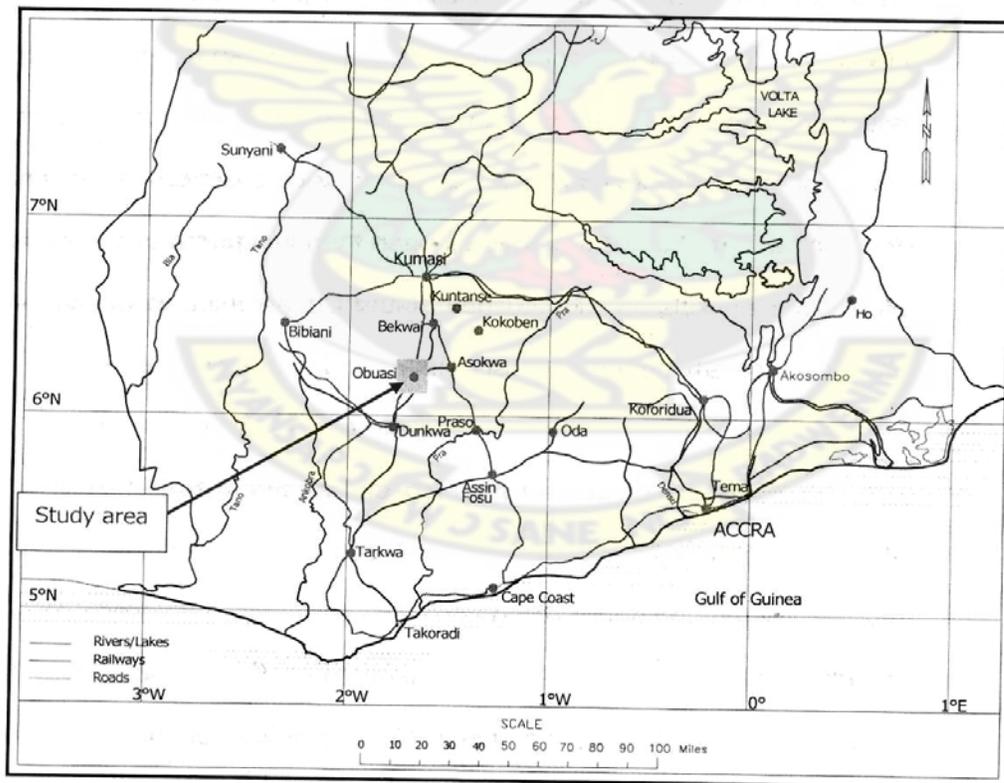


3.3 PROFILE OF ANGLOGOLD ASHANTI LIMITED- OBUASI

3.3.1 INTRODUCTION

The Ashanti mine, situated at Obuasi in the Ashanti Region, is located 300km northwest of Accra and 64km south of Kumasi (Figure 3.4). It is easily accessible by the Accra-Takoradi and Yamoranza-Ashanti-Bekwai inland roads (Foli, 2004). A small airstrip built by AGA for light aircraft also links the area. The western rail-line network links the Obuasi area to the Takoradi harbour in the south. Authority over the land is vested in the Obuasi Municipal Assembly. Figure 3.4 shows the map of the study area.

Figure 3.4: Location of AngloGold Ashanti Limited



Source: Modified after Atta-Quayson, 1999

Obuasi means “under the rock”. It is now part of AngloGold Ashanti Group. It started operation as a mine since 1897. It has yielded 28 million ounces of gold since 1897, with 7.5 million oz in the past 10 years (Obuasi Mines Presentation, 2006). The company expects to produce at least 9 million ounces next 15 to 20 years to come. However, it is the business principle of the company to respect the people in the communities in which it operates by having a positive impact on their cultures, traditions, values and the environment.

3.3.2 EVOLUTION OF ASHANTI GOLDFIELDS COMPANY LTD (AGC)

AGC has passed through many phases since its creation in 1897. It was founded by three Cape Coasters – Joseph Biney, Joseph Brown and Joseph Elias. It was officially incorporated and listed on the London Stock Exchange in 1897 by Edwin Arthur Cade (Obuasi Mines Presentation, 2006). The aim for enlistment was to raise funds to expand and modernize the mine. The company was also enlisted on the London Stock Market. In the late 1960's, Lonrho, under the leadership of Tiny Rowland, took over the ownership and direction of the Ashanti Goldfields Company. In 1969, the ownership structure changed with the Ghana Government having a stake in the company for the first time in the history of the company. The government had a 20% stake in the company with Lonrho maintaining the remaining 80% (Obuasi Mines Presentation, 2006). The ownership structure changed again in 1975 after a coupe d'etat. The government, together with Lonrho, agreed to increase Ghana Government's shares from 20% to 55%. To best serve the interest of the company, the technical management of the mine was placed under the minority shareholder (Lonrho), now Lonmin. History was made in the

history of Ashanti when Sam Jonah was appointed as the first African Managing Director in 1986 at the age of 35 (Obuasi Mines Presentation, 2006).

In 1994, the government sold 20-25% of its interest in share floatation and the company was listed on the London and Ghana stock exchanges. It was the largest floatation organised by any gold mining company. Each of the company's 10,000 employees received five free shares. In 1996 it was listed on the New York Stock Exchange and it became the first African Company to appear on Wall Street (Obuasi Mines Presentation, 2006). The merger was to create a synergy as well as to maximize the potential of the company assets for its shareholders and the stakeholders. This included:

- financial feasibility to develop access in the most efficient way.
- remove capital market constraints such as low tradability of Ashanti shares to achieving high market value.
- develop breadth of operational expertise particularly in the deep level mining and ensure that Ashanti is attracted to major international investors.

3.3.3 EMERGENCE OF ANGLOGOLD

Ashanti needed a partner, with deep level expertise and financial wherewithal to collaborate Ashanti's efforts. Ashanti and AngloGold joint venture operation in Geita was an example of how the two companies could cooperate further for their mutual interest in Africa and beyond. A merger with AngloGold addresses issues to secure the long-term future of Ashanti's assets. AngloGold will provide the expertise in deep level mining, especially in Obuasi. The merger will also create a company with the world's

largest gold reserves and resource base. Ashanti was at the time of the merger operating the following mines; Obuasi, Bibiani, Iduapriem, Siguiiri (Guinea), Freda Rebecca (Zimbabwe) and Geita (joint venture with AngloGold). It had explorative project in several African countries including Democratic Republic of Congo, Mali and others (Obuasi Mines Presentation, 2006).

3.3.4 ANGLOGOLD ASHANTI'S PRINCIPLES IN THE MINING COMMUNITIES

- AngloGold Ashanti's aim is to have a positive impact on the people, cultures and communities in which it operates. Accordingly, AngloGold Ashanti will be respectful of local and indigenous people, their values, traditions, culture and the environment.
- AngloGold Ashanti seeks to undertake social investment initiatives in areas of need where it can make practical and meaningful contributions. In particular, the company will contribute to those areas of education and health care, which are relevant to our business activities and those most likely to be sustainable once our operations have come to a conclusion in that community.
- The company will seek to acquire and use land in a way, which promotes the broadest possible consensus among interested people. Where voluntary resettlement is unavoidable, the company will abide by appropriate guidelines for resettlement, where they exist, and in any event will work with the local communities to develop workable plans for any resettlement, which may be necessary.

- The company will strive to contribute to the sustainable economic development of host communities through procurement activities, the contribution of redundant assets to the community, assistance in the establishment and growth of small to medium sized sustainable enterprise, and the outsourcing of goods and services from local vendors where appropriate.

3.3.5 ROLE OF ANGLOGOLD ASHANTI IN THE DEVELOPMENT OF GHANA

3.3.5.1 Community Development

The company provides employment in various forms to citizens in the surrounding communities as well as those outside the communities. It is on record that AngloGold Ashanti directly employs 7,656 employees and indirectly supports between 40,000 – 60,000 people.

AngloGold Ashanti responds to societal needs by providing schools, good drinking water, electricity, clinics, roads, places of convenience, national institutions and others. Details of these are discussed below. The Obuasi government hospital was built and furnished by the Company (Plate 1). To date many still patronize the services of the company's hospital as well (Plate 2). Currently, AngloGold Ashanti (AGA) is spending \$3 million in 3 years to fight malaria in Obuasi Municipality. The programme, inaugurated by the President of Ghana begun in April, 2006. The Programme has achieved a big success as the incidence of malaria has been reduced drastically.

Plate 1: The Obuasi Government Hospital Built by AngloGold Ashanti (formerly, AGC)



Source :Photographed by Author, 2007

Plate 2 : A sectional view of AngloGold Ashanti's Edwin Caden Hospital



Source: Photographed by Author, 2007

It is also worth noting that the 80 bed Edwin Caden Hospital is virtually free for all employees and their dependents (Plate 2). The people in the communities have access to the hospital. It serves as referral point for the several hospitals in the municipality and it also provides ambulance services to the people in the town. In addition, the company provided \$ 24,000 towards the setting up of Bryant Mission Hospital's Eye Clinic at Boete in Obuasi.

In the field of education, from 1994 until now, the company has spent over ₵2.4billion financing the construction of eight schools in eight rural communities in the Adansi, Amansie & Wassa Amenfi Districts. These include Sanso, Jimiso, Odumase, Anyinam, Brahabehome, Binsere, Dadieso and Adubirem.

Occasionally, the company provides material assistances, in the form of building materials, to construct new schools and renovate old school blocks. In 2003, the company provided roofing sheets and cement products worth ₵5.5million to assist the renovation of Kubi Primary School. Between January and May last year, the company provided 200 bags of cement and timber products worth over ₵20million to assist the construction of the New Bediem Community School Complex. Moreover, AGA financed the construction of a 40 room and 2 flat Student Hostel (Gold Hostel) as a residential facility for the School of Medical Sciences of the Kwame Nkrumah University of Science and Technology in Kumasi. Last year, the company donated ₵5million to the Bosomtwe-Kwanwoma District Directorate of Education in support of the launching of "Read-A-Book-Week" Literacy Programme. Last June, AGA donated ten (10) slightly used

computers and accessories valued at ₺20million to Odumase Primary/JSS School to promote computer literacy.

On apprenticeship programmes, it is on record that the Company runs an Engineering Apprenticeship Programme to train and impart employable skills to over 100 local artisans each year. Participants of the last batch of the programme passed out last year and more than 200 people, mostly from the locality benefitted from the scheme.

On urban and rural development, the Company committed ₺250million into the Obuasi streetlights projects. To date, the company has procured over 2,000 treated poles and harvested over 10,000 raw poles from its teak plantations to assist some 36 rural communities in the Obuasi, Bekwai, new Edubiase and Mansonkwanta districts in their rural electrification projects at the cost of over ₺800million. Between January and May this year, at the cost of ₺75million, AGA has procured 50 treated low tension poles to assist Kubi and Odumasi communities in their efforts to be hooked on to the National Grid under the 'shep' programme.

From 1992 to date, five (5) step down transformers have been donated to six (6) communities in the Obuasi and Bekwai districts to assist in their rural electrification projects at the cost of over ₺200million. Two (2) communities namely Sanso and Anyinam benefit from free electricity power supply from the company's VRA mains at an average annual cost of about US\$ 77,000 (₺734million) (Obuasi Mines Presentation, 2006).

To date, the company has provided 102 water systems to a total of 92 communities in four districts at the cost of over US \$900,000. 70% of the number was provided as goodwill gestures; while the remaining 30% are restitutions for traditional sources of water impacted upon by the operations of the Company. In extreme situations, the company assists in the repair of some broken down water systems to restore water supply. The benefits include less dependency on surface streams and less incidence of water borne diseases.

3.3.5.2 AngloGold Ashanti (AGA) National Projects

The company contributes to economic development by means of royalties in different forms to government and local authorities for onward development. The company has paid \$30.7million since the merger.

Recently, the company donated \$400,000 to sponsor the creation of the Kwame Nkrumah Chair at the Institute of African Studies at University of Ghana. AngloGold Ashanti has also donated \$100,000 to the proposed Neuro-Science Department at Korle Bu Teaching Hospital in Accra. (Obuasi Mines Presentation, 2006)

The company has built a \$90,000 steel bridge over the Pompo River at Diawuoso. It also, in 1992, built the Watereso Bridge over the Oda River at a cost of \$35,000. In addition, the AGA constructed the Footbridge over the Jimi River at Wamase in 1998 at a cost of \$25,000 (Obuasi Mines Presentation, 2006).

Last but not the least, AGA is the only private company to own a modern stadium, which is also used for local, national and international events.

CHAPTER FOUR

4.0 MINING ACTIVITIES WITHIN THE OBUASI MUNICIPAL AREA

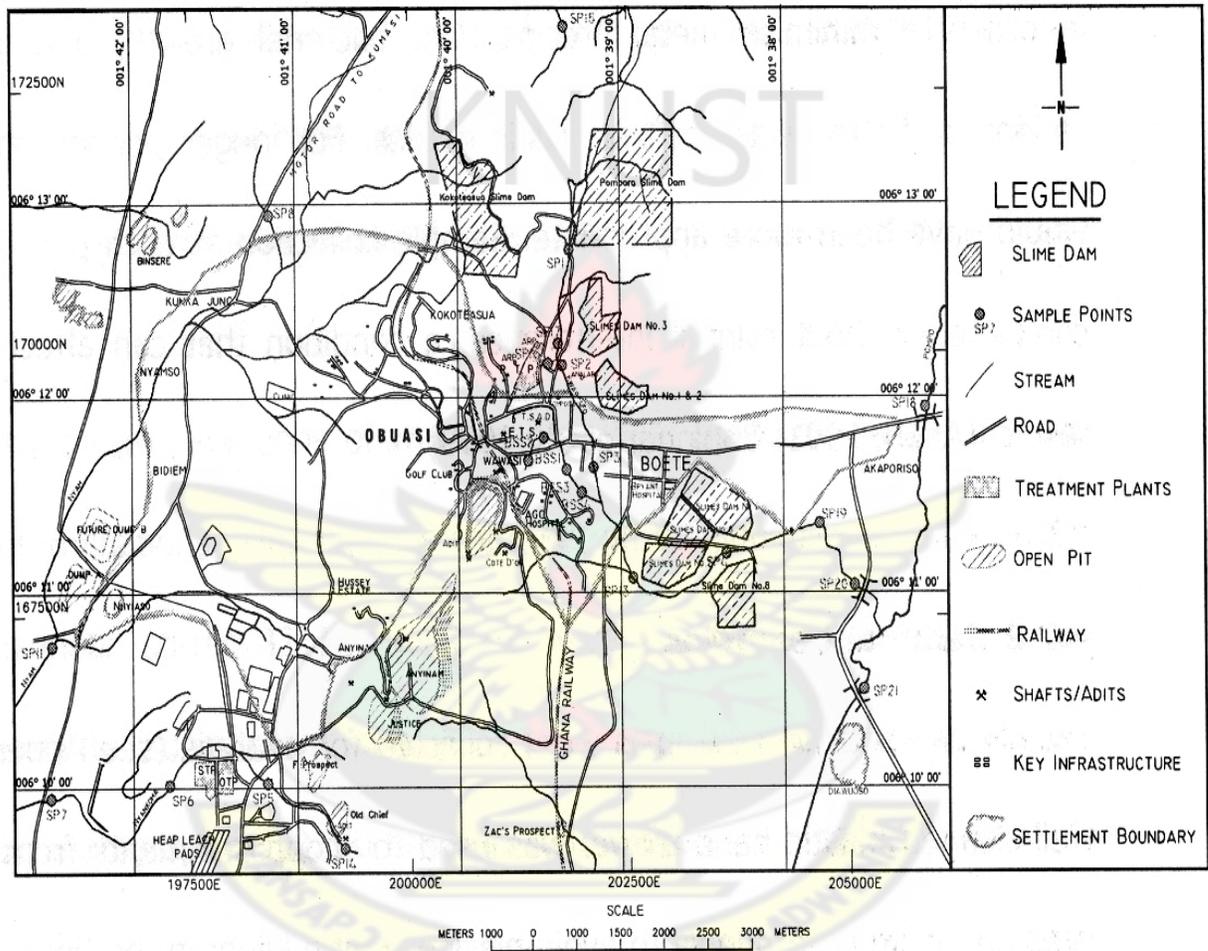
4.1 INTRODUCTION

Mining activities are viewed as one of the major economic activities found within the Obuasi Municipal area and most citizens and residents derive their economic livelihood from this activity. According to the Obuasi Municipal Medium Term Development Plan report, mining/industry employs about 35% of the working population (OMAMTDP, 2006). For the purpose of this research, views of three hundred (300) people from five communities within the municipal area were sampled to find out about their perception of mining activities within their respective towns/villages (Sanso, Anyinam, Anyimadukrom, Abompe and Tutuka). The chapter therefore deals with respondents' awareness and information about mining activities within the Obuasi municipal area. In addition, distribution of mining facilities and sampling sites in the communities, methods of mining, processes involved in gold extraction by AngloGold Ashanti are also examined.

4.2 DISTRIBUTION OF ANGLOGOLD ASHANTI'S MINE FACILITIES

As can be seen in any mining area, mining operations are designed to cover the concessionary area where the Company has the right to carry out its mining activities. AngloGold Ashanti Company Limited-Obuasi concessions extend beyond the Obuasi Municipal area to parts of Amansie Central, Adansi North and South districts. AngloGold Ashanti's mine operations consist of open pits, shafts or adits, sample points, slime dams, treatment plants and other support facilities such as hospitals, clinics and health posts

which are distributed across the concessionary area. It is worth noting that most of these sites are located close to the communities (village and towns) in the municipality (Figure 4.1). **Figure 4.1: A map showing mining, processing, mine spoil containment facilities and sampling sites.**



Source: Anon, (2002).

Respondents whose views were sampled for this research work were selected from some of the communities (that is Sanso, Anyimadukrom (Wawase), Anyinam, Abompe and Tutuka) based on their relative proximity to mine sites of AngloGold Ashanti operations. It is important to note that since the map essentially shows mine containment facilities and sampling sites at a reduced scale, not all the towns are shown on the map.

4.3 MINING METHODS BY ANGLOGOLD ASHANTI (AGA)

Respondents' views were sought concerning the methods of mining operations undertaken in their respective communities. A greater percentage of the respondents acknowledged the fact that AngloGold Ashanti undertakes both surface and underground mining within the mining area.

Some respondents were, however, quick to note that there were also “gallamsey” mining activities being carried out within the mining area. This, though, is not done by AngloGold Ashanti, since it is illegal but predominantly found among the youth in the communities. Table 4.1 illustrates respondents' knowledge of mining methods in their respective communities.

Table 4.1: Respondents' Knowledge of Mining Methods at Obuasi

Mining Methods		
	Frequency	Percent (%)
Surface	35	11.7
Underground	32	10.7
Gallamsey	13	4.3
Surface, Underground	26	8.7
Surface, underground, Gallamsey	96	32.0
Surface, Gallamsey	21	7.0
Underground, Gallamsey	50	16.7
Surface, Underground, Dredging, Gallamsey	9	3.0
No Response	18	6.0
Total	300	100.0

Source: Author's Field Sample Survey, 2007

With regard to the methods of mining, an official from the Environmental Management Department of the Company (AGA) made a clarification, saying that “*the company previously employed both surface and underground mining methods. However, over the*

past eight (8) years emphasis has been placed much on underground mining due to the depth of the gold ore, even though surface mining is carried out on a very small scale”.

4.3.1 Surface Mining (Open Pit)

Surface mining method involves the removal of the top soil up to the bedrock which bears the gold ore. Heavy machines of varied types are usually used for this purpose.

Gold bearing rocks, when reached after the removal of the overlying rocks and soils, are blasted with dynamite and other explosives before gold is finally extracted. Open-pit (surface) mines are used when deposits of commercially useful minerals or rock are found near the surface; that is, where the overburden (surface material covering the valuable deposit) is relatively thin or the material of interest is structurally unsuitable for tunneling (Wikipedia, 2007). Open-pit mines are typically enlarged until either the mineral resource is exhausted, or an increasing ratio of overburden rocks to the ore makes further mining uneconomic. When this occurs, the exhausted mines are sometimes converted to landfills for disposal of solid wastes. However, some form of water control is usually required to keep the mine pit from becoming a lake (Wikipedia, 2007).

The large impact of surface mining on the topography, vegetation, and water resources has made it highly controversial. There are issues of land degradation, loss of biodiversity and pollution of various forms. Surface mining can have adverse effects on surrounding surface and ground water if protection measures are not exercised. The result can be unnaturally high concentrations of some chemical elements, notably arsenic and sulfuric acid, over a significantly large area of surface or subsurface (Wikipedia, 2007).

4.3.2 Underground Mining

Underground mining is done when the rocks, minerals or gemstones are too far underground to get out with surface mining. Some examples of underground mining are borehole mining, draft mining, hard rock mining, shaft mining and slope mining (Think Quest, 2007). Shaft mining is employed by AngloGold Ashanti- Obuasi. It is on record that shaft mining is the deepest form of underground mining. The shaft mine has a vertical man-shaft, a tunnel where the men (miners) travel up and down in an elevator. Equipments are taken into the mine using the shaft too. When the ore is dynamited and broken into chunks, it is taken to the top and loaded into trucks through a second shaft for subsequent extraction (Think Quest, 2007).

Environmental issues can include erosion, formation of sinkholes, loss of biodiversity, and contamination of groundwaters and surface water by chemicals from the mining process and products (Wikipedia, 2007). For instance, use of heavy machines and chemicals underground do not only cause instability within the earth crust but also underground water which serves as source of water to various waterbodies in the area are affected by infiltration of toxic materials. Noise and vibrations are also associated with underground mining.

4.3.3 Method of Extraction

The method employed by Anglogold Ashanti in the extraction of gold is known as biological oxidation. This is done predominantly at the company's Sulphide Treatment Plant (STP). Since gold is covered in sulphide after collection, the Sulphide Treatment

Plant (STP) is designed to treat sulphide/ transition materials from Anglo-Gold Ashanti Company's open pit and underground mining operations.

Ore treatment is via the biological oxidation (BIOX) process, which employs bacteria to effect enzymatic and chemical changes on sulphide minerals, concentrated from the floatation process. The bacteria gold recovery plant (Biox) is the biggest in the world with a designed throughput of 960 tonnes per day of concentration.

Ore treatment process essentially involves crushing, milling, gracing recovery, flotation, biological oxidation, leaching in cyanide, carbon absorption, desorption, electro winning and smelting.

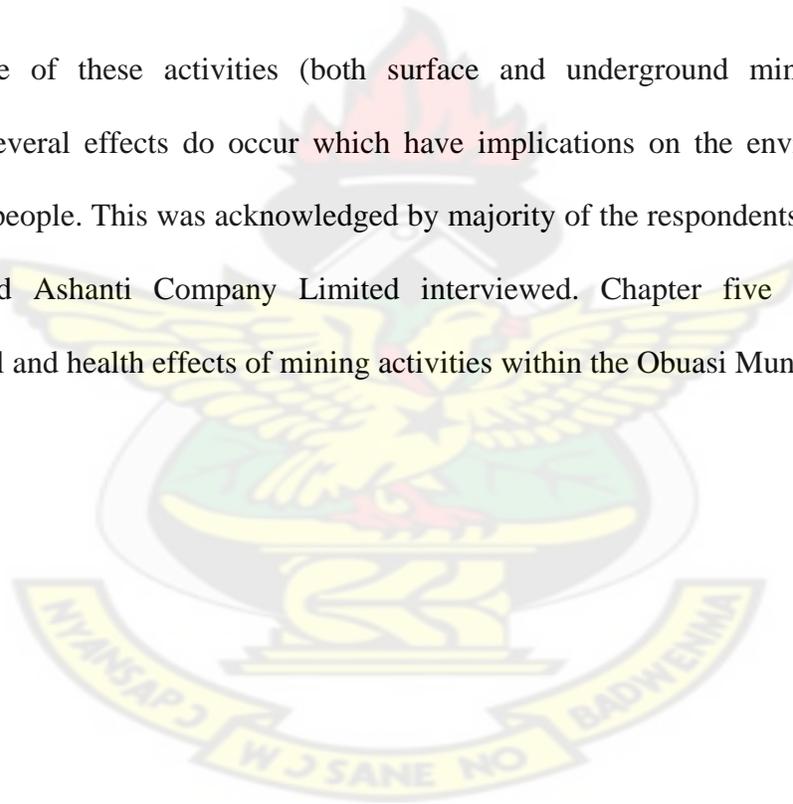
Plate 3: Gold ore covered in sulphide being sent for extraction after crushing at the Sulphide Treatment Plant (STP)



Source: Photographed by Author, 2007

Effects of the Biological Oxidation method includes air pollution as higher concentrations of chemicals used such as carbon, sulphide and arsenic trioxide are often released into the air. In addition, ore which has been processed is known as tailings, and is generally slurry. This is pumped to a tailings dam or settling pond, where the water evaporates. Tailings dams can often be toxic due to the presence of unextracted sulphide minerals, some forms of toxic minerals in the gangue, and often cyanide which is used to treat gold ore via the cyanide leach process (Think Quest, 2007).

In the course of these activities (both surface and underground mining and ore extraction), several effects do occur which have implications on the environment and health of the people. This was acknowledged by majority of the respondents and officials of AngloGold Ashanti Company Limited interviewed. Chapter five looks at the environmental and health effects of mining activities within the Obuasi Municipality.



CHAPTER FIVE

5.0 ENVIRONMENTAL AND HEALTH EFFECTS OF ANGLOGOLD

ASHANTI'S ACTIVITIES

5.1 INTRODUCTION

Mining activities are associated with lots of environmental and health problems. These emanate from the methods of mining and processes involved in the gold extraction.

The chapter deals with environmental effects of both surface and underground mining as well as methods of gold extraction. It also looks at the associated health effects on residents within the communities. Some activities by AngloGold Ashanti Company Limited at intervening in the negative environmental and health effects are also assessed.

5.2 MINING METHODS AND ITS ENVIRONMENTAL EFFECTS AS REPORTED BY RESPONDENTS

From the survey, about 274 respondents (representing 91.33%) of the total sample population admitted that mining methods affect the environment with just 26 (8.6%) failing to acknowledge this fact. Surprisingly, educational levels of respondents did not show any significant relationship regarding the effects of mining on the environment. This was found out to be the result of respondent bias since most of the highly educated were either mine workers or benefiting directly from the mining activities, hence, refused to be objective on the issue. However, there was a clearer picture when respondents' assertion that mining has affected the environment was compared with their (respondents') years of stay in the town or community (Table 5.1).

Table 5.1: Opinion of Respondents on Effects of Mining on the Environment

Count

Years of staying in town	Do methods affect the environment?			Total
	Yes	No	No Idea	
1-4 years	33			33
5-8 years	18			18
9-12 years	28	2	2	32
13-16 years	37	4		41
17-20 years	54			54
21-24 years	20	5	3	28
25-28 years	24			24
29-32 years	30			30
33-36 years	14			14
37-40 years	12			12
41 years+	14			14
Total	284	11	5	300

Chi square value calculated : 51.642 (20 df)

Tabulated value: 31.41 (20 df)

Probability (significance) value: 0.000128

Source: Author's Field Sample Survey, 2007

It is evident from table 5.1 that those who have stayed relatively longer period within the mining area gave a hundred percent attestation that mining methods affect the environment compared to those who have stayed for relatively shorter period where few of them responded 'no' to the question. The chi square analysis confirms this as it indicates that years of staying in town affect respondents' knowledge on mining effects on the environment. Therefore, the first hypothesis that residents' appreciation of mining effects on the environments is affected by their years of stay in the communities is validated (See appendix 2).

5.3 EFFECTS OF UNDERGROUND AND SURFACE MINING ON THE ENVIRONMENT AS REPORTED BY RESPONDENTS

Respondents demonstrated in-depth knowledge of environmental effects of both surface and underground mining activities in their respective communities. Respondents noted varied degrees of effects of both surface and underground mining and these are illustrated in Table 5.2.

Table 5.2: Respondents' responses to environmental effects of mining on the locality

Effects of Mining	Frequency	Percentage (%)
Land Degradation	77	25.7
Air Pollution	76	25.3
Water Pollution	68	22.7
Noise Pollution	61	20.3
No Effect	18	6
Total	300	100

NB: Responses represent respondents' first choice (there were a lot of them who noted more than one form of effect)

Source: Author's Field Sample Survey, 2007

About 94% of the respondents noted that environmental problems like land degradation and pollution (including air, water and noise pollution) are associated with mining activities in their respective communities whereas about 6% of respondents identified no effect of mining activities on their environment. Details of environmental effects of both surface and underground mining are discussed in the following section.

5.3.1 ENVIRONMENTAL EFFECTS OF SURFACE MINING

Environmental effects of surface mining are pronounced in the communities where respondents' views were sampled. Some of them, as noted by respondents, are discussed in the following sections.

5.3.1.1 Land Degradation

One of the major effects of surface mining, according to the respondents interviewed at the five communities, is land degradation. First, removal of the top soils, trees and vegetation with heavy machines deprives the land of its nutrients and renders the land infertile for agricultural purposes. For instance, at Sanso, there were areas where the land had been covered by rocks and other debris from mining activities. These have not only impeded plant growth on the land but has also rendered the surface rugged, making it impossible for farming activities to take place there.

In addition, respondents complained that pits and heavy holes/trenches are created as a result of these activities, and such areas eventually become inaccessible to the people as they become fatal zones. Field observations confirmed this as such pits were observed at Anyinam and Binsere with depths ranging from about 50-75m deep. Even where such pits are backfilled by the company, they are either covered with rocks (which render the land infertile) or are converted into tailings dams where waste and other toxic materials are deposited. There were scenes of tailings dams close to villages such as Kokoteasua, Abompe and others. Scenes of death trapped pits and rugged surfaces were also observed at a location close to the Company's Pompola Treatment Plant near Wawase (Plates 4 and 5).

Plate 4: A degraded land at Pompola Treatment Plant (PTP) near Wawase



Source: Photographed by Author, 2007

Plate 5: A Tailings Dam close to Abompe stretching for several kilometres covered with toxic waste from the mines, with ‘gallamseyers’ busily mining for gold.



Source: Photographed by Author, 2007

On the problem of land degradation, efforts by the company at addressing it were assessed. It was revealed that, in line with the company's Environmental Management Policy (which seeks to undertake resource conservation oriented mining), where the natural forest is tampered with, activities such as re-afforestation were undertaken to at least restore the degraded forest back to its original state. At Sanso, areas where there had been re-afforestation by the Company (covering over 2km sq) after its operation were identified. Plate 6 shows a re-afforested area by AGA.

However, the intensity of this activity in particular, cannot be over emphasized since the above attestation to the fact was observed only at Sanso.

Plate 6: A Re-afforested Area at Sanso by Anglogold Ashanti



Source: Photographed by Author, 2007

5.3.1.2 Pollution

A greater percentage of the respondents (70.9%) also complained of incidence of pollution of various types (that is water (22.7%), air (25.3%) and noise (20.3%) associated with surface mining methods which they attributed, among other things, to the

use of toxic materials, explosives, heavy machines and presence of tailings dams. These were confirmed by field observation. The research revealed that mining activities, particularly surface mining, have been a major source of both surface and underground water pollution. At Sanso, Anyimadukrom and Abompe, three main problems of water pollution including chemical pollution of ground water and streams, increased faecal matter and siltation of water bodies through increased sediment load were observed. Residents in these towns do not anymore depend on ground water and streams for drinking water; and those who do so are at risk of water –borne diseases. Plate 7 shows a polluted river at Sanso.

Plate 7: A polluted river at Sanso contaminated with toxic chemicals.



Source: Photographed by Author, 2007

Major rivers in the municipality that have been polluted in the municipality include Kwabrafo, Pompo, Jimi, San, and Nyame Rivers. Recent sample tests conducted on water quality on some of the polluted rivers by the Environmental Department of AGA revealed the following (Table 5.3).

Table 5.3 Sample Test Results of Some Polluted Rivers in Obuasi Municipality

Date of Test	Sample Source	pH	As (mg/l)	CN(F) (mg/l)	Pb (mg/l)
02/02/08	Kwabrafo River	7.7	6.30	0.21	0.05
07/02/07	Pompo River	7.1	3.70	0.21	0.04
02/02/08	Jimi River	7.6	1.52	<0.01	0.04
23/3/06	Nyam River	7.2	2.75	<0.01	0.24
<i>EPA Guideline Value</i>		6-9	0.2mg/l	0.2mg/l	0.1mg/l
<i>WHO Guideline Value</i>		6.5-8.5	0.05mg/l	0.2mg/l	0.01mg/l

NB: Date of Tests shows the latest tests on the rivers that were made available to the researcher

**pH- Acidity As- Asernic CN(F)- Cyanide Free Pb- Lead
mg/l- milligrams per litre WHO- World Health Organization
EPA- Environmental Protection Agency, Ghana**

Source: Anglogold Ashanti’s Environmental Department, 2008

It is evident from the test results that the arsenic levels in all the rivers were extremely high above the maximum concentration levels allowed by both WHO and the EPA for drinking water. Likewise, lead concentrations for all the rivers were also above both WHO and EPA standardized levels. For Free Cyanide concentrations, with the exception of Jimi and Nyam Rivers, which had less than 0.01mg/l concentration levels, Kwabrafo and Pompo Rivers had concentrations slightly above the WHO and EPA guideline values. With this, an official from the environmental department of AGA explained that *“cyanide concentration in the rivers used to be higher about five to seven years ago. The reduction in the concentrations is due to intervention measures adopted by the Company some years ago, and efforts are intensified to reduce levels of all other toxic chemicals in the waterbodies in the municipality”*.

The situation as evident from Table 5.3 explains the extent to which waterbodies in the mining area have been polluted.

Another form of pollution associated with surface mining activities is air pollution. The concerns of respondents were evident in their worry about periodic emission of airborne particulate matter such as chemicals with unpleasant smell and black smoke in the affected communities. In addition, they also complained of emission of dust particles into the air during periods of blasting, clearing of vegetation and loading and haulage of other materials by heavy trucks. They expressed the worry that these do not only impair visibility but also cause cardiovascular diseases in residents from time to time. This problem was evident from the responses of respondents particularly from Anyinam who are located close to AngloGold Ashanti's open pit site (0-1.5km away) and Anyimadokrom located close to the Pompola Treatment Plant (PTP) where a lot of chemicals are used in the treatment of the gold ore. Their concerns were confirmed by field observation. What was found was that the closer the community to the site the more offensive was the pollution.

Noise pollution is also predominant in communities that are close to mining areas, and surrounding communities of Anglo-gold Ashanti do not escape from this environmental problem. The sources of noise and vibration in the area include mobile equipment, air blasts and vibration from blasting and other machinery. Most respondents from Anyinam (56 respondents representing 80% of Anyinam sample) and Sanso (59 respondents representing 84.3% of Sanso sample) lamented that the noise and vibrations do not only cause cracks and destroy roofs of their buildings but also cause panic and shock in their respective communities periodically. The effect of high-pitched and other noises can also frighten animals, interfere with their mating processes and also cause abortions, therefore,

adversely affecting the animal population. At Anyinam, respondents complained that the peak periods of noise from blasting are around 2-3pm and at night around 10pm. According to one officer at the Anyinam open pit mines “average blasting noise levels measured in the area range from 75-80 decibels (dB) which exceeds the EPA’s highest permissible noise level of 70dB for heavy industrial area for both day and night”. At Anyinam, there was a scene of open pit mine very close to the town where blasting of rocks with dynamite is very frequent (Plate 8).

Plate 8: A scene of an open pit mine close to Anyinam where blasting of rocks is frequent



Source: Photographed by Author, 2007

5.3.2 ENVIRONMENTAL EFFECTS OF UNDERGROUND MINING

With underground mining, underground water is pumped to, among other things, power some of the equipments and machines used. This contaminates the reserves of underground water due to use and spillages of toxic chemicals beneath. Most respondents at Sanso (63 respondents representing 90% of Sanso sample) noted this fact giving reference to some of their contaminated water bodies. They also complained that water pumped from some of their abandoned dug bore holes were contaminated with toxic

chemicals since they previously suffered from waterborne diseases when they depended on them.

Noise and vibrations are also synonymous with underground mining since heavy machines used cause shaking beneath which are sometimes experienced on the surface. This problem occurs when the gold ore is dynamited and broken into chunks. Respondents, especially those at Anyinam and Sanso, complained vehemently about this problem. There was also evidence of large cracks (ranging from 5-8cm wide) in buildings which respondents attributed to vibrations from the mines at Sanso and Anyinam.

5.3.3 ENVIRONMENTAL EFFECTS OF BIOLOGICAL OXIDATION PROCESS

In the process of gold extraction through biological oxidation process, certain poisonous gases are employed at different stages. Examples are sulphide, carbon, arsenic trioxide, cyanide and others. These are highly toxic and harmful to human health if higher concentrations are released into the air. An official at the Sulphide Treatment Plant (STP) of the Company noted that *“there are periods of air pollution as concentration of these chemicals in the air sometimes becomes high, resulting in gas fume and others. In addition, there are events of exposures to the chemicals such as cyanide, harmful materials and others by both workers and people close to the surrounding communities”*. Moreover, toxic wastes released from these processes are dumped or directed into tailing dams which also serve as points of land and air pollution to the nearby communities. Communities such as Kokoteasua, Abompe, Binsere and others which are close to the dams are widely affected. Tailings dam failure at Kokoteasua in 2005 resulted in

spillages of toxic materials, thereby, affecting downstream communities of Kokoteasua, Abompekrom and Nkamprom causing diseases and deaths to some residents.

5.3.4 ENVIRONMENTAL EFFECTS OF MINING ON WATER AND FOOD RESOURCES IN THE OBUASI MUNICIPALITY.

Environmental effects of mining activities within the Obuasi area have had consequent impact on water resources and food production in the municipality. Details of these are discussed below.

5.3.4.1 Effects on Water Resources

Water resources in Obuasi Municipality are not in a very good state. Most of the streams, rivers and other water bodies are either polluted with chemicals or are dried up. According to the Obuasi Municipal Development Report, all of the major streams and rivers like Kwabrafo, Pompo, Nyam, Jimi, Akapori, Wheaseammo and Kunka are almost polluted by mining and other human activities (OMAMTDP, 2006). As the situation is now, according to an agricultural extension officer interviewed, there are no fishing activities within the Kwabrafo river since all species are dead due to intoxication. Moreover, citrus crops along the Jimi river are no more eaten by residents due to contamination with cyanide and other toxic chemicals. About four years ago, it was allegedly reported within the public circles that oranges from Obuasi are contaminated with toxic chemicals which caused stomach ulcer and other complications. Although no test was conducted to prove the credibility of this story, however, the researcher is convinced that there may be an iota of truth in this, looking at the situation observed in the field. Most of the communities visited such as Sanso, Anyinam, and Abompe do not

anymore depend on their streams for drinking water (see water quality test results in Table 5.3). They either depend on filtered sachet water or dug bore holes for drinking purposes. Where these are not accessible, residents who depend on streams and other waterbodies are at risk of waterborne diseases. Prevalence of diarrhoea in the municipality, recorded among the top ten diseases in the municipality for 2007 (Table 5.13), is attributed to poor water quality in some of the communities, according to the nutritionist interviewed at the Obuasi Government Hospital.

In an attempt to remedy the water situation and related health problems in the area, AngloGold Ashanti and the Obuasi Municipal Assembly have resorted to the provision of alternative sources of drinking water in the form of dug bore holes in most of the affected communities such as Sanso, Anyinam, Abompe, Anyimadokrom and others. The researcher identified some of these boreholes at the communities where the questionnaires were administered. However, there were some complains with regard to the maintenance and quality of water that is pumped from these dug boreholes. At Sanso and Abompe for instance, the residents complained of poor quality of water that is pumped from the borehole and alleged that the water may have been contaminated with some chemicals underground.

5.3.4.2 Effects on Food Production

Within the Obuasi municipality, domestic food production is low compared to the needs of the entire area. Respondents attributed this to the mining activities, as several farmlands have either been reserved for mining activities or degraded. Land degradation has resulted from the removal of the top soils, trees and vegetation with heavy machines

for gold deposits. This has deprived the land of its nutrients and rendered it infertile for agricultural purposes. Consequently, few farmlands are available for farming activities. Even of the lands available, some have been contaminated with chemicals from mining activities. An official from the Ministry of Food and Agricultural Directorate at Obuasi claimed that there are cyanide and arsenic concentrations in the land that were used for farming purposes due to mining activities (surface mining). These are no more used for such activities since they are unproductive. Affected communities include Sanso, Apetikoko, Dokyewa and Ahansonyewode. In addition, tailings dams cover considerable portions of lands in communities such as Binsere, Kokoteasua, Abompe and others (Plate 4). Field observations by the researcher confirmed these claims. Moreover, considerable tracts of lands previously used by farmers at Binsere, Dokyewa, Apetikoko and other communities now fall within the concessions of AGA, hence, farmers do not have access to such lands for farming activities. Effects of this situation on food production within the municipality are very remarkable. Tables 5.11A and 5.11B show crop forecast and production for major crops produced by farmers in the municipality.

Table 5.4A: Crop Forecast And Production For Obuasi Municipality 2001-2002

YEAR- 2001					YEAR- 2002				
CROP	TARGET		ACHIEVED		CROP	TARGET		ACHIEVED	
	Area (Ha)	Yield (Mt/Ha)	Harvested Area (Ha)	Output (Mt)		Area (Ha)	Yield (Mt/Ha)	Harvested Area (Ha)	Output (Mt)
Maize	2000	1.8	-	-	Maize	1000	1.8	750	9000
Cassava	2000	1.5	-	-	Cassava	2000	1.5	800	6240
Plantain	2000	6.0	-	-	Plantain	2000	6.0	700	4970
Cocoyam	600	1.2	-	-	Cocoyam	600	1.2	400	2240
Rice	50	1.4	-	-	Rice	50	1.4	30	30
Yam	100	11.0	-	-	Yam	100	11.0	60	426

Source: Ministry of Food and Agricultural-Obuasi Municipal Directorate, 2008

Table 5.4B: Crop Forecast And Production For Obuasi Municipality 2005-2006.

YEAR- 2005					YEAR- 2006				
CROP	TARGET		ACHIEVED		CROP	TARGET		ACHIEVED	
	Area (Ha)	Yield (Mt/Ha)	Harvested Area (Ha)	Output (Mt)		Area (Ha)	Yield (Mt/Ha)	Harvested Area (Ha)	Output (Mt)
Maize	200	1.5	180	3600	Maize	200	1.5	170	255
Cassava	150	12.8	100	900	Cassava	250	11.8	50	590
Plantain	80	7.8	-	-	Plantain	80	7.8	-	-
Citrus	50	35.0	-	-	Citrus	80	-	-	-
Yam	100	12.3	80	680	Yam	100	12.3	20	246

NB: Output for 2006 is up to the Third Quarter (September) of the Year

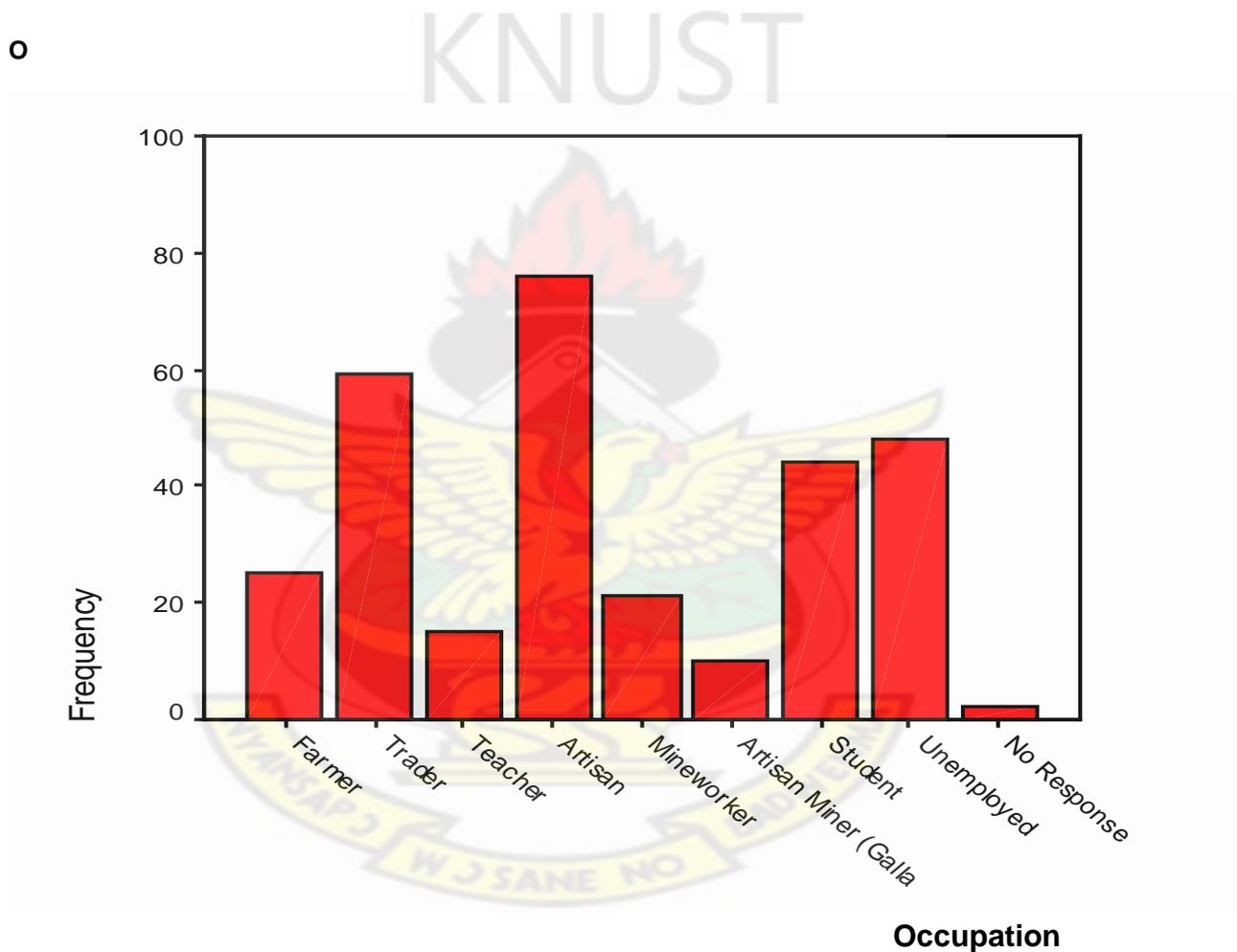
Source: Ministry of Food and Agricultural-Obuasi Municipal Directorate, 2008

The table shows crop production targets and achievements for crops such as maize, cassava, plantain, cocoyam, rice, citrus and yam in the municipality for 2001-2002 and 2005-2006. Prominent parameters of concern are targeted area for cultivation (in

hectares), harvested area (in hectares) and output (in metric tonnes). For 2001 and 2002 production seasons, the targeted area for cassava, plantain, cocoyam rice and yam cultivation were 2000, 2000, 600, 50 and 100 hectares respectively. For maize production, there was a reduction of 1000 hectares for the targeted area between 2001 and 2002. These (especially, maize, cassava, plantain) compared with the values for 2005 and 2006 show more than 100% reduction of the targeted area projected for cultivation. This suggests how much land (for agricultural activities) had been lost within a span of four years. That is, over 3000 hectares of land (for agricultural purposes) have been lost between 2001 and 2006. Both farmers and officials of the Ministry of Food and Agriculture interviewed attributed this to loss of land to AngloGold Ashanti and degradation of portions of farmlands due to mining activities. This eventually has effects on total output of crops. Referring to Tables 5.4A and 5.4B output levels for maize, cassava, plantain and yam showed a significant reduction with subsequent production years (season). Although from agricultural perspective, crop output is affected by interplay of factors such as land fertility, climatic factors, pest and diseases and others, however, the effect of mining activities in the case of crop production in the Obuasi area cannot be discounted. Additionally, officials interviewed mentioned that another factor that has contributed to low crop production in the municipality over the years is the steady shift of labour from the agricultural sector to the mining sector, seen as an indirect effect of mining activities on the environment. Evidently, the proportion of farmers within the Obuasi municipality has reduced drastically, and foodstuffs and agricultural products are imported from the other parts of the country. It is therefore not astonishing that the proportion of farmers currently within

the municipality is just about 15% of the entire working population (OMAMTDP, 2006). However, farming activities hitherto constituted one of the dominant economic activities in the area. The occupational distribution of the respondents interviewed underpins the declining rate of farming activities in the region. Figure 5.1 shows this distribution.

Figure 5.1: Simple Bar Graph Showing Occupational Distribution of Respondents



Source: Author's Field Sample Survey, 2007

Out of the total respondents of 300, farmers were just 25 representing 8.3% of the total respondents. Traders, artisans, mineworkers (together with artisan miners or 'gallamseyers') and the unemployed dominated the respondents. This gives a vivid

picture of the extent to which mining activities have impacted negatively on domestic food production in the Obuasi Municipal area. Effects of mining on the environment, water resource and food production in the Obuasi municipality are very pronounced and remarkable and have consequent effects on the health of the people; hence, a lot has to be done to remedy the situation.

5.3.5 SUMMARY

Environmental effects such as land degradation and pollution of various forms (that is, air, water and noise) in the surrounding communities of AngloGold Ashanti's Obuasi mines are associated with both surface and underground mining as well as the method of gold extraction (BIOX). Land degradation has resulted mainly from surface (open pit) mining. Air pollution has emanated from emission of dust and other particles into the air, emission of chemicals such as carbon, sulphur, arsenic from processing plants and waste disposed of into tailings dams. Noise and vibrations are essentially the effects of blasting of rocks with explosives from both surface and underground mines. Water pollution has resulted from intoxication of waterbodies with chemicals such as cyanide, arsenic and other suspended particles. As a result, water resources within the communities are not in a very good state as most of them have either been contaminated with toxic chemicals or polluted with waste from mining activities. Water quality tests conducted on major streams such as the Kwabrafo, Pompo, Jimi and Nyam rivers showed high concentrations of chemicals such as arsenic that were above WHO acceptable levels.

These have had adverse effects on food production in the municipality as most lands have either degraded due to loss of nutrients or reserved for mining activities, resulting in a significant reduction in yield of major crops from 2001 to 2006. Evidently, the proportion of farmers in the municipality has reduced drastically due to shift (of labour) to the mining and commerce sectors, hence the situation.

KNUST



5.4 HEALTH EFFECTS OF MINING ACTIVITIES ON OBUASI

5.4.1 Introduction

Associated with the numerous environmental effects resulting from mining activities are the consequent health effects or problems. Most respondents from the sample population at the various communities were quick to note this fact. Respondents went further to state that the diseases endemic in their respective areas were related to the mining activities in the region.

5.4.2 Relationship Between Mining and Health

Opinions on the effects of mining on health were sought from respondents. Years of schooling of respondents were cross tabulated with their opinions on impact of mining on health (Table 5.5).

Table 5.5 Respondents' views on relationship between mining and health by education

Years of schooling (Education)	Are diseases related to mining?			TOTAL
	YES	NO	NO IDEA	
None	28	8	14	40
Less than 4 years	5	0	0	5
4-6 years	18	13	4	35
7-9years	86	22	4	112
10-12years	78	5	1	84
13-15years	20	1	1	22
16-18years	2	0	0	2
Total	237	49	14	300

Chi square value calculated: 34.25 (12 df)

Tabulated value: 21.03 (12 df)

Probability (significance) value: 0.001

Source: Author's Field Sample Survey, 2007

Approximately, 79% of the respondents asserted that the diseases endemic in their communities were as a result of the mining activities with just 16.3% refuting this claim. The rest (about 4.7%) however had no idea about the situation. The chi square analysis showed that years of schooling of respondents (education) affected the views of respondents on relationship of diseases endemic in the area to mining activities. Those with 'none' or few years of schooling (0-9years) dominated the respondents numbering 192, constituting 64% of the total respondents. Out of this 71.4% asserted that mining activities had caused diseases endemic in the area. However, for those with higher years of schooling (10-18years) who constituted the minority of total respondents, numbering 108 (representing 36%) of the total respondents, 92.6% attested to the fact that mining activities had caused the diseases endemic in the area. Hence, respondents' appreciation of mining effects on health positively correlated with education (or years of schooling). The second hypothesis that knowledge of mining effects on health is positively related to educational levels of respondents is therefore validated (see appendix 3). To underpin the claims of respondents, the morbidity conditions and situations among residents observed at the study area are discussed below.

5.4.3 Morbidity and Mortality situation

It was evident from the research that diseases prevalent at the communities where views of respondents were taken were mining related diseases as revealed by the literature that was reviewed. These included malaria, skin diseases, diarrhoea, fever, colds and catarrh. Table 5.6 gives the respondents' responses on the diseases they usually contract in their respective communities.

Table 5.6: Diseases Frequently Contracted by Respondents in their respective towns

Diseases	Sanso (0-1.5km) from mine site (%)	Anyinam (0-1.5km) from mine site (%)	Anyimadokrom (0-1.5km) from mine site (%)	Abompe (1.5-3km) from mine site (%)	Tutuka (1.5-3km) from mine site (%)	Total (%)
Malaria	28 (40%)	28 (40%)	25 (41.7%)	27 (54%)	17 (34%)	125 (41.7%)
Respiratory Infection	22 (31.4%)	26 (37.1%)	15 (25%)	7 (14%)	11 (22%)	81 (27%)
Skin Diseases	17 (24.3%)	6 (8.6%)	16 (26.6%)	5 (10%)	9 (18%)	53 (17.7%)
Fever	2 (2.9%)	4 (5.7%)	1 (1.7%)	6 (12%)	5 (10%)	18 (6%)
Diarrhoea	1 (1.4%)	4 (5.7%)	1 (1.7%)	2 (4%)	2 (4%)	10 (3.3%)
Other Diseases	0 (0%)	2 (2.9%)	2 (3.3%)	3 (6%)	6 (12%)	13 (4.3%)
Total	70 (100%)	70 (100%)	60 (100%)	50 (100%)	50 (100%)	300 (100%)

NB: Other Diseases (injuries, anaemia, rheumatism etc.).

NB: Responses represent respondents' first choice

Source: Author's Field Sample Survey, 2007

It is obvious from table 5.6 that malaria alone constituted about 42% of the diseases frequently contracted by the people in the study area, followed by respiratory infections (27%) and skin diseases (17.7%). Fever, diarrhoea and other diseases constituted 13.6% of the diseases that are frequently contracted by the respondents in the study area. It can therefore be concluded that malaria remains a dominant disease in all the communities. The highest prevalence of cold or cough was at Anyinam (recording 37.1% of the responses) which is located very close to AngloGold Ashanti's open pit site where a lot of rock blasting and top soil removal with heavy machines are intense.

Skin diseases among respondents were reported predominantly by those from Anyimadokrom (recording 26.6% of the responses) and Sanso (recording 24.3% of the responses). At Sanso, respondents noted that prevalence of skin diseases was largely due

to contamination of water bodies with chemicals which some residents still depend on for drinking, food and other domestic purposes.

The high prevalence of skin diseases at Anyimadokrom is due to its location close to the Company's (Anglogold Ashanti) Pompola Treatment Plant (PTP) where a lot of chemicals such as arsenic (sulphur dioxide) were employed extensively. This is the cause of skin diseases particularly to the people of Anyimadokrom and Wawase. An official from the Environmental Management Department of Anglogold Ashanti Company admitted this fact, however, he explained that the company noticed the problem and mounted an Arsenic Recovery Plant (ARP) in 1996 to absorb the arsenic emissions which solved the problem eventually. It can therefore be concluded that the complains of skin diseases from some of the respondents from Anyimadokrom at the time of the research is partly due to the long term effect of the problem from the PTP and the possibility that the problem still exists in less significant quantities.

At Abompe and Tutuka, which are located about 1.5-3km from active mine sites, with the exception of malaria, prevalence of other diseases such as cold or cough, skin diseases, fever and diarrhoea were relatively low. This is attributed to their distance from active mine sites. High prevalence of malaria can be attributed to the fact that malaria has become a common disease within the Obuasi Municipal Area since the vectors (mosquitoes) are capable of travelling from areas of higher breeding and concentration to other parts provided they can find choked gutters and stagnant waters for further breeding.

It is therefore worth noting as evident from the table 5.6 that prevalent rates of diseases in the study area such as malaria, cold or cough and skin diseases decrease as one moves

further away from the mine sites. Communities such as Sanso, Anyinam and Anyimadokrom that are located 0-1.5km from mine sites recorded higher contraction rate of malaria, cold or cough and skin diseases by respondents compared to Abompe and Tutuka that are a bit far away from mine sites (1.5-3km). The third hypothesis that infection of malaria and respiratory infections among residents is inversely related to distance from the mines was therefore validated (see appendix 4).

On the whole, other diseases such as fever, diarrhoea, injuries, anaemia, rheumatism and others were not widely reported by respondents. The situation as recorded from respondents in the sampled communities can be compared with biostatistics data derived from Obuasi Government Hospital (Table 5.7).

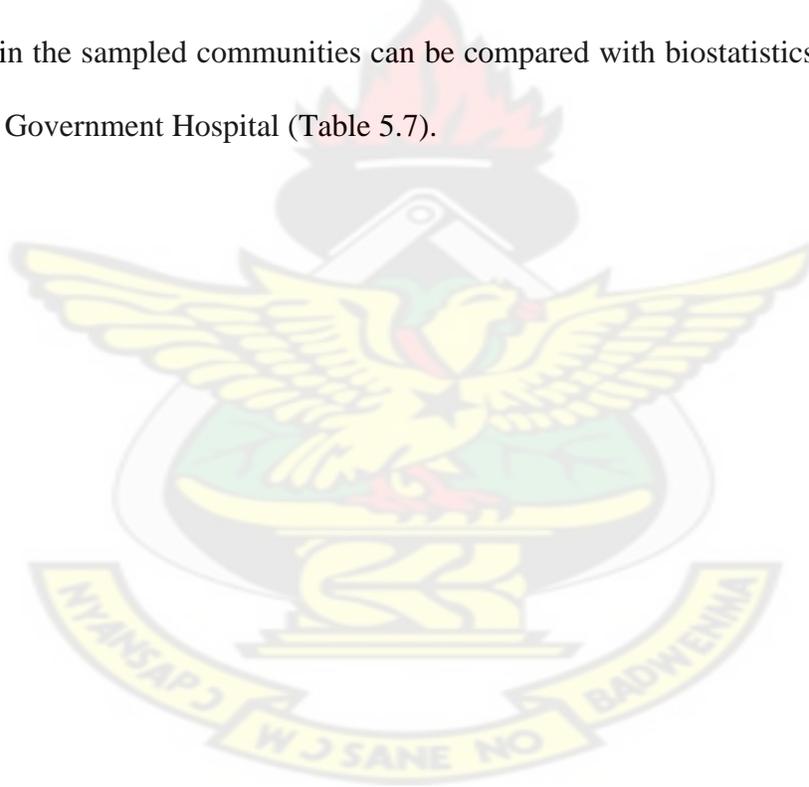


Table 5.7: Top Ten (10) Causes of Out Patient Attendance 2004-2006

No.	2004	2005	2006
1	Malaria	Malaria	Anaemia
2	Respiratory Infections	Respiratory Infections	Acute Urinary
3	Skin Diseases and Ulcer	Skin Diseases and Ulcer	Intestinal Worms
4	Home/Occupational Injuries	Diarrhoea	Vaginal Discharge
5	Rheumatic and Other Joint Pains	Home/Occupational Injuries	Pregnancy Related Diseases
6	Diarrhoea with No Dehydration	Rheumatic with Joint Conditions	Malaria
7	Pregnancy Related Diseases	Pregnancy Related Diseases	Diarrhoea
8	Diarrhoea with Blood	Dog Bite	Home/Occupational Injuries
9	Anaemia	Vaginal Discharge	Skin Diseases and Ulcer
10	Hypertension	Pregnancy Related Diseases	Respiratory Infections

Source: Obuasi Government Hospital, 2007

Table 5.7 gives the top ten causes of Out Patient Department (OPD) attendance from the Obuasi government hospital from 2004-2006. The Obuasi government hospital serves almost all the communities where views of respondents were sampled for the analysis of this research as well as other towns within the Obuasi municipal area where mining activities take place. It is evident from the records of the hospital that malaria, respiratory infections and skin diseases were the top three diseases recorded for 2004 and 2005.

The changes for 2006 are probably due to other factors among which are the interventions by AGA which would be discussed later. It is therefore undisputable that prevalence of these diseases is the result of pollution of varied types experienced in the area as discussed earlier on. To confirm this, five (5) health workers including medical officers and nurses interviewed at the hospital asserted that high prevalence rate of malaria, skin diseases and cough or cold among patients were effects of the mining activities in their communities.

It can therefore be inferred that high prevalence of malaria in the area is attributed to mosquito breeding from polluted water courses, tailings dams and other stagnant waters collected in holes and pits that are created as a result of mining activities as was evident in the responses of respondents from all the five communities. Refer to table 5.6.

Respiratory infections may have resulted from air pollution which has emanated from emission of dust and other chemicals into the air from the mines' open pits and processing plants. Skin diseases, fever and diarrhoea have been caused by polluted rivers and other waterbodies which are depended upon by residents in some of the communities.

It can be noted from the statistics of the Obuasi Government Hospital that malaria ranked sixth with skin diseases and Respiratory infections ranking ninth and tenth respectively for the year 2006, a fall from top three positions for 2004 and 2005.

For malaria, the decline is largely due to the Obuasi Malaria Control Programme which was initiated by AngloGold Ashanti Company in 2006. According to reliable sources, currently, Anglo-Gold Ashanti (AGA) is spending \$3million in 3 years to fight malaria in the Obuasi Municipality. This programme, inaugurated by the President of Ghana last two years, began in April, 2006. Activities include spraying insecticides from house to house every 3 months, education of residents on how to keep their surroundings clean in order to curtail mosquito breeding, among others. Records from the Obuasi Municipal Health Directorate underpin the successes of this programme. Table 5.8 shows this.

TABLE 5.8: Category of Malaria Cases for Obuasi Municipal Area - 2004-2006

CATEGORY	2004	2005	2006
Uncomplicated Malaria < 5yrs	17,605	13,395	15,037
Uncomplicated Malaria ≥ 5yrs	78,707	77,023	56,660
Complicated Malaria < 5yrs	-	1,598	1,647
Complicated Malaria ≥ 5yrs	-	13,726	4,980
Malaria with severe anaemia < 5yrs	-	1,516	1,005
Malaria with severe anaemia ≥ 5yrs	-	8,952	2,516
Malaria in Pregnancy	-	3,397	2,826
TOTAL	95,312	119,607	84,671

Source: Obuasi Municipal Health Directorate, 2007

The records from the health directorate of Obuasi Municipal Area attests to the fact that the Obuasi Malaria Control Programme initiative has brought down the number of malaria cases reported at the various health centres within the municipal area. This is evident in a significant reduction of number of malaria cases from **119,607 (for 2005) to 84,671 (for 2006)**, indicating a 29.21% decline. This sharply contrasts with a significant increase of malaria cases from **95,312 (in 2004) to 119,607 (in 2005)**, representing a swell of 36.65% prior to the introduction of the Obuasi Malaria Control Programme.

Reduction of cold or cough and skin diseases for the year 2006 may be due to the review of methods of operations and other intervention measures by AngloGold Ashanti Company Limited at some mining areas. Prominent among these is the mounting of the Arsenic Recovery Plant (ARP) at the Pompola Treatment Plant near Wawase and Anyimadokrom in 1996 which dealt with the problem of arsenic emissions that affected the people. Similarly, the provision of alternative sources of drinking by the Company in the form of bore hole to most of the communities has reduced high dependence on

contaminated water bodies by residents. This has contributed to the reduction of skin diseases and diarrhoeal cases reported at the Obuasi Government Hospital for 2006.

5.4.4 Morbidity Situation Among Mine Workers

In line with the objectives of the research, mine workers were not among the target population, however, for the purpose of assessing health impacts of mining activities, a sample of twenty (20) mine workers from different departments of mine operations (including underground miners and workers at the mine’s processing plant) were interviewed on their health status as well as the diseases they frequently contract.

Table 5.9 gives details of the diseases mine workers frequently suffer from.

Table 5.9 Diseases frequently contracted by Mine Workers of AGA

Disease	Frequency	Percent (%)
Malaria	5	25
Respiratory infections (Cold or Cough)	3	15
Skin Diseases	2	10
Occupational Injuries	6	30
Fever	1	5
Other Diseases(cancer,hypertension,diarrhoea)	3	15
Total	20	100

Source: Author’s Field Sample Survey, 2007

Some of the mine workers complained of incidence of periodic injuries from their activities. Some also noted periodic infection of malaria, fever and skin diseases. Others also noted long term impacts such as cancers and other respiratory conditions. Some underground miners also complained of risks of high blood pressure, heat exhaustion and

others. However, periodic occupational injuries and malaria remain dominant among mine workers interviewed.

5.4.5 Impact on Nutrition Deficiency Related Diseases

Adverse effects of mining activities on water resources and food production has had consequent effects on nutrition within the municipality. Since other foodstuffs are imported from other parts of the country to augment the low production in the municipality, the total effect of nutrition deficiency may have been reduced. However, an interview with a nutritionist at the Obuasi Government Hospital revealed that prevalence of diseases such as anaemia, hypertension and diabetes in the area are nutrition deficiency related diseases. It can be noted that these diseases formed part of the top ten causes of hospital admissions at the various health centres within the municipality for the year 2007 (Table 5.10).

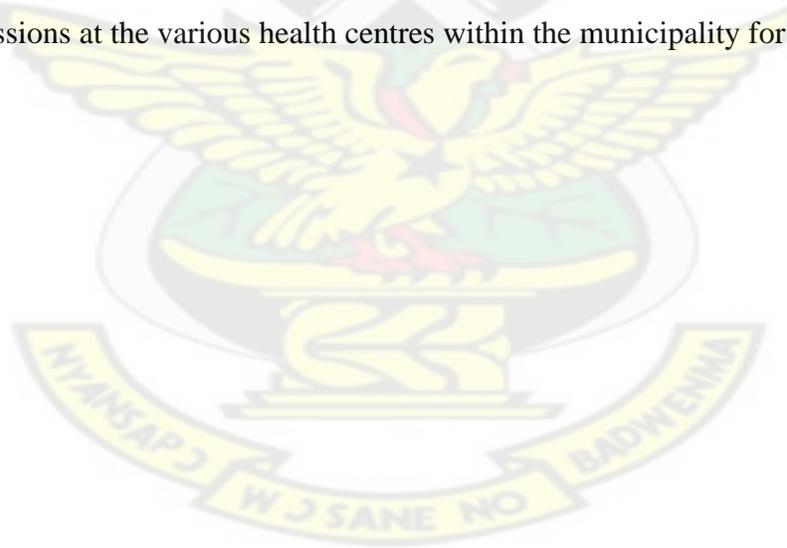


Table 5.10: Top Ten (10) Causes of Hospital Admissions for Obuasi Municipal Area, 2007



TOP 10 causes of Hosp Admission, 2007

No.	Disease	# recorded	%
1	Malaria	304	5.7
2	Hypertension	53	0.9
3	Anaemia	41	0.7
4	Diarrhoea Diseases	39	0.7
5	PUO	31	0.5
6	Diabetes mellitus	25	0.4
7	Pneumonia	25	0.4
8	Typhoid	21	1.3
9	Hernia	20	0.3
10	Asthma	19	0.3
Total Admission		5,318	100

* Above report excludes AGA

NB: The table shows only top ten causes of hospital admissions. Percentages show individual percentages of diseases out of the total admissions of 5,318.

Source: Obuasi Municipal Health Directorate, 2008

It is evident from table 5.10 that hypertension, anaemia and diabetes mellitus ranked 2nd (recording 0.9%), 3rd (recording 0.7%) and 6th (recording 0.4%) respectively among the top ten (10) causes of hospital admissions in the municipality.

5.4.6 Mortality

Data on details of mortality situation in the municipality was not made readily available to the researcher. However, data showing clinical situation in the municipality that

captured aspects of mortality situation in the area was made available to the researcher.

(Table 5.11)

Table 5.11 Clinical Care Indicators for Obuasi Municipality 2005-2007



Clinical Care

Clinical care	2005 actual	2006 actual	2007 target	2007 actual
Total No. of beds	300	317	500	312
Total no. of discharge	8,306	9049		9,058
Total no. of deaths	315	210		184
No. of patient days	30,595	28,947		26,686

Source: Obuasi Municipal Health Directorate, 2008

Table 5.11 shows the clinical care indicators for the Obuasi Municipality from 2005-2007. Among the indicators, one of much interest is the total number of deaths for the period under consideration. 315 deaths were recorded in 2005 whilst 210 and 184 deaths were recorded for 2006 and 2007 respectively. Data on top ten causes of deaths for the period was not made available to the researcher, however, a medical expert interviewed at the health directorate disclosed that *“the diseases that are notable causes of deaths include diabetes mellitus, anaemia, HIV/AIDS, malaria, hypertension, AFP (Polio), typhoid fever, diarrhoeal diseases, infectious hepatitis, tuberculosis, home/ occupational accidents, pregnancy and related complications, tetanus and buruli ulcer and upper tract*

infections”. It is therefore undisputable that most of the diseases that result in deaths are mining related diseases or infections.

It is also obvious from the table that figures for mortality decreased from 315 (2005) to 184 (2007) indicating a reduction of 58.4%. This shows an improvement in life expectancy over the period under consideration. This is attributed to high patronage and utilization of modern health facilities and improvement in health care delivery in the municipality. It was established from the field survey that there is high patronage and utilization of modern health facilities as respondents indicated their choices of health care (Table 5.12)

Table 5.12: Respondents’ Choice of Medical Care by Sex

Source of Medical Care	SEX					
	MALE	%	FEMALE	%	TOTAL	%
Hospital	69	51.5	98	59.0	167	55.7
Clinic	21	15.7	34	20.5	55	18.3
Traditional Medicine	5	3.7	8	4.8	13	4.3
Drug Store	32	23.9	21	12.7	53	17.7
No Response	7	5.2	5	3.0	12	4
Total	134	100	166	100	300	100

NB: Responses represent respondents’ first choice

Source: Author’s Field Sample Survey, 2007

It is obvious from table 5.12 that most of the respondents utilize modern health facilities since about 74% patronize both hospitals and clinics followed by those who frequently buy from drug stores (constituting 17.7%). Utilization of traditional medicine (constituting 4.3%) is poorly patronized due, probably, to the easy accessibility to modern health facilities and, or the fading away of that sector in the municipality.

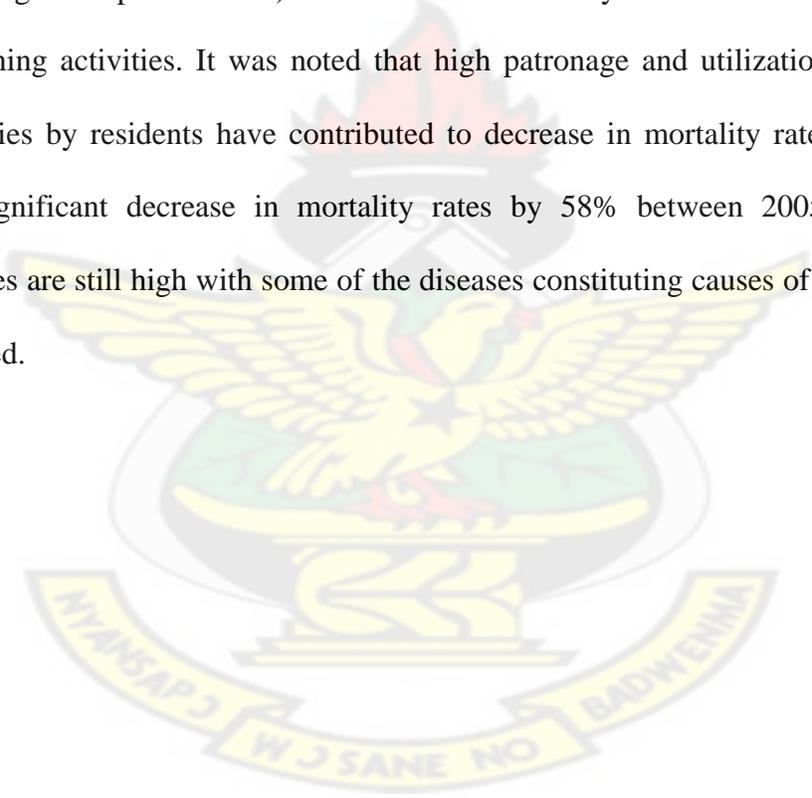
Respondents' main reasons given for choice of medical care are that diseases are well treated at hospitals and clinics, easy accessibility to modern health facilities and benefits from the National Health Insurance Scheme (NHIS). The few who were not patronizing the hospitals and clinics were constrained by the high hospital/clinics bills which they could not afford whereas others saw drug stores as granting the same services as hospitals and clinics, especially when the sickness is not that serious. It is also worth noting that females utilize modern health facilities more than males with 59% and 20.5% patronage of hospitals and clinics respectively (for female) as against that of males with 51.5% and 15.7% utilization of hospitals and clinics respectively. Reasons accounting for this were behavioural since men generally sometimes find it a bit lazy and difficult to attend hospitals and unless sickness is very serious.

Notwithstanding the high patronage and improvements in the health care delivery, the mortality situation in the municipality is still high, and efforts have to be made to bring it further down. This can be achieved by reducing the negative environmental and health effects of mining on the people.

5.4.7 SUMMARY

Health effects associated with mining activities are noteworthy. The research revealed that there is high prevalent rate of diseases such as malaria, respiratory infections (cough or cold), and skin diseases among residents which were direct and indirect effects of mining activities. High prevalence of malaria in the area is attributed to mosquito breeding from polluted water courses, tailings dams and other stagnant waters collected in holes and pits that are created as a result of mining activities.

Respiratory infections (cold or coughs) have resulted from air pollution which has emanated from emission of dust and other chemicals into the air. Skin diseases, fever and diarrhoea have been caused by polluted rivers and other waterbodies which are depended upon by residents in some of the communities. It was established that prevalent rate of diseases in the study area such as malaria, respiratory infections (cold or cough) and skin diseases decrease as one moves further away from the mine sites. The research also revealed that prevalence of diseases such as anaemia, hypertension and diabetes in the area (according to hospital records) were nutrition deficiency related diseases; an indirect effect of mining activities. It was noted that high patronage and utilization of modern health facilities by residents have contributed to decrease in mortality rates. However, despite a significant decrease in mortality rates by 58% between 2005 and 2007, mortality rates are still high with some of the diseases constituting causes of deaths being mining related.



CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 SUMMARY OF RESEARCH FINDINGS

6.1.1 INTRODUCTION

The research examined the mining methods of AngloGold Ashanti Company Limited and their environmental and health effects on the surrounding communities. Moreover, measures being put in place by AngloGold Ashanti Company Limited to mitigate the environmental, health and other socio-economic effects of their activities on the people were assessed. In addition, the roles of some public sector mining industry support organizations were also examined.

6.1.2 Methods of Mining

The research revealed that AngloGold Ashanti Company Limited-Obuasi employs both surface and underground methods of mining with biological oxidation (BIOX) as the method of gold extraction. Surface mining method involves the removal of the top soil up to the bedrock which bears the gold ore. Heavy machines of varied types are usually used for this purpose. Underground mining is employed when the rocks, minerals or gemstones are too far underground to get out with surface mining. Shaft mining is employed by AngloGold Ashanti- Obuasi. Gold extraction is through ore treatment process which essentially involves crushing, milling, gracing recovery, flotation,

biological oxidation, leaching in cyanide, carbon absorption, desorption, electro winning and smelting.

6.1.3 Environmental Effects

Environmental effects such as land degradation and pollution of various forms (that is, air, water and noise) in the surrounding communities of AngloGold Ashanti's Obuasi mines are associated with both surface and underground mining as well as the method of gold extraction (BIOX). Land degradation has resulted mainly from surface (open pit) mining with the use of heavy machines, toxic chemicals and creation of tailings dams. Air pollution has emanated from emission of dust and other particles into the air, emission of chemicals such as carbon, sulphur, arsenic from processing plants and waste disposed off into tailings dams. Noise and vibrations are essentially, the effects of blasting of rocks with explosives from both surface and underground mines. Water pollution has resulted from intoxication of waterbodies with chemicals such as cyanide, arsenic and other suspended particles. These have had adverse effects on food production as most lands have either degraded due to loss of nutrients or reserved for mining activities. Data on annual production of crops such as maize, cassava, plantain and yam showed a significant reduction in yield from 2001 to 2006. Also, water resources within the communities are not in a very good state as most of them have either been contaminated with toxic chemicals or polluted with waste from mining activities. Water quality tests conducted on major streams such as the Kwabrafo, Pompo, Jimi and Nyam rivers showed high concentrations of chemicals such as arsenic that were above WHO acceptable levels. It was hypothesized that appreciation of mining effects on the

environment by residents is related to their number of years of stay in the communities. The hypothesis is validated as the Chi-Square (Pearson) SPSS analysis showed that respondents' appreciation of mining effects on the environment is affected by their duration (years) of stay in the communities (see appendix 2). The first and third objectives of the study which sought to examine the methods operations and their effects on the environment as well as effects on farming activities were therefore justified.

6.1.4 Health Effects

Associated health effects of mining activities are also remarkable. The research revealed that high prevalent rate of diseases such as malaria, cough or cold, and skin diseases among residents were direct and indirect effects of mining activities. malaria alone accounted for 41.7% of the diseases frequently contracted by respondents, followed by respiratory infections (27%) and skin diseases (17.7%) whereas fever, diarrhoea and other diseases mentioned constituted less than 15%. Hospital records from the Obuasi government hospital confirmed this as Malaria, cough or cold and skin diseases were the top three among the top ten of the Out Patient Department (OPD) attendance for 2004 and 2005.

It was established that prevalent rate of diseases in the study area such as malaria, cold or cough and skin diseases decrease as one moves further away from the mine sites. The hypothesis that infection of malaria and respiratory infections among residents is inversely related to distance from the mines was therefore validated (see appendix 4). Communities such as Sanso, Anyinam and Anyimadokrom that are located 0-1.5km from mine sites recorded higher contraction rate of malaria, cold or cough and skin diseases by

respondents compared to Abompe and Tutuka that are a bit far away from mine sites (1.5-3km). The research revealed that prevalence of diseases such as anaemia, hypertension and diabetes (according to hospital records) in the area are nutrition deficiency related diseases. It was noted that these diseases formed part of the top ten diseases frequently reported at the various health centres within the municipality for the year 2007. Despite a significant decrease in mortality rates by 58% between 2005 and 2007, mortality rates are still high with some of the diseases constituting causes of deaths being mining related. The second objective which sought to determine diseases prevalent in the area resulting from mining activities was justified.

6.1.5 Efforts at Restoration

AngloGold Ashanti Company, on its part, has realized the effects of their activities (mining) on the people living in the communities and has consequently sought to institute certain measures to curtail and mitigate the environmental, health and other effects on the people. Measures that have been undertaken, to some extent, include re-afforestation of degraded lands, reviewing methods of operation, resettlement of affected communities and providing alternative sources of drinking water like bore holes to communities whose water resources have been contaminated with toxic chemicals.

On health, AGA has built hospitals, clinics and health posts within the communities for the benefit of both workers and people within the communities. In addition, the Company has embarked on health educational programmes for the benefit of the people.

A major health activity is the Obuasi Malaria Control Programme. This Programme which began in April, 2006 includes spraying of insecticides from house to house every

three (3) months, education of residents on how to keep their surroundings clean in order to curtail mosquito breeding, among others. It has therefore achieved successes as malaria cases reported and diagnosed within the municipality were reduced by 29.21% in 2006. The fourth objective which sought to determine the interventional measures of AGA in ensuring the safety of the residents was justified.

With the view to ensuring better conditions for residents within the mining area, some public sector mining industry support organizations such as the Environmental Protection Agency (EPA), the Ghana Minerals Commission and Ghana Chamber of Mines are playing specific roles in diverse ways.

The Environmental Protection Agency (EPA), whose primary duty is to ensure that mining companies (including AGA) undertake their operations in conformity with the laws, has sought to monitor the activities of the company from time to time. An official interviewed commended AGA with the level of compliance with EPA guidelines but said that there is more room for improvement.

The Ghana Minerals Commission, a governmental agency responsible for fostering the efficient and effective regulation and management of the utilization of Ghana's mineral resources has not only provided mining lease to companies but has also provided the legal framework under which mining activities can be carried out in the country. In addition, the Commission has implemented and supervised social support programmes in mining areas (Ghana Minerals Commission, 2007).

The Ghana Chamber of mines, the peak minerals industry association in Ghana, represents the collective interest of companies involved in mineral exploration, production and processing in Ghana. The Chamber has not only functioned to promote and protect the interest and image of the mining industry but has also committed itself to addressing mining related environmental and socio-economic problems. This is evident in the Chamber's commitment in initiating alternative livelihood programmes and executing its corporate social responsibility in host communities of mining activities (Ghana Chamber of Mines 2007).

Despite efforts by these organizations in ensuring that mining activities are carried out on sustainable basis without serious problems to the environment and the host communities, the public is yet to feel the impact of their activities. A critical assessment of their activities therefore shows that there is more to be achieved than what has been accomplished so far as far as environmental and health problems in the mining industry are concerned.

6.2 CONCLUSION

In as much as we acknowledge the economic benefits of mining activities in Ghana, there is the need also to recognize the environmental and health hazards that come with it in order to find ways of dealing with them. This was the main focus of the research.

After a thorough investigation into the problem as pertains in Obuasi and its surroundings, the area of operation of AngloGold Ashanti Company limited, it has come

to light that mining activities have resulted in land degradation leading to limited land available for local food production within the municipality. There is also incidence of pollution of varied kinds (that is, air, noise and water) to the environment. Water pollution has affected mainly water resources within the area. All of the major streams and rivers in the area like Kwabrafo, Pompo, Nyam, Akapori, Wheaseammo and Kunka have been polluted by mining activities.

The combined effects of above problems have culminated into health problems with high prevalence of diseases such as malaria, respiratory tract infections and skin diseases endemic in the area. Other nutrition deficiency related diseases such as anaemia and hypertension are also prevalent in the area. These were seen as the indirect effects of mining activities on food production in the area. These diseases, according to medical experts, form part of the notable causes of deaths (mortality) in the municipality.

In view of the above problems, it has been recommended that Environmental Management Department of AngloGold Ashanti Company Limited revises its environmental management policy to ensure that the environmental effects of mining activities in the area are reduced to the barest minimum. Even though the Company has adopted measures such as re-afforestation, providing alternative sources of drinking water, reviewing operation methods and resettlement of affected communities, this initiative is essential.

The research was not carried out without certain constraints. Among the constraints encountered were financial constraints due to lack of funding, problems with data collection (including respondents' bias and reluctance to answer questions) and lack of co-operation from some institutions. Another major constraint was the inadequate time of one year allotted for the completion and submission of this work which was further aggravated by the load (power) sharing experienced countrywide for almost one and half years due to the country's power crises which began in mid 2006. To overcome these problems, the researcher had to depend on his own sources of finance (from relatives, friends) and to some extent, thesis grants from Ghana Government Bursary which were just peanuts. Data collection problems were tackled through frequent visits to the communities and institutions needed for relevant data as well segmenting the target population to cross check the authenticity of information gathered. These were backed with verifications from field observations.

Notwithstanding the constraints and other challenges, it can be emphasized that the research has contributed immensely to the existing knowledge. First, the research has revealed that mining effects on health of residents in the communities is related to distance from the mines. That is, proximity to mine site is very crucial in determining the prevalence of mining related diseases such as malaria, respiratory infections and skin diseases in the Obuasi area. It was established that rates of mining related diseases (malaria, skin diseases and respiratory infections) decrease as one moves further away from mine sites. Besides, both qualitative and quantitative methods have been employed successfully to analyse the findings of this research work. This debunks the notion by

some that quantitative methods are difficult to use in social researches hence should be limited to natural and physical sciences.

It is recommended that further researches are conducted into the assessment of intervention measures adopted and implemented by mining companies and stakeholder organisations in reducing as well as mitigating the economic, social, environmental and health impacts of mining activities on the people in the surrounding communities. There should also be funding from the government and other institutions for researches conducted at higher institutions, with a move to educate the general public on the need to provide information needed for academic researches since they will ultimately lead to the development of the country

6.3 RECOMMENDATIONS

After a thorough and meticulous study and analysis of the problem and all its ramifications as indicated in the preceding chapters, the following recommendations are made to address the environmental and health problems created by the mining operations:

a. The Environmental Management Department of AngloGold Ashanti Company Limited should revise its environmental management policy to ensure that the environmental effects of mining activities in the area are reduced to the barest minimum. The Company tries as much as possible to employ and release toxic chemicals and other materials in their operations provided the amounts fall within E.P.A specifications without actually

considering the adverse environmental and health effects on the people. It is therefore recommended that health considerations and sustainability of the environment should be prioritized before methods of operations are devised.

b. Stringent and rigorous efforts at re-afforestation, resettlement of affected communities and other measures aimed at restoring back degraded lands to its original state after mining activities should be intensified by the Company. These will not only reduce the negative environmental and health impacts on the people but also land would be available particularly to farmers for agricultural purposes. In addition, employment opportunities will receive a significant boost so as to trim down the high rate of unemployment in the region.

c. Similarly, the Government of Ghana, who holds right to all minerals in trust for all Ghanaians, in collaboration with the Ghana Minerals Commission, should make conscious efforts to reduce the rate at which lands or concessions are granted to mining companies in the country. This is necessary because despite several efforts and measures put in place, environmental and health effects of mining activities continue to remain a huge predicament, particularly to those living in the surrounding communities, and to a greater extent, the country at large.

d. On health, in as much as AngloGold Ashanti Company Limited will be commended for its efforts at providing hospitals, clinics, health posts and the malaria control programme initiative, it will be recommended that health facilities, particularly those that belong to

the Company should also be made accessible to non-workers as well at affordable charges. This is crucial because the Obuasi Government Hospital and the few government-owned health centres alone cannot serve adequately the health needs of all residents in the municipality. Moreover, the government, through the Obuasi Municipal Assembly, should build additional health centres, principally, in the villages such as Sanso, Anyinam, Abompe and others that are close to the mining containment points. In addition, the Obuasi Municipal Health Directorate should institute periodic free medical check ups for mining related diseases among the populations so that serious cases can be detected and cured early enough before they escalate into mortality situations. With such programmes initiated, sponsorship can be sought from AngloGold Ashanti Company Limited and other donor agencies.

e. Individual and households in the communities should be educated on the need to use mosquito nets in their rooms to avoid malaria infections through biting by mosquitoes.

f. More importantly, since most of the water resources in the municipality (particularly the villages) have been polluted with toxic chemicals, there should be rigorous efforts by the Company (AngloGold Ashanti) and the Obuasi Municipal Assembly to provide alternative sources of well treated drinking water in the form of bore holes and others. This exercise should, however, be backed by intensive education so that the people will see the need to utilize them.

g. Last but not the least, there is the need for an effective collaboration and co-ordination among governmental agencies such as the E.P.A., the Ghana Minerals Commission, the Forestry Commission and others so that they can perform their roles effectively in dealing with the environmental and health problems associated with mining activities within the affected communities.

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APPENDICES

APPENDIX 1

ENVIRONMENTAL AND HEALTH IMPACT OF MINING ON SURROUNDING COMMUNITIES. A CASE STUDY OF ANGLOGOLD ASHANTI (AGA) IN OBUASI.

QUESTIONNAIRE SCHEDULE FOR RESIDENTS IN THE SURROUNDING COMMUNITIES.

A. Personal Information

1. Residence.....
2. Sex.... Male [] Female [] 3. Age..... 4. Occupation.....
5. Marital status: a. Married [] b. Unmarried [] c. Divorced []
6. Highest level of educational attainment
a. Illiterate [] b. Basic [] c. Secondary (S.S.S, Training College, Vocational) []
d. Tertiary (Polytechnic, University) [] e. Others, specify
7. For how long have you been staying in this town/village?

B. MINING ACTIVITIES AND IMPACTS ON THE ENVIRONMENT

8. Do you have any idea about mining activities in this town/village? Yes [] No []
9. If yes, what method(s) of extraction is/are used by the company? (*Tick all that apply*)
A. Surface Mining B. Underground Mining C. Dredging D. Gallamsey Method
E. Other, specify.....
10. Do you think the methods of operation by the mining company have some effects on the natural environment? Yes [] No []
11. If yes, what are some of the effects? (*Tick all that apply*)
A. Degradation of land and vegetation B. Water pollution C. Air pollution
D. Noise pollution E. Other, specify
12. What actually cause(s) land degradation? (*Tick all that apply*)
A. Presence of tailing dams B. Use of toxic materials C. Use of heavy machines

D. Clearing of Vegetation E. Long period of extraction
Other, Specify.....

13. What cause(s) pollution (of any sort as chosen in Q11) on the environment?
(Tick all that apply)
A. Presence of tailing dams B. Use of toxic materials C. Use of heavy machines
D. Clearing of Vegetation E. Long period of extraction
Other, Specify.....

14. Has AngloGold Ashanti (AGA) made attempts to reduce or curtail the adverse environmental effects of mining activities? Yes [] No []

15. If yes, what are some of the measures being undertaken?
A. Re-forestation B. Resettlement of affected communities C. Providing alternative sources of drinking water D. Compensation to affected communities
E. Reviewing or varying methods of operation F. Others, specify
.....

16. Are the efforts at reducing the environmental impacts satisfactory and effective?
Yes [] No []

C. MINING AND HEALTH

17. Which of the following diseases do you usually suffer from or contract?
A. Malaria B. Diarrhoea C. Skin diseases D. Fever E. Colds and catarrh
F. Other disease(s)

18. What diseases do people in your family frequently contract?
A. Malaria B. Diarrhoea C. Skin diseases D. Fever E. Colds and catarrh
F. Other disease(s)

19. Would you say the disease(s) chosen above are related to the mining activities?
Yes [] No []

20. What are the sources of medicine to address your health needs?
A. Clinics B. Hospitals C. Traditional (herbal) medicine D. Drug stores
E. Other, specify

21. Give reasons for your answer in Q20
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22. Is AGA doing anything to address the health needs of the community?
Yes [] No []

23. If yes, what are some of these activities?

.....
.....
.....

24. Has AGA built any health facility in this community for the service of both workers and people in the community? Yes [] No []

25. Does AGA carry out any health campaign programme to educate people in the community? Yes [] No []

26. If yes, give any example of such campaigns you know of

.....
.....

D. ROLES OF LEGAL REGULATING AGENCIES AND OTHER STAKEHOLDER ORGANISATION WITHIN THE MINING SECTOR

27. Do you have any idea of agencies or organisations that hold stake in monitoring, regulating and addressing the activities of the mining sector in the country? Yes [] No []

28. If yes, what are some of them? (*Tick all that apply*)

- A. EPA B. Chamber of mines C. Ghana Minerals Commission D. NGO's
- E. Other, specify

29. Do you often hear of any of the above organisation's activities relating to mining activities in the town? Yes [] No []

30. If yes, which of them do you usually hear of (*Tick all that apply*)

- A. EPA B. Chamber of Mines? C. Ghana Minerals Commission
- D. NGO's (Name.....)
- E. Other, specify

31. Would you say that these (any of them) agencies and organisations are doing well in monitoring and regulating mining activities in the town? Yes [] No []

32. Give reasons for your answer to Q31

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QUESTIONNAIRE SCHEDULE FOR STAFF OF AGA.

A. Personal Information

- 1. Residence.....
- 2. Sex.... Male [] Female [] 3. Age.....
- 4. Department.....
- 5. Marital status: a. Married [] b. Unmarried [] c. Divorced []
- 6. Highest level of educational attainment
a. Illiterate [] b. Basic [] c. Secondary (S.S.S, Training College, Vocational) []
d. Tertiary (Polytechnic, University) [] e. Others, specify

B. MINING ACTIVITIES AND IMPACTS ON THE ENVIRONMENT

- 7. What method(s) of extraction is/are used by the company? Tick all that apply
A. Surface Mining B. Underground Mining C. Dredging D. Gallamsey Method
E. Other, specify.....
- 8. Do you think the methods of operation by the mining company have some effect on the natural environment? Yes [] No []
- 9. If yes, what are some of the effects?
A. Degradation of land and vegetation B. Water pollution C. Air pollution
D. Noise pollution E. Other, specify
- 10. Has AngloGold Ashanti (AGA) made attempts to reduce or curtail the adverse environmental effects of mining activities? Yes [] No []
- 11. If yes, what are some of the measures being undertaken? (**Tick all that apply**)
A. Re-forestation B. Resettlement of affected communities C. Providing alternative sources of drinking water D. Compensation to affected communities
E. Reviewing or varying methods of operation F. Other, specify
.....
- 12. Are the efforts at reducing the environmental impacts satisfactory and effective?
Yes [] No []

C. MINING AND HEALTH

13. Which of the following diseases do you usually suffer from or contract?

(Tick all that apply)

- A. Malaria
- B. Diarrhoea
- C. Skin diseases
- D. Fever
- E. Colds and catarrh
- F. Other disease(s)

14. What diseases do people in your family frequently contract? *(Tick all that apply)*

- A. Malaria
- B. Diarrhoea
- C. Skin diseases
- D. Fever
- E. Colds and catarrh
- F. Other disease(s)

15. Would you say the disease(s) chosen above are related to the mining activities?

Yes [] No []

16. What are the sources of medicine to address your health needs?

- A. Clinics
- B. Hospitals
- C. Traditional (herbal) medicine
- D. Drug stores
- E. Other, specify

17. Give reasons for your answer in Q20

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.....
.....

18. Is AGA doing anything to address the health needs of the community?

Yes [] No []

19. If yes, what are some of these activities?

.....
.....
.....

20. Has AGA built any health facility in this community for the service of both workers and people in the community? Yes [] No []

21. Does AGA carry out any health campaign programme to educate people in the community? Yes [] No []

22. If yes, give any example of such campaigns you know of

.....
.....
.....

**D. ROLES OF LEGAL REGULATING AGENCIES AND OTHER
STAKEHOLDER ORGANISATION WITHIN THE MINING SECTOR**

23. How is the relationship of AGA with the E.P.A?
A. Very cordial B. Cordial C. Bad D. Very bad

24. Does EPA conduct Environmental Impact Assessment on the activities of AGA?
Yes [] No []

25. If yes, how often are such exercises carried out?
A. Monthly B. Quarterly C. Bi-annually D. Yearly Other, Specify.....

26. Has EPA ever cautioned the company on issues of environmental degradation or pollution? Yes [] No []

27. If yes, what steps did the company take in any of such instances?
.....
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.....
.....

28. Does the Ghana Chamber of Mines provide guidelines regarding methods of operation in reducing the rate of environmental hazards?
Yes [] No []

29. Does Ghana Chamber of Mines conduct Environmental Impact Assessment on the activities of AGA-Obuasi? Yes [] No []

30. If yes, how often?
A. Monthly B. Quarterly C. Bi-annually D. Yearly Other, Specify.....

31. Does Ghana Minerals Commission carry out similar activities as asked in (Questions 24, 26, 28 and 29)? Yes [] No []

32. What other stakeholder organisations apart from EPA, Chamber of Mines and Ghana Minerals Commission do your company (AGA) deal with in carrying out your activities?.....
.....
.....

33. Any role(s) by the companies/organisations provided in question 32?
.....
.....
.....

QUESTIONNAIRE SCHEDULE FOR HEALTH WORKERS

A. Personal Information

1. Workplace (Name Clinic/Hospital).....
2. Sex.... Male [] Female [] 3. Age.....
4. Department/Position.....
5. Marital status: a. Married [] b. Unmarried [] c. Divorced []
6. Highest level of educational attainment
a. Illiterate [] b. Basic [] c. Secondary (S.S.S, Training College, Vocational) []
d. Tertiary (Polytechnic, University) [] e. Others, specify
7. Which of the following diseases are frequently reported and diagnosed at the Hospital/clinic? (**Tick all that apply**)
A. Malaria B. Diarrhoea C. Skin diseases D. Fever E. Colds and catarrh
F. Injuries Other disease(s)
8. Which of the diseases mentioned above tops the chart for the past three years?
A. Malaria B. Diarrhoea C. Skin diseases D. Fever E. Colds and catarrh
F. Injuries Other disease(s).....
9. Are some of the diseases directly or indirectly associated with mining activities?
Yes [] No []
10. If yes, which of the diseases are caused by or associated with mining activities within the Obuasi Municipality? (**Tick all that apply**)
A. Malaria B. Diarrhoea C. Skin diseases D. Fever E. Colds and catarrh
F. Injuries Other disease(s).....
11. Do the diseases mentioned above constitute a significant cause in mortality rates in the communities? Yes [] No []
12. Is your clinic/hospital fully equipped to handle such cases frequently reported at the hospital/clinic? Yes [] No []
13. If no, what are the constraints?
.....
.....
.....

14. Is the health sector doing anything possible to address the health problems associated with mining activities within the municipality? Yes [] No []

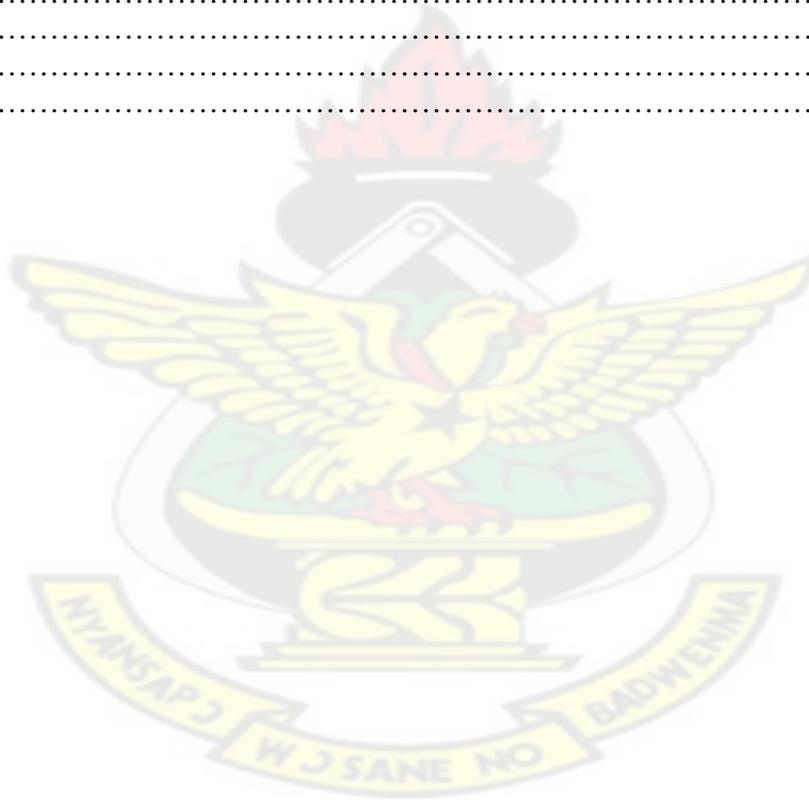
If yes, what are some of the measures?

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15. Is AGA doing anything to address the health needs of the community?
Yes [] No []

16. If yes, what are some of these activities?

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QUESTIONNAIRE SCHEDULE FOR STAFF OF OBUASI MUNICIPAL ASSEMBLY

A. Personal Information

- 1. Residence.....
- 2. Sex.... Male [] Female [] 3. Age.....
- 4. Department/Position.....
- 5. Marital status: a. Married [] b. Unmarried [] c. Divorced []
- 6. Highest level of educational attainment
 - a. Illiterate [] b. Basic [] c. Secondary (S.S.S, Training College, Vocational) []
 - d. Tertiary (Polytechnic, University) [] e. Others, specify

B. MINING ACTIVITIES AND IMPACTS ON THE ENVIRONMENT

- 7. What method(s) of extraction is/are used by the company? Tick all that apply
 - A. Surface Mining B. Underground Mining C. Dredging D. Gallamsey Method
 - E. Other, specify.....
- 8. Do you think the methods of operation by the mining company have some effects on the natural environment? Yes [] No []
- 9. If yes, what are some of the effects? (*Tick all that apply*)
 - A. Degradation of land and vegetation B. Water pollution C. Air pollution
 - D. Noise pollution E. Other, specify
- 10. What actually cause(s) land degradation? (*Tick all that apply*)
 - A. Presence of tailing dams B. Use of toxic materials C. Use of heavy machines
 - D. Clearing of Vegetation E. Long period of extraction
 - Other, Specify.....
- 11. What cause(s) pollution (of any sort as chosen in Q11) on the environment? (*Tick all that apply*)
 - A. Presence of tailing dams B. Use of toxic materials C. Use of heavy machines
 - D. Clearing of Vegetation E. Long period of extraction
 - Other, Specify.....
 -

12. Has AngloGold Ashanti (AGA) made attempts to reduce or curtail the adverse environmental effects of mining activities? Yes [] No []

13. If yes, what are some of the measures being undertaken?

- A. Re-afforestation
- B. Resettlement of affected communities
- C. Providing alternative sources of drinking water
- D. Compensation to affected communities
- E. Reviewing or varying methods of operation
- F. Others, specify

.....

14. Are the efforts at reducing the environmental impacts satisfactory and effective?

Yes [] No []

C. MINING AND HEALTH

15. What are the sources of medicine to address your health needs?

- A. Clinics
- B. Hospitals
- C. Traditional (herbal) medicine
- D. Drug stores
- E. Other, specify

16. Give reasons for your answer in Q20

.....
.....
.....

17. Is AGA doing anything to address the health needs of the community?

Yes [] No []

18. If yes, what are some of these activities?

.....
.....
.....

19. Has AGA built any health facility in this community for the service of both workers and people in the community? Yes [] No []

20. Does AGA carry out any health campaign programme to educate people in the community? Yes [] No []

21. If yes, give any example of such campaigns you know of

.....
.....

D. ROLES OF THE MUNICIPAL ASSEMBLY AND OTHER REGULATING BODIES

22. How is the Municipal Assembly's relationship with AGA-Obuasi?

- A. Very cordial B. Cordial C. Bad D. Very bad

23. Does the Municipal Assembly undertake steps to check and address the adverse environmental and health effects of AGA's activities? Yes [] No []

24. If yes, what are some of the measures?

.....

25. Are the following Agencies/ organisations monitoring and assessing the environmental and health impacts of mining activities in this municipality?

- | | | |
|----------------------------------|---------|--------|
| A. EPA | Yes [] | No [] |
| B. Ghana Chamber of Mines | Yes [] | No [] |
| C. Ghana Minerals Commission | Yes [] | No [] |
| D. Lands and Forestry Commission | Yes [] | No [] |
| E. NGOs | Yes [] | No [] |

26. Which of these agencies/organizations are very active? (*Tick all that apply*)

- A. EPA B. Chamber of Mines? C. Ghana Minerals Commission
 D. Lands and Forestry Commission
 E. NGO's (Name.....)

28. Would you say that these (any of them) agencies and organisations are doing well in monitoring and assessing mining activities the municipality? Yes [] No []

29. Give reasons for your answer

.....

APPENDIX 2

HYPOTHESIS ONE (1)

H₀: Appreciation of mining effects on the environment by residents is not related to their number of years of stay in the communities.

H_A: Appreciation of mining effects on the environment by residents is related to their number of years of stay in the communities.

Count		Does mining affects the environment?			Total
		Yes	No	No Idea	
Years of staying in town	1-4 years	33			33
	5-8 years	18			18
	9-12 years	28	2	2	32
	13-16 years	37	4		41
	17-20 years	54			54
	21-24 years	20	5	3	28
	25-28 years	24			24
	29-32 years	30			30
	33-36 years	14			14
	37-40 years	12			12
	41 years+	14			14
Total		284	11	5	300

Chi-Square (Pearson) SPSS

$$\text{Formula: } X^2 = \frac{(O-E)^2}{E}$$

Where O is the Observed Frequency and E is the Expected Frequency.

$$\text{Procedure: } \frac{(33-31.24)^2}{31.24} + \frac{(18-17.04)^2}{17.04} + \frac{(28-30.29)^2}{30.29} + \dots + \frac{(0-0.233)^2}{0.233}$$

= 51.642, DF 20 Significance 0.000128

$$X^2_{20(\text{Calculated})} = 51.642$$

$$X^2_{20(\text{Tabulated})} = 31.41 \text{ (at 0.05 level of significance)}$$

Decision Rule = Reject H₀ if $X^2_{(\text{Calculated})} > X^2_{(\text{Tabulated})}$

Conclusion: Since the calculated Chi-square value is greater than the tabulated value, the null hypothesis (H₀) is rejected and the alternate hypothesis (H_A) accepted.

APPENDIX 3

HYPOTHESIS TWO (2)

Ho: Knowledge of mining effects on health is not related to years of schooling (education) of respondents.

HA: Knowledge of mining effects on health is positively related to years of schooling (education) of respondents.

Years of schooling (Education)	Are diseases related to mining?			TOTAL
	YES	NO	NO IDEA	
None	28	8	14	40
Less than 4 years	5	0	0	5
4-6 years	18	13	4	35
7-9years	86	22	4	112
10-12years	78	5	1	84
13-15years	20	1	1	22
16-18years	2	0	0	2
Total	237	49	14	300

Chi-Square (Pearson) SPSS

$$\text{Formula: } X^2 = \frac{(O-E)^2}{E}$$

Where O is the Observed Frequency and E is the Expected Frequency

$$\text{Procedure: } \frac{(28-31.6)^2}{31.6} + \frac{(5-3.95)^2}{3.95} + \frac{(18-27.65)^2}{27.65} + \dots + \frac{(0-0.0933)^2}{0.0933}$$

= 34.25, DF 12 Significance 0.001

$$^2 12(\text{Calculated}) = 34.25$$

$$^2 12(\text{Tabulated}) = 21.03 \text{ (at 0.05 level of significance)}$$

Decision Rule = Reject Ho if $^2 (\text{Calculated}) > ^2 (\text{Tabulated})$

Conclusion: Since the calculated Chi-square value is greater than the tabulated value, the null hypothesis (Ho) is rejected and the alternate hypothesis (HA) accepted.

APPENDIX 4

HYPOTHESIS THREE (3)

H₀: Infection of malaria and respiratory infections (cold or cough) among residents is inversely related to distance from the mines.

H_A: Infection of malaria and cold or cough among residents is directly related to distance from the mines.

Community/ from mine site	Distance	Frequency of malaria, cold or cough infection		Total
		Yes	No	
Sanso	(0-1.5km)	50	20	70
Anyinam	(0-1.5km)	54	16	70
Anyimadokrom	(0-1.5km)	40	20	60
Abompe	(1.5-3km)	33	17	50
Tutuka	(1.5-3km)	28	22	50
Total		205	95	300

Chi-Square (Pearson) SPSS

$$\text{Formula: } X^2 = \frac{(O-E)^2}{E}$$

Where O is the Observed Frequency and E is the Expected Frequency.

$$\text{Procedure: } \frac{(50-47.8)^2}{47.8} + \frac{(54-47.8)^2}{47.8} + \frac{(40-41)^2}{41} \dots\dots\dots \frac{(22-15.8)^2}{15.8}$$

$$= 6.538, \text{ DF } 4 \text{ Significance } 0.162$$

$$^2_4(\text{Calculated}) = 6.538$$

$$^2_4(\text{Tabulated}) = 9.49 \text{ (at 0.05 level of significance)}$$

Decision Rule = Reject H₀ if $^2(\text{Calculated}) > ^2(\text{Tabulated})$

Conclusion: Since the calculated Chi-square value is less than the tabulated value, the null hypothesis (H₀) is accepted and the alternate hypothesis (H_A) rejected.