UNIVERSITY OF CAPE COAST

SURFACE MINING REGULATIONS AND ENVIRONMENTAL MANAGEMENT PRACTICES IN GHANA: A CASE STUDY OF IDUAPRIEM GOLD MINE

BY

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DECLARATION

Candidate's declaration

I hereby declare that this dissertation is the result of my own original research and that no part of it has been presented for another degree in this University or elsewhere.

Candidate's signature: ..... Date: 28/05/09

DAVID AKROWAY

Supervisor's declaration

I hereby declare that the preparation and presentation of the dissertation were supervised in accordance with the guidelines on supervision of dissertation laid down by the University of Cape Coast.

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DR. PATRICK K. AGBESINYALE

ABSTRACT

Increasing surface mining activities in Ghana and particularly the advent of large multinational companies into the country in the last few decades has awakened the environmental awareness of the government and the people of Ghana. Consequently, the government of Ghana has put in place regulations by which the negative impacts of mining can be mitigated.

The mineral sector contributes substantially to the economy of Ghana. However, there are serious misgivings about the environmental stewardship of mining companies. In the view of some people, the mining companies are doing more harm than good and the government's quest to attract foreign direct investment to enhance economic growth has made the environment a victim of circumstances.

The negative impacts of surface mining operations include land degradation, air and water pollution, waste generation and ground vibration due to blasting. At Iduapriem Gold Mine, these impacts have led to a number of social upheavals. The company has introduced a proactive environmental programs to ensure that her operations are within safe environmental bounds. Some of these measures include the introduction of agro-forestry trial plots, recycling of used water and the rehabilitation of degraded lands among others. However, the question is "are they doing enough?" to ensure good environmental stewardship, there should be adequate regulatory provisions to provide the framework for environmental regulation and state institution responsible for monitoring the environment should be well resourced.

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I also thank my wife, Araba, for shouldering the copious job of typing this work in addition to managing business and taking care of the kids whilst I was out there schooling. I have not forgotten the numerous well-wishers whose names are not mentioned. Thank you all and may God richly bless you.

DEDICATION

This work is dedicated to my wife Araba, Ankee, and the twins, Naa-na and Nana-Kyi.

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LIST OF ABBREVIATIONS

AQS	Ambient Quality Standard
BOD	Biochemical Oxygen Demand
CFC	Chlorofluorocarbons
CIL	Carbon in Lead
COD	Chemical Oxygen Demand
EAP	Environmental Action Plan
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EPA	Environmental Protection Agency
EPC	Environmental Protection Council
ERP	Economic Recovery Programme
EU	European Union
GAG	Ghanaian Australian Goldfields
GDP	Gross Domestic Product
HP	Heap Leach
IGM	Iduapriem Gold Mine
ISO	International Organization of Standardization
MBH	Monitoring Borehole
NEP	National Environmental Policy
NGO	Non-governmental Organization
NOSA	National Organization of Safety Association
PNDC	Provisional National Defense Council

PVC	Polyvinyl Chloride.
RWD	Raw Water Dam
SHE	Safety, Health and Environment
TDS	Total Dissolved Solids
TGL	Teberebie Goldfields Limited
TSP	Total Suspended Particulate
TSS	Total Suspended Solids
TWA	Time Weighted Average
UNEP	United Nations Environmental Programme
USA	United States of America
USBM	United States Bureau of Mines
WACAM	Wassa Association of Communities Affected by Mining
WCED	World Commission on Environment and Development
WDA	Weak Dissolved Acid
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

Background

Increasing emphasis on environmental protection and ecological preservation makes it important and desirable to analyze the conceptual framework in which environmental polices are based. Also, the legal, political and social concerns on the environment and resource utilization constitute a sufficient justification for studies into policies aimed at environmental protection. Interactions between natural elements and human beings create some problems in the environment. These problems are mainly the result of how human beings use the resources of the environment and what they do with the waste they generate through the use of these resources (Bush, 2000)

Some people believe that as the twenty-first century advances with its associated technological advancement, international law is vital for the continued viability of the planet. Current events are a constant reminder that the protection of the global environment is an international responsibility. International concerns cannot be resolved by states acting individually, because of the nature, scope and the effect of environmental pollution. Environmental problems are increasingly trans-boundary. The chlorofluorocarbons (CFCs) and the methane released into the atmosphere by residents of Europe for example have a global effect. The

common formulation today is that the environment knows no frontiers. Environmental protection efforts thus require cooperation and concerted efforts.

At the international level, there are international agreements, rules of customary international law, general principles of law and non-binding legal agreements that are used as instruments of environmental protection. A number of principles underpin international environmental laws. Two of these principles are paramount: these are the Precautionary Principle and the Principle of Good Neighbourliness (Charis, 1998).

The Precautionary Principle states that whenever enough evidence exist to suggest that the world community needs to take action to protect the environment, then the whole community should act without delay. In other words, the lack of conclusive scientific evidence should not be used as an excuse to postpone action. The principle of Good Neighbourliness, on the other hand, means that a country has a duty not to cause harm beyond its frontiers to the environment of other countries. Whatever a state does within its boundaries to the environment is likely to cause harm elsewhere. Thus, every state has a duty to protect the environment even within its own borders.

The environment

The Environment is the embodiment of the complex inter-relationship between living and non-living entities. It performs three important functions. It serves as an abode for living things; it provides resources to support life, and also serves as a receptacle of waste. These three functions are performed more or less

concurrently, and if any one of them overshadows another or others, environmental imbalance is the result. This imbalance can limit the environment's ability to provide resources and sustain life (Charis, 1988). In the extraction of resources from the environment, other environmental components are damaged. Industrial activities such as surface mining negatively affect land and pollute air and water bodies. The damage done to the land, for instance, results in deforestation. This affects forest cover which in-turn impacts negatively on agriculture, and livelihood. To correct the imbalance, there is the need to strike a balance between environmental protection and resource utilization. Policies are thus formulated and guidelines designed to protect the natural and cultural heritage of man. Requirements such as Environmental Impact Assessment (EIA), Environmental Management Plan (EMP), and Environmental Audit Report (EAR) are required of companies whose activities have serious environmental implications (Ghana Chamber of Mines, 2002). There are also other legislative and non-binding standards such as those of the International Organization of Standardization (ISO) and the National Organization of Safety Association (NOSA) that provide guiding principles aimed at the protecting the natural heritage.

Natural heritage is the element of the environment which mankind plays no part in its creation, but can influence its existence. It includes the hydrosphere, atmosphere, lithosphere and the Biosphere (Pertzel, 1989). Natural heritage is linked to cultural heritage (the intellectual, artistic, social and historical records of a group) and the survival, progress and protection of both is interdependent, with

human beings serving as the bridge between the two. For instance, because of the presence of gold in Ghana (which is a natural heritage) the country, during the colonial era was referred to as the Gold Coast (a cultural heritage). If humans by their activities had depleted the gold, before the arrival of the Europeans, the name Gold Coast might not have been given to Ghana.

The nature and character of environmental issues play a decisive role in determining the scope and content of environmental regulatory policies, their substance and direction. Environmental regulatory policies on salt mining for example may not have the same substance and direction as those affecting gold mining. Even within the gold mining sector, environmental regulatory policies affecting underground mining may not be valid under surface mining operation. Environmental policies may be shaped by the requirements of environmental problems as they operate in the short run to affect the present generation and in its inter-temporal dimension, affect future generation through consequences extending into the future.

Environmental policies determine, among other things, the order of priorities in which environmental issues need to be considered. The order of priorities varies with the perspective applied to them. In a situation where agricultural development is a priority for example, environmental regulatory policies would be tilted towards land and forest protection. Differences in perspective, however, can be expected according to the nature of the interest involved. Emphasis on development has a great impact on the choice of priority. However, the need to pool knowledge and experience, coupled with advancement

in globalization makes it imperative for governments and civil societies to consult international trends when formulating policies that affect the environment.

Efforts towards environmental protection

Problems associated with surface mining include land surface transformation, soil degradation and water and air quality deterioration (Akabzaa, 2000). In order to promote best environmental management practices in the mining industry, a number of environmental regulatory guidelines have been suggested. Until the promulgation of the guidelines on mining, mining laws sought to encourage mineral exploitation rather than ecological rehabilitation (Montgomery, 1995). The 1872 mining laws of the United States of America, for example, were aimed at encouraging mineral exploitation by granting mineral rights and often land title to anyone who located mineral deposit on federal lands. Individuals in this respect did not necessarily have to notify government of the exact location of the land or even pay royalties. The style of mining was not regulated and there were no provisions for reclamation after mining was completed (Montgomery, 1995). Though the Mining Lease Act for Acquired Lands of 1947 in the US introduced the payment of compensation and granting of mining rights for a definite period, there were no conscious attempts at environmental protection. Real efforts to protect the environment in the mining industry is traceable to the United Nations (UN) sponsored first major international conference on environmental issues held in Stockholm, Sweden in 1972 (Montgomery, 1995). This meeting resulted in the creation of the United

Nations Environment Programme (UNEP). The major focus of the UNEP was to study ways of encouraging sustainable development. In 1992, in Rio de Janeiro in Brazil, the UN Conference on Environment and Development was held. Popularly called the Earth Summit, it sought to encourage a reduction in the emission of gases leading to global warming and also an agreement on biodiversity requiring countries to develop plans to protect endangered species and habitats (Montgomery, 1995).

Although the UN, the World Bank and other international bodies are leaving no stone unturned in their effort to protect the environment, politics, capitalism, social and economic pressures are having a great toll on environmental preservation. It is with this background that environmentalists, Non Governmental Organizations (NGOs) and civil society groups as well as well meaning individuals are always on the neck of governments and society to be more pro-active on environmental issues, and to give them the attention they deserve. For example, the Ghanaian Times of Friday, 9th May 2003, carried a story asking for the revoking of mining leases in the closed forest reserve. Public Agenda newspaper of October 30th 2000, also carried a banner "WACAM protest against surface mining", and the Daily Graphic of 30th December 2001, and of 30th may 2004, cried that "pollution is not an academic exercise and that all should help reverse degradation respectively. By 1989, about 60% of land area covered by moist tropical forest worldwide had disappeared. It was estimated that the rate of deforestation was around 1.5% per annum in the tropics (Myers, 1989).

In Ghana, the situation is not different, with 8.2 million hectares of forest cover in the 1900s; Ghana's forest has dwindled drastically and is now estimated to be less than 1.6 million hectares. Even out of the 1.6 million hectares, only 32,000 hectares representing about 2% of the remaining forest reserve is said to be in excellent condition (Ghanaian Times, Friday May 9, 2003). Devastation is estimated to be going on at the rate of 75,000 hectares per annum (Daily Graphic, March 8, 2003). The Ghana Biodiversity Strategy Document suggests that the country loses billions of Cedis annually through bad environmental practices that result in deforestation and land degradation. The amount represents about 4% of the country's Gross Domestic Product (GDP) (Daily Graphic, March 8, 2003).

To save the situation, the nation has developed some environmental regulatory guidelines to promote and facilitate the application of the best environmental management practices (Sackey, 1998). For example, in 1906, a law was passed to control the felling of commercial tree species. In 1948, the Forestry Policy that provided for the creation of a permanent forest estate for the welfare of people, protection of water supplies and the maintenance of favorable condition for agricultural crops was adopted. Ghana has also endorsed a number of international agreements including those contained in the guidelines for tropical forest management.

In 1973, Ghana created the Environmental Protection Council (EPC), which became the first governing body in Africa to focus on issues of environmental management (Anon, 1994). In 1983/84, several plans were drawn up on environmental protection in the country in collaboration with the World

Commission on Environment and Development (WCED) (Montgomery, 1995). The Ministry of Environment was also established to implement policies concerning the environment through the EPC. In 1988, a group of experts were mandated to review the environmental polices and propose strategies to address key issues including deforestation, reduction in soil fertility and in water and air quality, and to suggest better management of natural resources. To address specific environmental problems in the minerals industry, the EPC and the Minerals Commission prepared Ghana's Mining and Environmental Guidelines which covered exploration, exploitation, decommissioning, Environmental Impact Assessment and Environmental Action Plan (Anon, 1994). These guidelines included the rehabilitation of the land to a condition consistent with pre-existing character and utility. Another policy, which represents a corporate commitment to environmental management, is the Ghana Chamber of Mines Environmental Code (Ghana Mining Journal, 2000). It is an embodiment of a set of processes that provide a framework to enhance an industry's environmental stewardship. An important feature of this code is that it is designed not to police, but to encourage self-regulation among all member companies to promote responsible mineral exploitation (Ghana Chamber of Mines, 1996).

The legislative framework for mining in Ghana is laid down in the Minerals and Mining Law 1986, (PNDC Law 153), and the Minerals and Mining Amendment Act of 1993 (Act 475). The Environmental Impact Assessment (EIA) and the Environmental Protection Act of 1994 (Act 490) all contain relevant regulatory and enforcement sections to control mining and mineral exploitation.

All minerals in Ghana are vested in the president on behalf of and in trust for the people of Ghana. Thus, regardless of who owns the land upon or under which minerals are situated, the exercise of any minerals right is granted by the Minister of Mines who acts as an agent of the state for the exercise of powers relating to minerals (Anon, 1994). In surface mining, a large surface area is disturbed. It is therefore imperative that necessary considerations are made during the planning and designing stages so that adequate provisions are made to effectively handle the social and the environmental impacts associated with it.

In Ghana, Environmental Impact Assessment (EIA) and Environmental Management Plan (EMP) are instruments that attempt to address some of the potential dangers of mining on the environment. EIA documents the legacy of past mining and other land uses on the acquired concession prior to commencement of operation. Environmental Action Plan (EAP) also called Environmental Management Plan (EMP), on the other hand, outlines the environmental issues that result on the commencement of mining operations and commits the company to a work plan of environmental monitoring (Anon, 1994).

In recent times, some communities in the Wassa West District of the Western Region of Ghana have been involved in discussions concerning environmental problems primarily due to intensive surface mining activities in the area. Mining in this area can be traced back to the 1400s when traditional method of mining (dig and wash) was practiced (Anon, 1994). Mechanized mining commenced in 1878 by a Frenchman Pierre Bonnart and an Englishman, Horton. It was reported that, by 1894, about 22 Europeans and 2,400 Ghanaians were

employed in the gold mines of Tarkwa and Prestea (Junner, 1973). Mining has continued in this area since.

Gold mining is of immense benefit to Ghana it contributes about 60% of the total annual foreign exchange earnings, and employs about 5% of the country's labour force (Akabzaa, 2000). However, mining, and particularly surface mining, has come under severe criticism in recent times. Surface mining is abhorred by many people on the basis that it is an environmentally unfriendly enterprise. For example, *The Public Agenda* of September 14 -20, 1998, carried the story that "Gold is killing us" and the *Daily Graphic* of November 7, 1996, cried, "Wassa chiefs protest against environmental degradation". Each stage of the mineral production process, from the initial exploration through concentration, smelting, refining and fabrication stages has certain environmental effects. Ghana's Environmental Action Plan (EAP), which spells out the strategies of environmental protection in the country, enumerates some of the major problems associated with mining as:

- Land devastation;
- Solid wastes disposal;
- Soil degradation;
- Air pollution; and
- Water quality deterioration.

The study area

Iduapriem Gold Mine (IGM) is located in the Wassa West District in the Western Region of Ghana. It is about 17km southwest of Tarkwa. Ashanti Goldfields Limited owns about 80% shares while the International Finance Corporation (IFC) owns the remaining 20%. Two concessions make up the Iduapriem Gold Mine. These are the Iduapriem and Teberebie Concessions. It was predominantly a farming area with abandoned farms and secondary forest at various stages of succession. The original forest had been destroyed in most areas leaving less than three percent of the required area as forest reserve in the southwest of the concession. Timber exploitation, farming and other human activities such as charcoal burning; chainsaw operation and illegal mining had had their own negative impact on the environment. There were also numerous small farm holdings of mixed crops including oil palm, coconut, cocoa, citrus, plantain, banana, cassava, maize, pepper and other vegetable crops. The activities of chainsaw operators, galamsey miners and farmers have been the causes of forest degradation in the Iduapriem area before the advent of the mine (Iduapriem Annual Audit Report, 2003). The first mining leases in the project area were granted in the early 1900s. Prior to this, gold was probably won in small amounts from sporadic activities initiated by the local inhabitants soon after their settlement and later influenced by European settlement in the 15^{th} and 18^{th} centuries.

The operations of Iduapriem Gold Mine are based on the conventional open pit mining. Drilling and blasting are undertaken in all the pits. Ammonium

Nitrate and fuel oil are used as blasting agents. There is an average of three blasts every week. The operational area of the mine has been demarcated into smaller units for convenience. These units are called Blocks. There are Blocks 1,2,3,4,5,6,7 and 8. Blocks 7 and 8 are located within the Teberebie concession. Iduapriem Mine acquired a portion of the concession of Teberebie Goldfields Limited when the company folded up. Appendix "A" shows the boundaries of Iduapriem Gold Mine. Mining at the time of this work had ended in blocks 4 and 5, but was continuing in blocks 7 and 8 at the rate of 640,000 BCM (Bank per Cubic Meter) per month. Two ore processing methods are used in the extraction of gold from the ore. These are the Carbon-In-Leach (CIL) and the Heap Leach (HL) methods. The company has built significant infrastructure to support mining operations. These include the construction of roads, power lines, an eleven-kilometer water supply pipeline from river Bonsa to the ore treatment plant and the construction of buildings for use as offices, workshops, magazines and residential units.

Statement of the problem

The Wassa West District has a good number of mining companies actively doing surface mining; this has probably contributed to the pronounced environmental problems in the district. About 35% of the total land area of 2,498 km^2 has been given out as concession to multi-national mining companies (Anon, 1994). Table 1 shows the concession size of large scale mining companies in the Wassa West District and Figure 1 shows the District's land use pattern.

Table 1: Large scale mining companies in the Wassa West District

Name of company	Size of concession	Location
Bogoso Gold Limited	95 km^2	Bogoso
Abosso Goldfields Ltd.*	298.81 km^2	Aboso
Barnex *	129.05 km^2	Prestea
Ghanaian Australian Goldfields (GAG)	31 km^2	Tarkwa
Goldfields Ghana Ltd.	235 km^2	Tarkwa
Teberebie Goldfields *	41.03 km^2	Tarkwa

** Either merged, changed name or taken over by another company*

Source: Minerals Commission, 2000.

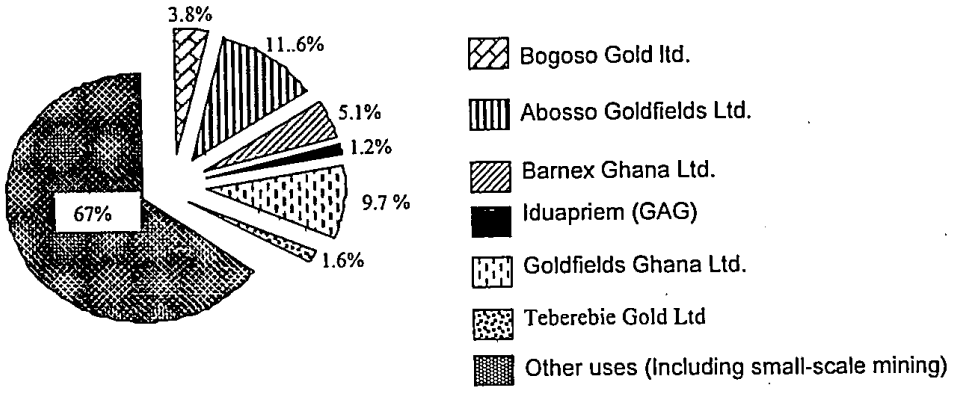


Figure 1: Land use pattern in the Wassa West District

Source: Author's creation from literature review

The scale of land appropriation by surface mining companies in the district has grave implications on livelihood. There are agitations and confrontations over social, cultural and environmental health and safety issues. The African Agenda of 14th November, 1996, reported that the chiefs and people of Wassa Fiase Traditional Area in the Western Region of Ghana went on demonstration through the mining town of Tarkwa to highlight their anger against the conduct of mining in the area. According to the paper, the chiefs protested against environmental degradation, pollution, inadequate compensation, poor social services as well as lack of consultation in the granting of mineral concessions. Akabzaa (2000) has identified four major land-use conflicts in the Wassa West District. These are:

- Mining and local agriculture;
- Mining and forest reserves;
- Mining and maintenance of cultural and natural values; and
- Mining activities and rural settlement.

There have been a number of community-company disputes as a result of some of these land-use conflicts. To appreciate the situation, we may consider the experiences of three mining communities in the Wassa West District namely Koduakrom, Abekoase and Nkwantakrom as contained in a document "Mining and Agriculture - The Wassa West Experience" (Owusu-Koranteng, 2002).

Kuduakrom is to the east of Tarkwa and is affected by the operations of Abosso Goldfields limited an Australian company. The company refused to pay compensation for farms destroyed when the company was constructing a raw

water dam for gold treatment. The farmers demonstrated against the actions of the company on 10th September, 1999. The company's security personnel arrested some of the demonstrators, beat them up and put them in police cells for 6 days. In the Abekoase experience, Goldfields Ghana limited on October 16, 2001 spilled cyanide into river Asuman, which provides the fishing needs of the members of the community. After a series of legal battles, the company requested for an out of court settlement. In May 2003, there was another reported case of cyanide seepage; but while the company claimed the seepage was contained within its operational area, the community alleged that there was an overflow into the nearby environs. In the Nkwantakrom experience, the people claimed that Ghanaian Australian Goldfields (GAG) had directed its sewage into River Angonabeng which serves as their source of drinking water.

People living in mining areas have used various methods to respond to what they consider as environmental and human right abuses by mining companies. These include violence, negotiations, court actions and peaceful demonstrations. For example, on November 7, 1996, some divisional chiefs of the Wassa Fiase Traditional Council staged a demonstration through the principal streets of Tarkwa in protest against the activities of the mining companies in the area. These situations make one to ask how mining companies are managing the environment.

Relevance of the study

The Wassa West District is located in the tropical rainforest that is established to have an estimated disappearance rate of 75,000 hectares per annum. The district has a land area of about 2498 km^2 out of which about 878 km^2 representing some 35% has been given out as mineral concession to gold mining companies (Ghana Mining Journal, 2000).

The choice of Iduapriem Gold Mine for the study is informed by that fact that its concession lies within the Ajopa range and the Nueng forest (Appendix A). The company is also a member of the International Organization of Standardization (ISO) and the National Organization of Safety Association (NOSA). These are international bodies, and give preeminence to corporate environmental health and safety issues. However, members of communities living around the company's concession have raised a number of pollution concerns about the company's operations.

It is for these reasons that I undertake this study to examine how the company is mitigating the negative impacts of her operations on the environment. It is expected that the experiences gathered from Iduapriem Gold Mine will give an insight into some of the environmental management practices of mining companies in Ghana and also engender further studies.

Organization of the study

This Dissertation is organized in five chapters with references and appendices. Chapter One introduces the research topic, gives background

information about the study area, the objectives of the research, the research questions, and the relevance of the study. Chapter Two presents a review of related literature. Chapter Three presents methodology, type of data and how they were collected and analyzed. Chapter Four makes a presentation and a discussion on the data collected from the field. Chapter Five is about the summary, the conclusions and the recommendations.

CHAPTER TWO

LITERATURE REVIEW

Introduction

Minerals play important roles in the economy of many nations. The rise in the world price of gold in the 1980s brought about a dramatic transformation in the gold mining sector worldwide. Old mines were revived and exploration activities were increased in the early and mid 1980s. Gold production from within the western countries notably the United States of America (USA), Canada and Australia almost doubled from 962 tons in 1980 to 1,744 tons in 1990. From 1981 to 1987, world gold production increased by 90 percent (Agbesinyale, 2003). Today, gold is mined in about sixty countries worldwide, but the world's largest producers include South Africa, USA, Australia, Canada, China and Russia.

Worldwide gold production currently amounts to over 2,300 tons annually (Aryee, 2001). World gold reserve, as estimated by the US Geological Survey stands at 100,000 tons of which 15% to 20% is by-product resource. South Africa alone accounts for more than half of these reserves while Brazil and the USA have about 9% each (Aryee, 2001). Table 2 presents world gold productions in metric tons from 1994 to 2000.

Table 2: World gold productions in metric tons (1994 -2000)

Country	1994	1995	1996	1997	1998	1999	2000
South Africa	580	524	498	462	464	449	440
United States	326	320	318	360	366	341	330
Australia	256	254	289	311	312	303	300
China	160	140	145	175	178	170	170
Russia	147	150	120	115	104	104	105
Canada	146	132	164	169	166	158	150
Brazil	76	72	63	59	55	NA	NA
Other countries	500	583	580	660	732	735	665
World Total	2300	2200	2250	2410	2460	2540	2445

Source: Agbesinyale, 2003.

The bulk of the world's gold production comes from Africa with South Africa leading in the production capacity. The rest of Africa's contribution to the world gold production has been increasing from 45 tons in 1982 to an estimated 84 tons in 1992 (Keatley, 1992). By the close of the millennium, the rest of Africa's total production stood at 120 tones; this accounted for about 5% of the share of total world production. At least twelve countries within the rest of Africa are currently known to be industrial producers of gold. They are Ghana, Zimbabwe, Democratic Republic of Congo, Mali, Guinea, Burkina Faso, Niger, Ethiopia, Tanzania, Madagascar, Namibia and Cote D'Ivoire. In other African Countries, artisanal or small-scale informal gold mining dominates the gold sub

sector. It is estimated that artisanal mining contributes between 20 and 30% of Africa's gold outpour (Keatley, 1992).

The role of the mineral industry in Ghana

Mining is an important sector in the economy of Ghana; it accounted for more than 40% of the country's export earnings as at the end of the 1990s, and for about 5% of the Gross Domestic Product (GDP) during the period. Today, the mineral sub sector contributes about a third of Ghana's export earnings and it is a major source of direct and indirect employment. Gold alone is responsible for about 95% of the country's total mineral exports earnings (Agbesinyale, 2003). The Daily Graphic of Monday, 6th October, 2004, reported that Ashanti Goldfields alone paid seven million US dollars ($ 7,000,000) in royalties to the government of Ghana for the year 2003.

Ghana was at one time the world's leading producer of gold. According to Keately, (1992), Ghana produced about 35% of the entire global output during the period 1493-1600. However, this dropped to 22.8% between 1601 and 1700; it fell steeply to 8.9% during 1701 to 1800. By 1900, Ghana had lost its position as a major producer of gold to South Africa that had emerged as the world's largest producer of gold. The introduction of the Economic Recovery Programme (ERP) in Ghana in 1983 brought about significant improvements in the mineral sub sector. By the 1990s, investment in gold had attained a dramatic height. The introduction of cheaper and state-of-the-art technology in mining (with a shift from the traditional underground deep mining system operated by most of the

large companies) contributed to the increase in gold production during the period as shown in Table 2.

Table 3: Ghana mining production 1989 – 2001

Year	Gold (Ounces)	Diamond (Carats)	Bauxite Metric tons	Manganese Metric tons
1989	429,476	285,636	374,646	273,993
1990	541,408	636,503	368,659	246,869
1991	845,908	687,736	324,313	311,824
1992	998,195	656,421	399,155	276,019
1993	1,261,424	590,845	364,641	295,296
1994	1,430,845	757,991	451,802	238,429
1995	1,708,531	631,707	530,389	186,901
1996	1,606,880	614,737	383,370	267,000
1997	1,758,005	829,524	536,728	332,443
1998	2,382,339	822,619	341,118	384,400
1999	2,620,089	648,033	355,263	611,500
2000	2,447,591	989,851	503,825	895,339
2001	2,117,273	1,169,633	678,449	763,311

Source: Minerals Commission, 2000

Notwithstanding the significant contribution of the mining sector to the economy of the nation, surface mining has brought in its trail grave social and environmental conflicts between mining companies and local communities on the one hand, and the government and civil society groups on the other. On one

extreme, many environmentalists argue for an outright ban of surface mining on the fact that the net benefit of mining to local communities is negative when the long-term implications are brought into focus. To the other extreme, some investors and beneficiaries of surface mining argue that environmental issues on mining are used by developed countries and some Non Governmental Organizations, to stifling the development of mineral rich developing countries. In Ghana, the mining boom which was brought about as a result of the government's adoption of the Economic Recovery Programme (ERP), led to the establishment of institutions such as the Minerals Commission, Mines Department, Chamber of Mines and the Environmental Protection Agency (EPA) to regulate the activities of industries including mining companies in order to strike a balance between mineral exploitation and environmental protection (Agbesinyale, 2003).

Conceptual framework

The ultimate goal of a firm is to maximize profit. Managers of firms consider low cost of production as an important component in the realization of their objective. The maintenance of a sound environmental health is achieved at a great cost to industries. A number of factors influence a firm's response to environmental quality regulations. These include the non-availability of regulatory bodies and/or monitoring instruments, the non-punitive nature of available laws and ignorance on the part of the public and social institutions. To appreciate why firms may want to comply with or evade environmental regulatory requirements, a closer look is made of the theory of Firms' Behaviour. This

theory suggests that firms in general can be categorized into two basic groups. The first group would be firms that would comply with environmental regulations as a means of gaining competitive advantage and hence prevent new entrants into that sector, and those that would evade environmental regulations to maximize profit.

Theory of firms' behaviour

Explaining why firms do not comply with the regulations, Russell, Harrington and Vaughn (1986), noted that government-monitoring activities are often quite limited and in most cases, financial constraints prevent governments from undertaking any effective monitoring activity. Moreover, even if firms are found to be non-compliant, fines are low and as such not deterrent enough.

Downing and Kimball (1982), commenting on the Theory of Firms' Behaviour said although it is possible that firms comply with environmental laws because of the threat of being placed on the enforcement agency's target list, that is not the only reason why many do not comply. The absence of documented laws, penalties for non-compliance and the unavailability of subsidies and tax incentives are some of the causes of non-compliance. They stated further, that some firms on the other hand adhere to stringent regulations that serve as entry barriers to new firms.

Downing and Kimball (1982) further noted that the fact that repeated violations are dealt with more harshly provides impetus for a risk aversion decision-maker to comply instead of risking future monitoring. Finally, investors

care about profit and their corporate image and would not want to be involved in any act that would taint their image and goodwill. Cahill (1994), and Doonan (1998), posit that firms may not comply with environmental standards if they realize that expected penalty for violating the law is after all light. On the other hand, if they realize that penalty for non-compliance is heavy, environmental laws and regulations are obeyed.

Arora and Gangopaday (1995), explain why firms comply with environmental laws as they do with existing social norms. They argue that social norms can operate to yield significant compliance rates even in the absence of penalties. In their view, a firm, as a member of the society will comply with social norms including statutory laws because it does not want to be considered to be abnormal to the society or branded a social deviant.

Hayford (1997) offers a new dimension to the theory suggesting that large public trading firms might be more inclined to comply with environmental standards than small firms. He contends that public trading firms, apart from being responsible to shareholders, board of directors, and external donors, have an image to protect. Cohen and Alexander (1998) add to this by saying that public trading firms whose top management incentives are closely aligned with shareholders are less likely to commit corporate crimes. According to them, environmental violations that occur in large public trading firms are caused by negligence, or employees shirking responsibility, and not as a deliberate corporate policy. Pagal and Wheeler (1996), and Konar and Cohen (1998), also mention the role of formal and informal pressure groups in attaining compliance with

environmental policies. They contend that pressure from civil societies, NGOs, individuals, and other pressure groups is rife on public trading firms.

Mining companies in the Wassa West District in recent times have come under great pressure from communities and civil societies in relation to their environmental stewardship. Some people have expressed a number of views on the perceived poor environmental performance by the mining companies. To some, there are not any better environmental regulatory policies governing mining in the country. To others, the laws are available, but the government lacks the enforcement machinery to ensure compliance. There are, yet, others, who posit that penalties for non-compliance to mining environmental regulations are not punitive enough and hence the poor environmental performance by mining companies in Ghana. It is against this background that the theory of Firms' Behaviour has been adopted as the conceptual framework for this project work to enable an assessment of the country's mining environmental regulations and the mining companies' response.

Approaches to pollution control

Early environmental policies and regulations in the world and especially in Europe were geared towards stimulating economic growth (Montgomery 1995). Later, the European Union Environmental Policy was developed in line with general concerns in Europe and the deteriorating environmental position in which Europe found itself. By 1990, about 160 legislations had been passed covering air, water, noise, chemical waste, wildlife and the prevention of industrial

accidents in Europe (Akuffo, 1998). These laws were aimed at the protection of human health and improvement in the quality of the environment (Montgomery 1995).

In 1992, the European Community's fifth Environmental Action Programme was introduced. The first Environmental Action Programme, which was introduced in 1973 (Montgomery 1995), set out a number of principles that have formed the basis of environmental action plans in the European Union (EU). Until 1987, EU environmental policies were centered on the application of Command and Control directives. More recently, on realizing that environmental policies are of little use unless enforced, EU environmental policy has given increased emphasis to improved enforcement of existing legislations. Emphasis have also shifted from the use of traditional command and control instruments in environmental policy, to the application of economic market based instruments such as the proposed Carbon Tax and voluntary agreements such as Eco-Labeling and Eco-Management audit schemes. The aim of all these legislative incentives and agreements was to encourage a change in all sectors of the industry and society in a more general way than could be achieved through the use of tightly defined legislative instruments (Akuffo, 1998).

In Ghana, until recently, environmental issues were not a priority and this was expressed in the Mining Laws of the country Akabzaa (2000). According to Akabzaa (2000), environmental issues as reflected in the Mining and Minerals regulations, were vaguely mentioned. He pointed out that the entire 36 pages of the Mining and Minerals Laws contain just one sentence on the environment.

This states that "The holder of a mineral right shall in the exercise of his right under the license or lease, have due regard to the effect of the mineral operation on the environment and shall take such steps as may be necessary to prevent pollution on the environment" (Akabzaa, 2000). Until recently, it was the Monitoring and Evaluation Department of the Minerals Commission that handled environmental matters. This role was largely seen, as contradictory since the main function of the Commission is to promote mining investment. There were public concerns that the Commission could not effectively play a promotion and policing roles at the same time (Akabzaa, 2000).

The first attempt to address the problem of industrial pollution in Ghana started in 1992 with the adoption of the National Environmental Policy (NEP) Akabzaa (2000). The NEP sought to assess the potential impact of all major projects and to establish and implement appropriate standards and guidelines for acceptance level of environmental quality standards.

Environmental regulatory framework in Ghana

Environmental issues and considerations took a long time to find a place on the development agenda and development policy priorities of the government of Ghana. For a long time, environmental goals were only marginal to the overall development goals and aspirations of the country. However, following the nation's participation in the 1972 United Nations sponsored conference on the Human Environment in Stockholm, which agreed on the need to give a human face to all forms of developments, Ghana became committed to the global efforts

aimed at ensuring an acceptable balance between development and environment management. As a practical manifestation of this commitment, the Government created the Environmental Protection Council (EPC) in 1974.

The establishment of the EPC symbolically marked the beginning of the need to mainstream environmental issues into the national development agenda. However, the Council remained a mere advisory body without any regulatory authority until 1994, when its status was changed into an agency with regulatory powers. Akabzaa and Diramani (2001), argue that the EPC was born out of reasons external rather than by a decisive action on the part of government to regulate the country's environmental resources. Reinforcing this assertion of the government's 'window dressing' attitude to environmental issues was the fact that it took several years to get the EPC placed under a permanent sector ministry. In fact, since its inception, it moved from one ministry to another until the Ministry of Environment was created for the first time in 1992 (now Ministry of Environment and Science)

In Ghana, environmental protection is guided by preventive approach (Mensah, 1997), and there is recognition that development should be undertaken in such a way to avoid environmental problems. The general philosophy of environmental management in the mining industry is to encourage companies to adopt pro-active environmental management practices and to integrate these practices in their operations. The government on its part sets minimum standards for environmental management. Mensah (1997) recognized that a mix policy instrument is required to ensure sound environmental stewardship. Experience

elsewhere has shown that a combination of laws, regulations, enforcement mechanisms and incentives are necessary to address the problems of environmental degradation. Efforts are being made to use a mix of "polluter pays principle", "pollution prevention principles" and economic incentives to ensure that companies adopt good environmental management practices. Voluntary compliance and integrated management systems are also being encouraged (Ghana Chamber of Mines, 2002).

Prior to the onset of the current gold boom, there was hardly any national environmental regulatory framework for controlling mining operations to ensure that they conform to acceptable environmental standards. The 1986 Minerals and Mining Laws were largely ambiguous with respect to the protection of the environment against mining operations (Akabzaa, 2000). These of course demonstrate the priorities of the state, which was aimed at attracting and protecting foreign investment inflows into the mining sector as against priorities related to environmental quality. This means that the institutional regulatory framework for safeguarding environmental integrity in the face of aggressive mining as part of the gold boom had been either non-existent or very weak from the onset (Akabzaa, 2000). The priority had been to obtain as much gold as possible, which would rake in the needed foreign exchange revenue.

During the preparation of the National Environmental Action Plan, a review of the existing mining legislations showed that Ghanaian mining laws were made up of a framework whose specifics have been left to the discretion of the Minister of Mines to address through a legislative instrument (Akabzaa,

2000). It is noted that omnibus provision for the environment was specified in the Mineral and Mining Law (PNDCL 153, section 83). This section empowers the Minister of Mines to make regulations for the conservation and development of mines and minerals. In accordance with this provision in the law, the minister requested the Minerals Commission to coordinate a study funded by the World Bank to formulate environmental guidelines to be used in drafting regulations for controlling the activities of mining companies (Anon, 1994).

The study resulted in the provision of baseline information on all large-scale mines operating in the country and the formulation of draft guidelines in 1991. A national seminar was held in June 1992, to discuss the guidelines. Participants included representatives from mining companies, NGOs, government agencies, research institutions, and the general public. Based on the interventions, contributions and subsequent written comments, the draft guidelines were reviewed and finalized in 1992. The guidelines were published in 1994, and were in three parts, namely:

- General guidelines for exploration, mining, mineral processing and decommissioning;
- Detailed Guidelines for the preparation of Environmental Impact Assessment; and
- Guidelines for the preparation of Environmental Action Plan (EAP).

The guiding principles used in the preparation of the guidelines were that:

- All mining activities have environmental impact;
- Environmental impact can be minimized through proper planning;

- Ensure sound management of natural resources and the environment,
- Guide developments in accordance with quality requirements to prevent, reduce and as far as possible eliminate pollution and nuisance,
- Integrate environmental considerations in structural and socio-economic planning at the national, regional, district and grassroots levels, and
- Adequately protect humans, animals and plants, their biological communities and habitats against harmful impacts and destructive practices.

These policy objectives enjoined the government of Ghana to:

- Commit herself to environmentally sound use of renewable and non-renewable resources of the environment in the process of national development,
- Institute and implement environmental quality control programmes,
- Oblige all concerned to provide the appropriate agencies with the relevant information needed for the enforcement of environmental regulations, and
- Establish adequate legislative and institutional framework for monitoring, coordinating and enforcing environmental matters.

The requirements of EIA and EAP discussed below:

Requirements for environmental impact assessment (EIA)

- Any company prospecting to develop a mining project that will affect an area of land surface greater then 25 acres (10 hectares) shall submit an EIA to the EPA.

- The Company shall honour all commitments made in the EIA except where written permission is given by the EPA.

Guidelines on environmental action plan (EAP)

- All existing mining operations shall submit an EAP every two years. The plan shall cover five years and shall comprise a 2-year EAP and a 3-year rolling plan for the subsequent years.
- The company shall honour all commitments made in the EAP except where written permission has been given for modification by the EPA in the light of new field evidence.
- New mining companies shall submit EAP as part of EIA.
- A copy each of the EAP submitted to EPA for approval shall be sent to the Minerals Commission and the Mines Department.

Between 1989 and 1994, the requirement that environmental impact must be assessed, prior to the commencement of mining was carried out through an administrative directive. Following the enactment of the Environmental Protection Act in 1994 (Act 490), the EIA requirement received legislative backing, and the EPA obtained the powers to request for EIAs and Environmental Management Plan (EMP). The relevant section of Act 490 states that "The EPA shall ensure compliance with any laid down environmental impact assessment procedure in the planning and execution of development project including compliance in respect of existing ones."

Mining companies are required to cooperate with the EPA to ensure that they operate in accordance with the above guidelines. The liberalization of the mining sector within the framework of the Economic Recovery Programme (Structural Adjustment Programme) and the new Minerals and Mining Law promulgated in 1986 gave a considerable boost to the mining sector in Ghana. However, these reforms were not accompanied by an equal measure of reforms in the existing environmental laws and regulations of the country to cater for the consequences of increased mining activity. The preparation and adoption of the National Environmental Policy (NEP) and the National Environmental Action Plan (NEAP) in 1991, was in broad terms to ensure sound management of resources of the environment. The fundamental aims of the NEP and the NEAP were to be pursued and achieved through the harmonization of relevant laws and agreements on the environment. Firms were also requires to prepare annual reports, copies of which were to be sent to the regulatory bodies.

Guidelines on annual reporting

The requirements for annual reporting according to Anon (1994) are as follows:

- That, companies shall submit annual reports at the end of each calendar year to the EPA, Minerals Commission and the Mines Department.
- Companies shall submit Environmental Audit Report to the EPA, Mines Department and the Minerals Commission. Such reports will be kept confidential and shall not be in the public domain.

Guidelines on exploration

- Exploration shall be carried out by a company with a valid prospecting license.
- Where exploration would be carried out in a forest reserve, the company shall prior to the start of fieldwork contact the Forestry Department to determine the department's requirement. Where it will affect wildlife, the requirements of the Game and Wildlife department must be met.
- At least seven (7) days prior to the commencement of each phase of work, the company, or its representatives shall visit the land owners or users or their representatives and determine or describe the following:
  - The area of land to be explored.
  - The expected effects of land, air and water quality and noise levels.
  - The location of any secret grooves, burial grounds and other fetish lands.
  - The location of any environmentally sensitive sites to the local people.

Guidelines on drilling and excavation

- The company shall position drill holes and excavations in appropriate areas in order to avoid areas of environmental and local sensitivity.
- The company shall minimize the size of any excavation by using appropriate equipment and technology.
- The company shall construct drill ponds so that the drilling rigs and storage area for fuel, haulage oil, drilling fluid etc will drain into a sump.

- The company shall recycle drilling fluid as much as possible and/or use biodegradable fluids.
- The company shall allow uncontaminated water based drilling fluid to settle before discharging to the natural drainage.
- The company shall at all times store oil based drilling fluid in steel or appropriate plastic tanks. Disposal of oil based drilling fluid would be by incineration or other environmentally acceptable means.

Guidelines on waste rock disposal

The requirements for waste rock disposal according to Anon (1994) are that:

- The company shall, where practicable, dispose of waste rock by backfilling existing excavations.
- For waste rock disposal on the surface, the company shall dispose of any chemically reactive waste rock so that the potential for acid generation and contaminant leaching is minimized.
- All waste dumps shall be progressively reclaimed where practicable.

Guidelines on heap leach operations

The company shall design and operate the heap leach to achieve the following minimum requirements (Anon, 1994):

- Containment of contaminated process liquors during extreme rainfall events. The EIA and or EAP will specify the return period of the extreme rainfall events used in the design.
- All ponds containing contaminated process liquors will be equipped with an under pond drainage and monitoring system. If leakage is detected in the under drainage waters, then those waters will be collected and used as process water.
- All heap leach pads will be equipped with an under–pad leak detection system.
- Neither surplus processing circuit water nor water drained from spent heaps shall be discharged into the natural drainage until the requirements for 'Discharges to Water' are met.

Guidelines on tailings disposal

The design and operation of tailing disposal system is to achieve the following minimum requirements (Anon, 1994):

- Tailing impoundment structures shall be constructed of chemically suitable materials in accordance with sound geo-technical, structural and hydraulic engineering design and construction practices to withstand the expected seismic activity in the area.
- The capacity of the impoundment will be sufficient to contain the volume of tailing anticipated over the life of the mine, or alternatively, the impoundment will be designed and operated to provide staged increases in capacity.

- An emergency (alternative) spillway/passageway or arrangement will be provided to pass the runoff from an extreme rainfall event and prevent overtopping of the embankment. The EIA or EAP will specify the return period of the extreme rainfall event and design criteria for the emergency spillway. In staged construction, the EIA or EAP will specify the spillway configuration for each stage.
- Where applicable, the tailing impoundment will be located downstream of the processing plant so that runoff and any spillages will drain into the impoundment.
- Tailing water will be recycled as much as possible and used as process water.
- In the rare event of a discharge to the natural drainage via the emergency spillway, the company shall immediately notify the EPA, the Mines Department and the Minerals Commission and explain the circumstances necessitating the discharge.
- Any discharge to the natural drainage, other than via the emergency spillway, will not be permitted until the requirements of Discharges to Water are met.
- Seepage from the impoundment will be monitored as specified in the EIA.
- Where significant seepage of contaminated water is predicted or observed, a seepage collection system will be constructed downgrading of the main embankment(s) and any seepage water will be pumped back to the impoundment.

- Phreatic water levels will be routinely monitored as specified in the EIA or EAP. Stabilization by revegetation of the main embankment(s) will commence within 12 months of the completion of construction.

Requirements for reclamation

In the area of reclamation, Anon (1994) notes that:

- The companies are required to prepare initial Reclamation Plan as part of the EIA and EAP and execute the plan to achieve the following minimum standards:
- The reclamation objective for restorable land will chemically and physically stabilize the land into a safe condition and return it to similar land capability as prior to mining.
- The reclamation objective for non-restorable land will be to chemically and physically stabilize the land and leave it in a safe condition to encourage revegetation.

The Reclamation Plan shall encompass all lands on the concession disturbed by the company and any of its distributors.

Guidelines on decommissioning

Companies are required to prepare a de-commissioning plan as part of the EAP. The de-commissioning plan must:

- Nominate the end use(s) of all lands affected by the mining project.

- Nominate the end use(s) of all buildings, housing and other mine infrastructure.
- Describe the state of all fixed equipment.
- Describe the steps required to make the area safe.
- Describe how public access will be managed after mine closure.
- Describe the type and duration of post de – commissioning monitoring.

The Company is also required to submit to the EPA and the Mines Department, through the Minerals Commission, a detailed de-commissioning plan. In the case of a mine located in a forest/wildlife reserve(s) a copy of the plan should be submitted to the Forestry Commission.

The company is required to honour all commitments made in the detailed de-commissioning Plan except where written permission is given by EPA in the light of new field evidence. Mining companies are required to cooperate with the EPA and ensure that they operate in accordance with the above guidelines. A closer working relationship between governmental agencies with responsibilities for environmental management in the mining industry will result in a well-integrated governmental approval process and this is being progressively developed.

Environmental policy of Ghana chamber of mines

The Ghana Chamber of Mines promotes the responsible exploration, extraction and use of minerals. The Ghana Chamber of Mines therefore endorses:

- The concept of sustainable development and the objectives of the conservation strategies of the Government to maintain essential ecological balance.
- Development of an environmentally responsible culture by demonstrating management commitment, implementing management system, and providing resources to train employees on environmental safety.
- Recognition of environmental management as a priority and integrating environmental management systems into all mining activities.
- Adherence to the legal and regulatory requirements of Ghana, and to any guidelines, which may be adopted by the Ghana Chamber of Mines.
- Establishment of environmental performance targets not necessarily limited to legislations, licenses and permit requirements.
- Ensuring that decommissioned sites are rehabilitated and left in a safe and suitable form capable of sustaining life.

It is important to mention that the aim of the Ghana Chamber of Mines Environmental Code is not to police but to encourage self-regulation among all member companies.

CHAPTER THREE

METHODOLOGY

Introduction

This chapter describes the research method employed in the study. It also deals with the types and sources of the data.

Types and sources of data

The research is composed of both primary and secondary data. The bulk of the data however is from secondary sources. This involved data gathered from the Wassa West District Assembly, the EPA and particularly from the environmental department of Iduapriem Gold Mine. Measured values of particulate matter, water quality and noise level from the company were corroborated with those from the EPA monitoring stations.

Primary data was collected from direct observation of IGM's environmental management practices. The researcher visited about six water monitoring and four noise monitoring stations of the company to observe the sampling procedure employed in taking samples for analysis. Method of selecting monitoring stations for visit was random and it was based on the availability of vehicle and a company official to escort the researcher. Field trips were also made

to revegetated and waste dump sites to observe the company's practices on reclamation and waste management.

To ascertain from community members their opinion on the environmental stewardship of Iduapriem Gold Mine, a set of questionnaire were administered to one hundred (100) respondents from three communities within the concession of IGM. The communities are Teberebie, Adieyie and Adisakrom. The content of the instrument was to find out the views of the local people about the Environmental performance of the company. Appendix D is a sample of the questionnaire administered. A period of one month was used to collect the questionnaire and a total of eighty two (82) were gathered from the respondents.

Sampling procedure

The respondents were chosen from the communities of Teberebie, Adieyie and Adisakrom by means of proportionate sampling based on the size of the voter population (Information to this effect was available at the Wassa West District office of the Electoral Commission). The respondents as well as the communities were selected at random. Out of the 82 questionnaires collected, 34 were from Teberebie, 28 from Adieyie and 20 from Adisakrom.

Data analysis

Secondary data were analyzed by comparing values with EPA ambient Quality Standards as well as with EU, WHO, and USA permissible levels of pollution and were subjected to descriptive analysis to make inferences. With

regards to the primary data, the questionnaire received were edited and coded for analysis. The Statistical Package for Social Scientists was used to analyze the data.

Scope of work

Environmental issues of concern studied in this work were Iduapriem Gold Mine's environmental management practices on Air quality monitoring, Water monitoring, Waste management Practices, Noise Pollution, and Reclamation and Revegetation Programmes. The work also covered some of the regulations and guidelines governing the environmental management concerns of surface mining operation in Ghana.

Limitations of the study

The following may be some of the limitations of the study:

- This research work is limited to a particular method of mining, which is surface mining in Ghana and does not consider other methods of mining.
- The research is also limited to the environmental management practice of Iduapriem Gold Mine and the difficulty in getting data from, and access to all of the company's operational sites hindered the researcher from making a detailed study of all of the environmental management practices of the company.
- Another limiting factor was finance and time constraint that made it impossible for the researcher to tour the whole of the company's concession

and also visit all monitoring stations and revegeted sites and also observe the company's environmental management practices over a considerable period of time.

However, these limitations notwithstanding, the importance of the study cannot be understated because it will help to address a particular problem in the country.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

Introduction

This part deals with the presentation and analysis of data collected. The data collected involves data on atmospheric environment, noise generation, water environment and waste management practices to analyze the environmental stewardship of Iduapriem Gold Mine. The company's environmental monitoring plan involved two approaches. The first was a multimedia sampling method, which was used to detect the potential environmental impacts of the mine's operation. The other was a monitoring plan involving the evaluation of the environmental management programmes within the concession. This was done through:

- A routine inspection of containment systems (raw water dam, tailings dam, heap leach pads, and pond systems), and
- A review of reclamation success (plant growth and survival rate)

The ultimate objective of Iduapriem's environmental monitoring plan is to ensure effective intervention measures to encourage sustainable development. To achieve this objective, the company employed an environmental management strategy with the overall goal of ensuring greater comparability in monitoring parameters and methodology. The strategies included:

- Determining the status and trend at the impact areas necessary for early recognition of environmental pollution problems,
- Identifying types, sources and path of contamination and their effects on the environment,
- Determining compliance with regulatory requirements and the effectiveness of the monitoring plan, and
- Integrating all departments into the company's environmental management plan and responding to emergencies.

The specific environmental management practices of IGM are presented below:

Particulate matter (dust) monitoring

Air pollution is the presence of one or more air contaminants (dust, fumes, gas, mist, smoke odour and vapour) in sufficient quantities in the air and of duration long enough to be or threaten to interfere with the comfortable enjoyment of life (Bush, 2000). Reduction in air quality caused by the operations of Iduapriem Gold Mine includes noise generation, particulate matter emission, and vibration due to blasting. Air emission from mining activities can be difficult to control since they often cover a large surface area, and involves materials capable of producing fugitive dust. Control of air pollutants at IGM can be categorized into two. They are:

- Control of point and area emission with control equipment and process technologies, and

- Implementation of practices to minimize emissions.

Particulate matter is emitted in relatively large amounts in all aspects of the mine's operations. In addition to mining, major sources of emission include stationary fuel combustion, various industrial processes, road construction and use, and other construction projects. To be able to measure the impact of their operations, IGM has established two types of dust monitoring stations. These are:

- Impact Stations, and
- Trend Stations.

Impact stations are established mainly at residential areas outside the company's operational areas (communities located in and around the concession of the mine) to measure the impact of mining activities on them. There were impact stations in the following communities:

- Mile six;
- Teberebie village;
- Adieyie village;
- Bankyim;
- Akympim;
- Adisakrom;
- Teberebie Lower Housing area; and
- Access security gate to plant site.

Trend stations on the other hand are established to monitor the trend or the level of pollutants at specific areas to compare with compliance limits and to verify the effectiveness of control strategies. This was applied to only

exceptionally dusty work areas such as the crusher, drilling rig, open pits and haul road areas. Measurement at the sampling points at the various work areas was done quarterly. Table 4 presents the averages of particulate matter measurements from eight monitoring stations for the year 2003.

Table 4: Total suspended particulate (TSP) matter measurement from various sampling stations, 2003 (Averages)

Location	TSP ($\mu g/m^3$) TWA for 24 hr period	Recommended TWA for 24 hr period ($\mu g/m^3$)
Main gate to plant area	10.97	230
Administration block area	10.97	230
CIL crusher area	197.4	230
Heap leach crusher area	186.4	230
Access gate	216.3	230
Mile six (canteen)	53.6	150
Mile one (GAG junction)	128.5	150
Mile seven	112.8	150

Source: IGM Annual Report, 2003.

From Table 4, the Total Suspended Particulate (TSP) and the Time Weighted Average (TWA) for a twenty-four (24) hour period from all the eight monitoring stations are within the recommended TWA threshold. It is important to mention that TSP levels at the CIL crusher and the Heap leach crusher areas

both of which are mine operational areas are even less than the TSP recorded at the Access gate. This perhaps is due to the activities of commercial vehicles since the Access Gate is located on the feeder road leading to some of the communities within the Iduapriem concession.

There is a threshold signal that serves as an indicator for corrective action. The EPA has a proposed Ambient Quality Standards (AQS) that differentiates between residential and industrial TSP and states that a 30% increase in measurement over proposed limits recorded for two consecutive readings is a sufficient condition for investigation (Environmental Protection Agency, 1994). Using Table 4 as a reference point, it can be said that IGM is not doing badly in its strategy of controlling point and area emissions as well as in the implementation of practices that minimize emissions. However, the European Union (EU), the World Health Organization (WHO) and the EPA have recommended threshold values for health and safety with regards to air quality monitoring (Akabzaa, 2000). Level of pollutants as recommended by the EU, WHO and EPA are 50 gm-3, 70 gm-3 and 70 gm-3 respectively. Since some monitoring stations such as those at GAG junction, Mile 6, Mile 7 and Access Gate are closer to areas of residential activities, the high-recorded values of particulate mater in the atmosphere should be a matter of public health concern.

Noise monitoring

Noise can be defined as undesirable or psychologically impairing sound (Bush, 2000). Sound is a variation in pressure occurring in the air, detected by the ear and interpreted by the brain (Langley et al, 2001). Noise depends on amplitude and frequency. Amplitude is the loudness measured in decibels $dB_{(A)}$. Low decibel sound is perceived as soft and high decibel sound as loud. Frequency on the other hand is the pitch and is measured in hertz (Hz). Low frequency sound is perceived as bass and high frequency as high notes. The proposed EPA Ambient Noise Quality Standards categorizes noise reception areas into residential, commercial, industrial and mixed zones with the permissible levels of noise in respect to the time of the day. At Iduapriem Gold Mine, noise levels measured within the operational area are compared with permissible levels of industrial zones. Noise pollution at Iduapriem Mine is due mainly to friction between moving parts of all types of equipments and motors. Notable areas with considerable amount of noise include:

- Drill rigs in mining pit areas,
- Crusher areas , Ball mill area,
- Carbon in leach plant area (control room, above tank and cyclone),
- Excavators, dozers and loaders, and
- Maintenance workshop and Store yard

Noise due to mining activities excluding that due to air blast is monitored on regular basis. Measurements are concentrated on exceptionally noisy operations or equipment. Noise due to detonation of blasting agents is

instantaneous and normally of a higher peak than other noise sources. There are no specific days or times for measuring noise due to blasting. They are measured as and when blasting is done. The frequency of measurement is quarterly for all sources known to have higher than permissible noise levels. Table 5, presents noise level recorded at various monitoring station for the month of July, 2003.

Table 5: Noise level measurements for July 2003

Location	Noise level (dB_A)	Recommended level (dB_A)
Crusher base	88.8	80/70
Crusher floor	86.8	80/70
CIL (cyclone)	87.9	80/70
JSO 1 Crusher	88.9	80/70
JSO 2 (inside operator's cabin)	102.3	80/70
Ball mill	88.3	80/70
SAG mill	88.8	80/70
Drill Rig 2 (Pit area)	101.8	80/70
Heavy Duty Workshop (Taywood)	76	80/70
Administration (General Office)	59.2	80/70

Source: Iduapriem Gold Mine Annual Report, 2003

From Table 5, it can be observed that with the exception of values from the workshop and the administration, all other noise levels are above the recommended threshold level of 80/70 (dB_A). Noise levels at Drill Rig 2 and JSO

2 are even much higher. Relating Table 5, to Table 6, which spells out EPA Ambient Noise Level guidelines, it can be observed that if we classify IGM as a heavy industrial area, the noise it generates is above the permissible levels of industrial areas. Referring to the decibel rating and interpretation of sound as shown by Figure 2, it can be concluded that since the noise generated by IGM is between 80 and 120 decibels, then the company generates very loud noise.

Table 6: EPA ambient noise level guidelines

Zone	Description of area of noise reception	Permissible noise levels in dB (A)	
		Day (0600-2200)	Night (2200-0600)
A	Residential area with negligible or infrequent transportation	65	48
B1	Educational and health facilities	55	50
B2	Area with some commercial or light industry	60	55
C1	Area with some light industry place of entertainment, assembly or worship	65	60
C2	Predominantly commercial areas	75	65
D	Light industrial areas	70	60
E	Predominantly heavy industrial area	70	70

Source: EPA Environmental Review Report, 1996/97

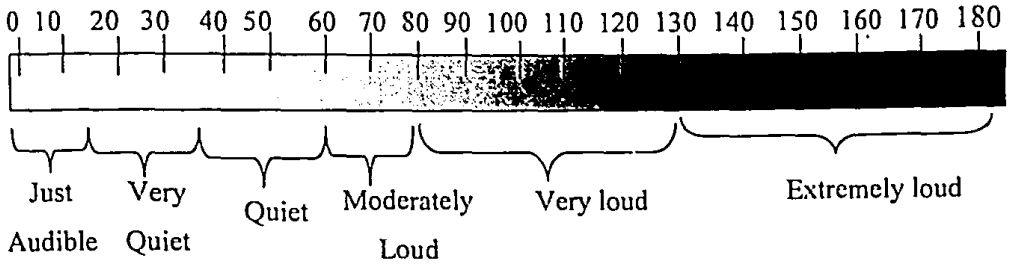


Figure 2: Decibel rating and interpretation of sound - $dB_{(A)}$

Source: EPA Environmental Review Report, 1996/97

Blast monitoring

Major impacts of blasting are:

- Ground vibration
- Fly rock
- Dust and gases release and
- Air blast

Ground vibration and air blast are potential causes of property damage and human annoyance, but are very unlikely to cause personal injury. Fly rock is a potential cause of death, serious injury and property damage. Fly rock, ground vibration and air blast all represent wasted explosive energy. When a blast is detonated, the bulk of the energy is consumed by fragmentation and the permanent displacement of rock close to the location of the drilled holes containing the explosive. This activity normally occurs a few meters of the blast hole. The leftover energy is dissipated in the form of waves moving outwards from the blast either through the

ground or through the atmosphere. The ground waves produce oscillation in the soil or rock with the intensity decreasing with distance.

One measurable quantity of interest in blasting is particle velocity that is how fast a particle is moved by passing seismic waves measured in millimeters per second (mm/s). According to the United States Bureau of Mines (USBM), particle velocity is more directly related to structural damage than particle displacement or acceleration (Anon, 1994). It is not how much, but how fast the ground under a structure is moved by passing seismic waves that determine the likelihood of damage (Montgomery, 1995). The proposed EPA Standard for Ambient Air Quality does not contain any value for regulating blasting. The US Bureau of Mines however states that a safe blasting limit is 50.8 mm/s, and that measurement from any three mutually perpendicular directions in the ground adjacent to a structure should not be exceeded if the probability of the damage to the structure is to be small (<5%). Standards for blasting at Iduapriem Mine are based on international standards. Table 7, represents average monthly blast measurements recorded from March to December, 2003.

From Table 7, it can be observed that with the exception of the average measurement from Taywood workshop for the month of November, all other values are within the acceptable levels of air blast. However, since the frequency of blast and the resultant ground vibration have caused cracks in many buildings in communities located within mining concessions, then it is worth mentioning that since EPA has not as yet recommended any threshold level for blasting, then

the nation should adopt the threshold values of the United States Bureau of Mines which has set the acceptable blasting limit at 50.8 mm/s.

Table 7: Average monthly blast measurement for 2003

Month	Location of blast	Location of measurement	Air blast (dBA)	Air blast acceptable (dBA)	Peak velocity (mm/ss)	Peak velocity Acceptable (mm/ss)
March	Block 7 pit	Teberebie clinic	107.3	130	1.33	9.0
April	Block 7 pit	South gate	114.7	130	1.12	9.0
May	Block 8 pit	South gate	108.3	130	1.15	9.0
June	Block 8 pit	Teberebie clinic	125.0	130	3.46	9.0
July	Block 8 pit	Teberebie clinic	121.4	130	1.20	9.0
Aug	Block 8 pit	Teberebie clinic	125.5	130	2.19	9.0
Nov	Block 7 pit	Taywood workshop	134	130	4.0	9.0
Dec	Block 8 pit	Teberebie clinic	116.5	130	1.31	9.0

Source: Iduapriem Gold Mine Annual Report, 2003

Water monitoring

Mining impacts on groundwater as well as surface water, this is because mining can change groundwater path and the geo-chemical environment. Any disturbance imposed on watershed due to natural or human activity influences the stability of the watershed. This can change slope, divert stream flow and impact negatively on bank stability (Ghana Mining Journal, 1998). All these disturbances have the potential to modify the erosive and sediment characteristics

of streams. When this happens, ground and surface waters adjust to new equilibrium conditions that affect water runoff and sediment transport.

Mining can increase the permeability of rock units and expose fresh rock surfaces and ground water. The result is a disturbance of the established geo-chemical system that can affect ground water quality. The impact of these changes on groundwater however depends on the presence of flow paths that result in the movement of surface water into groundwater, soluble minerals and geo-chemical barriers (Langley et al, 2001). Changes in groundwater static levels occur during mine operations as a result of de-watering efforts and open pit in-filling. This situation was observed in Block 1 pit. Water levels in ground water monitoring wells around Block 1 as well as the pit being used for tailing dump were monitored monthly to detect changes. The geo-chemical nature of waste affects the quality of seepage through waste rock storage facilities. The heavy rainfall pattern of the mine area (1600-mm/a average) means that waste rock seepage has an impact on surface as well as groundwater quality. Water quality measurement at Iduapriem Gold Mine includes all major ions and trace metals. The presence of elevated nitrate levels (from residual explosives) serves as an indicator of rock waste seepage into water bodies. In addition, elevated sulphate levels are also used as an indicator for seepage from waste rock.

Groundwater monitoring at Iduapriem Gold Mine focuses on the determination of groundwater quality within the concession. Water table (water depth) and quality are monitored on weekly, monthly and quarterly basis depending on the area of interest and uses of the water sources involved. Water

samples were collected from community wells, bore holes and specially constructed monitoring boreholes (piezoholes) for analysis. Appendix "B" is a map showing water monitoring points at Idiapriem Gold Mine. The physical, chemical and the biological characteristics of surface and ground water are monitored and the parameters of interest include:

Total cyanide*

Free cyanide, pH*

Sulphate *

Arsenic

Total Suspended Solids (TSS)

Total Dissolved Solids (TDS)*

Conductivity*

Copper, Lead

Cadmium, Iron

Chromium (IV)

Zinc

Magnesium

Mercury

Silver

Selenium

Nickel

Sodium

Total residual chlorine

Nitrate, nitrogen,

Calcium, hardness, and

E. Coliform*

* *Monitored monthly.*

Sampling and analysis for these parameters were done on quarterly basis except for parameters in asterisks, which were measured on monthly basis. Community wells and boreholes used for drinking purposes were sampled monthly and analyzed for microbiological parameters. However, samples were taken on weekly basis from Mile 6 borehole for analysis for Total Residual Chorine and E. Coliform. The presence of E. Coliform is an indication that the water is not wholesome for drinking. Levels of other parameters were compared with baseline and international standards to determine whether changes have occurred and whether these changes merit further investigation or remedial measures. The company undertakes regular chlorination of water sources to make the sources safer for drinking. Records from the company indicate that there were no seepages of supernatants from Blocks 1 and 2 pits into the surrounding groundwater system for the year 2003, despite tailings deposition into those pits. On surface water monitoring, IGM pays particular attention to the three main streams that drain the Iduapriem and the Teberebie concessions. They are the *Angonabeng, Bediebewu* and *Awumabru* streams. All of them flow in southwesterly direction into the *Bonsa* River, which in turn flows into the *Ankobrah* River. Bediebewu stream flows through the Teberebie concession and enters the northeastern part of Iduapriem and then flows into the Neung Forest

Reserve. Awumabru stream drains the western side of the Teberebie Concession and enters the northwestern corner of Iduapriem. Angonabeng stream, on the other hand, flows westwards of the Iduapriem concession and joins the Awumabru stream near the village called Adisakrom. Since all streams pass through the Teberebie concession first, monitoring of surface water by Iduapriem Gold Mine is designed to access the load of pollutants entering from the Teberebie concession (now boundary between Goldfields Ghana Limited and Iduapriem) and the final loading of the stream on exit from the concession. There are monitoring stations at the entry and exit points of these streams, which enable the company to access the effects of its operations on surface water. Sampling from monitoring stations on stream courses were done on monthly basis for some parameters and others on quarterly basis. Appendix B is a map that shows the water sampling stations of Iduapriem Gold Mine. The parameters of measurement are the same as those for groundwater monitoring in addition to the following:

- Cyanide as Weak Dissolved Acid (WDA)
- Biochemical Oxygen Demand (BOD)
- Chemical Oxygen Demand (COB)
- Dissolved Oxygen*
- Oil and Grease
- Total Coliform
- Mercury
- Selenium and silver

*Monitored monthly

Table 8: Iduapriem water monitoring report (average monthly) for 2003

Sampling point	Zn	Pb	Ni	pH	TSS	Fe	Mn	SO_4	Cd
SW1	0.01	0.01	0.01	6.68	20.1	1.45	0.6	-	0.01
SW2	0.39	0.01	0.01	7.14	39.8	2.3	0.13	-	0.01
SW4	0.04	0.01	0.01	7.06	13.4	2.3	2.6	-	0.01
SW6	0.60	0.01	0.01	3.7	11.7	1.81	3.75	-	0.01
Bediabewu	0.11	0.01	0.01	6.8	57.8	6.2	3.0	-	0.01
RWD	2.2	0.01	0.01	9.5	23.2	5.2	1.2	-	0.01
MB1	0.05	0.01	0.01	6.9	55.6	1.62	1.0	-	0.01
MB3	0.11	0.01	0.01	6.8	72.1	2.3	1.5	5.3	0.01
MB5	0.06	0.01	0.01	6.5	23.1	3.8	1.2	-	0.01
Tailings Dam	0.08	0.01	0.01	8.2	13.3	0.46	0.05	-	0.01
MBH1	0.16	0.01	0.01	5.07	5.8	0.13	0.03	-	0.01
MBH4	0.28	0.01	0.01	5.9	8.4	0.3	1.2	-	0.01
MBH6	0.08	0.01	0.01	4.43	18.7	0.5	0.13	-	0.01
MBH8	0.10	0.01	0.01	4.82	9.2	0.4	0.05	-	0.01
Pit 2	0.12	0.01	0.01	9.98	25.2	8.1	0.76	-	0.01
Pit 4	0.01	0.01	0.01	7.8	16.8	0.27	0.01	-	0.01
Plant Site	0.03	0.01	0.01	7.0	2.8	0.54	0.5	11.8	0.01
Mile 8A	0.05	0.01	0.01	5.5	12	2.6	0.18	4	0.01

Table 8 continued

Mile 7A	0.01	0.01	0.01	5.5	0.8	0.2	0.02	0.1	0.01
TM 9	0.11	0.01	0.01	5.8	60	2.59	3.6	-	0.01
TM 13	0.08	0.01	0.01	7.0	8.7	1.14	0.06	-	0.01

Note: Cd =cadmium, Zn =Zinc, Ni =Nickel, Fe =Iron, Mn =Manganese, Pb = lead, TSS =Total Suspended Solids, pH =Measure of acidity or alkalinity

With the exception of pH all results are measured in milligrams per litter (mg/l)

Source: Iduapriem Gold Mine Annual Report, 2003

Table 8, represents the concentration of chemicals in water from various monitoring stations for the year 2003 (average values). Appendix C describes the water sampling points. Table 9, on the other hand gives the guide values for maximum allowable concentration of chemicals in drinking water. From Table 8, it can be seen that values for Pb, and Cd are all within the EU, WHO and USA allowable limits of concentration. With regards to SO_4 concentration, with the exception of MB2 and TM5, recorded values are slightly higher than the allowable limits. Concentration of iron recorded at Pit 2, which recorded average Fe concentration of 8.1 mg/l in the year 2003 is on the high side. So are RWD and MB3 which recorded 5.2 and 3.8 mg/l respectively. Records from all these sites are above the allowable levels as set by the EU, WHO and USA. These values though high are not too startling, since they are within the operational area of the mine with less probability of surface water run-off to the nearby environment. However, recorded values of 2.59, 1.14, 2.3, 2.3 and 6.5 mg/l recorded at, TM 9, TM 13, SW 2, WS 4 and Bediabewu respectively, are

worrying. This is because, TM 9 is a tributary of Angonabeng stream located to the north of the Teberebie village, TM 13, is also a tributary of Bediabewu stream on the access road to Teberebie village. Bediadewu stream is on the access road to Bankyim and SW 4 is on the Asufoe stream before the confluence of Angonabeng stream. Since all these streams from which the samples were taken are closer to residential areas, high values of iron above the allowable threshold in drinking water can be injurious to human and aquatic health. The high concentration of TSS at almost all monitoring stations is also a matter of concern. Almost all value recorded for the year 2003, are higher than the EU, WHO and USA allowable limits of TSS in drinking water. High values of 57.8, 8.7, 60, 13.4 and 39.8 mg/l from Bedukrom, TM 13, TM 9, SW 4 and SW 2 monitoring stations respectively which are all stream tributaries represents pollution of water due to the activities of surface mining.

Table 9: Guide values for maximum allowable concentration of chemicals in drinking water

Parameters	Guide values		
	EU	WHO	USA
pH	6.5-8.5	6.5-8.5	6.5-8.5
Colour (Hu)	20	15	15
Suspended Solids (SS)	4	4	1-5
Zinc (Zn)	0.1	3.0	5.0
Lead (Pb)	0.05	0.01	0.05
Cadmium (Cd)	0.005	0.005	0.005
Manganese (Mn)	0.02	0.5	0.05
Iron (Fe)	0.05	0.3	0.05
Chloride (Cl)	25	250	
Sulphate (SO_4)	25	25.0	25.0
Chromium (Cr)	0.005	0.05	0.05
Nickel (Ni)	0.05	0.02	
Faecal Coliform (Counts/100m)	0	0-3	1

Source: Akabzaa and Darimani, 2001.

Waste management

Waste is described as something that the owner at a particular time or place does not have any use for (Field, 2000). By this definition, it can be said

that someone's waste may be another person's resource. Waste can be classified by their physical characteristics. In this case, we can group waste into solids, liquids and gases. Waste can also be classified by their source of generation. In this category, we can have industrial, domestic, agricultural and clinical wastes. Another means by which waste can be classified is their ability to cause harm. Waste in this sense can be classified as ordinary, hazardous or toxic. At Iduapriem Gold Mine, waste management procedure is in place for the collection, storage, recycling, reuse, transportation, treatment and disposal of waste. The broad objective of this procedure is to guide generators and handlers of waste on the best practices of waste management to the safety and health of persons and the environment. The waste generator is responsible for the initial waste collection, segregation (if required), temporal storage of the waste in appropriate containers and removal to the disposal site where applicable. There is a pollution control officer who is responsible for ensuring that waste management procedures are followed and that waste generated were properly disposed. To facilitate proper handling of waste generated on site, the company has adopted a system of waste classification based on the ability of the waste to cause harm to people and the environment. The following classification was available:

Class A mildly hazardous

Class B Hazardous

Class C very hazardous

Table 10 shows some waste generated at IGM and their hazard rating.

Table 10: Waste type and classification

Type of Waste	Hazard Label/Rating
Empty cyanide boxes and bags	A
Clinical waste	C
Empty acid drums	A
Empty flammable liquid containers	A
Used lead acid batteries	B
Fluorescent tubes	A
Waste lubricating oil and grease	C

Source: Field Data, 2004

IGM has put in place a procedure to ensure that waste such as clinical waste and waste lubricating oil classifies as very hazardous do not get into the environment, they are disposed of under the authorization of the company's pollution control officer. Table 11, shows where certain waste types can be generated at IGM.

Table 11: Sources of Waste Generation at Iduapriem Gold Mine

Source of waste	Estimated composition of waste
Medical Centre	Hypodermic needles, drug waste, plastic bottles and dressings, etc
Equipment maintenance workshop	Oil filters, scrap metals, plastics, lead batteries, paper packaging, used rubber tyres, oil contaminated cloth, waste lubricating oil, fluorescent tubes etc
Treatment plant	Packaging materials, wooden boxes, pallets and plastic bags, plastic and metallic chemical containers, rubber liners, broken equipment parts and papers.
Assay (Metallurgical and analytical laboratories	Slag, paper, plastic, chemical effluent, and expired chemicals
Crushing/milling/ agglomeration plant	Plastics, paper, wooden boxes, scrap metal and steel ball, grease and other hydrocarbon wastes.
Mine residential area	Metal cans, glass bottles, plastics, paper, dead vegetables, food waste and sewerage
Mine offices and canteen	Metal cans, paper, plastics, used cartridges from office machines, sewerage and food wastes

Source: Field Data, 2004

Empty cyanide boxes and bags because of their bulky nature are not stored in waste bins. They were normally set aside and are therefore not labeled. Acid

drums are also bulky and as such not subjected to any special waste containers. The drums are cleaned of any residual acid and reused. With the exception of drums that were used to bury environmentally hazardous substances such as fluorescent tubes and grease, drums do not normally enter the company's waste stream.

Disposal of clinical waste

For the disposal of clinical waste, which IGM classifies as hazardous, the following procedure was observed in its handling:

- The waste was collected and stored temporally in special bins lined with plastic bags.
- At the close of the day, the waste was collected and soaked with fuel and deposited at the incineration chamber, which was kept under lock and key.
- Incineration was done twice every week.
- The ashes and residue from the incineration was stored in a waste bin and disposed of at a landfill site.

Disposal of solid combustible waste

Solid combustible wastes generated at the mine site include wooden materials, Papers, plastics and cloth or fabric. Special bins were provided for the collection and storage of this type of waste. Disposal was by incineration in designated landfill sites. Access to the landfill site was limited and waste not conforming to the above criteria was not permitted for incineration there.

Disposal of solid non-combustible waste

Solid non-combustible wastes generated at the plant site included:

- Pressed oil filters, oil contaminated cloth/fabrics, Pressure hoses, rubber liners
- Metal tins and cans, small scrap metals and metal straps
- Springs, and other plastic/metal equipment parts and cables.

A separate waste bin was provided for this type of waste and disposed of in a rubber-lined pit. When the pit was full, it was sealed off and the area re-vegetated.

Disposal of used rubber tyres

A contracting firm, OTR Limited was responsible for removing old tyres and replacing them with new ones. Heavy-duty equipment and light vehicle tyres were involved in this arrangement. Unless needed for reuse for purposes such as beautification, used tyres were disposed of at the active face of waste rock dumps. Stacking of the used tyre during disposal was not allowed.

Disposal of fluorescent tubes

Used fluorescent tubes are classified as hazardous pollutants because they contain mercury. The following procedure was identified in the disposal of fluorescent tubes:

- All fluorescent tubes were dropped in a specially constructed tube breaker for breaking and storage.
- The content of the tube breaker was transferred into plastic drums and sealed.

- The sealed plastic drums were then buried with the broken tubes at a convenient place, where the company does not anticipate ground disturbance.

Disposal of waste lubricating oil

The following procedure was identified with the handling of waste lubricating oil:

- Waste lubricating oil was drained into trays and emptied into isolated oil storage tanks. The storage tank was located in a bounded area.
- Mobil Ghana (the bulk oil supplier) then transferred the content of the waste oil storage tank into road tankers for conveyance to Tema.

To prevent oil spillage or leakage from getting into the nearby environment, an oil-water separator has been fitted at the point where water from the maintenance workshop enters the environment. The oil-water separator traps any residual oil. The trapped waste oil was later emptied into the waste oil storage tank pending conveyance by the bulk oil supplier.

Disposal of steel, PVC and plastic pipes

Waste Steel, PVC and plastic pipes were stored in heap leach ponds and later removed to the scrap/salvage yard where they were either collected by scrap dealers or sent to the incineration or the rubber-lined pit.

Disposal of solid domestic waste

Waste from residential houses occasionally contained other items but the most common wastes identified were: cans and tins, glass bottles and broken glass ware, Plastics and papers, food waste, and used dry cell batteries and round bulbs. All these types of wastes were collected in plastic bins and disposed of in a designated landfill site. At the canteen, two different bins had been provided, one for the disposal of food waste and the other for the disposal of plastic bottles, sachet water bags, disposable food containers, crown cocks and tissue papers. The content of the container containing the food waste was collected by agreed dealers whilst that containing plastics, tissue papers, crown cocks etc are disposed of at the landfill site.

Disposal of liquid domestic waste

A septic tank treatment of liquid domestic waste was undertaken at Iduapriem Gold Mine. Septic tank sludge was collected in cesspool septic emptier for treatment at an effluent plant treatment located at Teberebie.

Disposal of waste rock

Three waste rock dumps, namely: Awunaben, West Teberebie and East Teberebie waste dumps were actively in use at the time of this project work. Rock wastes from the pits were disposed of at these sites. During the construction of waste dump, topsoil was removed and stockpiled for use during reclamation. The slopes of the sites were constructed at an angle to facilitate revegetation.

Peripheral diversion channels were constructed to collect storm water and divert it around the dump. The exposed portions of waste dumps were sheathed with neutralizing compound (lime) before the spreading of topsoil for revegetation so that acid drain effect may be reduced.

It is significant to mention that compliance to these elaborate procedures in waste disposal is a positive approach towards sound environmental stewardship. Since procedures do not implement themselves, IGM has put in place a management policy of training personnel as Safety Health and Environment (SHE) representatives for the various departments of the organization whose duty it is to ensure that their departments comply with health, safety and environmental standards. SHE representatives were required to prepare periodic reports on their department's conformance to standards. IGM has also developed an emergency response procedure to ensure that spillages and other environmental accidents were addressed as early as possible. Relating the waste management practices of IGM to the regulations on mine waste management practices, one can say that the company is proactive in her waste management practices.

Disposal of oil-contaminated soil

Mineral oil degrades very slowly. Oil in water forms a layer on the surface thereby preventing the penetration of oxygen into the water. This situation leads to suffocation and death of aquatic life. It is estimated that a litre of oil in water can form a layer as large as a standard football field. Oil in

groundwater forms a scum on the surface of the water table. This scum affects oxygen exchange and hence produces an unpleasant ordour in the water. The following procedure was identified with the disposal of oil-contaminated soil at Iduapriem Gold Mine:

- The oil-contaminated soil was scrapped.
- A site preferably near a waste dump was excavated. The burrow was rubber lined with excesses extending at the edges of the burrow so that complete folding can be affected to cover the burrow.
- The joints of the lining material were properly sealed to prevent seepage.

The principle observed was that the contaminated material when sealed with the rubber lining does not exceed a height of 300cm from the surface of the burrow. The top of the folded lining was filled with laterite or oxide material and compacted to seal it off and the area was revegetated. In the light of the all the examined practices, one can conclude that IGM has a standard waste management practice.

Land rehabilitation

Land rehabilitation programmes have been designed to prevent soil erosion and restore disturbed land surfaces and cavities to conditions that can enhance productive utilization for farming or forestry by the local communities. Rehabilitation programmes and projects were initiated by considering the site that was to be reclaimed and the plant species to be selected. The criteria for the selection of species was that, the species should have the ability to thrive on open

lands, withstand stress and be capable of adding nitrogen to the soil and also provide products that can serve the needs of the local communities. The family of Leguminosae (e.g. *Acacia auriculiformis* and *Cacia siamia*) was predominant because they were more able to colonize newly cleared lands and provide nitrogen to the soil. Rehabilitation was in progress at three main sites at the time of this work. These were Block 1 north waste dump, Old Tailings Dump and the Teberebie Spent Heap. At Block 1 north waste dump, revegetation was carried out by encapsulating exposed reactive waste rocks in order to prevent future acid mine drainage. The baths of runoffs was blocked with *vertiver* grass. Trees planted on this site include *Cassia siamea, Gliricidia sepium, Leucaena leucocephala, Cieba pentandra, Danta* and *Terminalia superba.* In order to test the productive capability of rehabilitated areas, an agro-forestry trial plot covering an area of 768.6 m^2 was established in August 2003 at Block 1 north. Species planted included cocoa, plantain and cocoyam and at the time of this research work the plants looked healthy. Another agro-forestry trail plot covering an area of 212.5 m^2 was established in the old tailings dam also to test the productive capability of the rehabilitated old tailings dam. Plants identified included cocoa and a few citrus plants. Additionally, an area of 2500 m^2 had been cultivated on the Teberebie spent heap, cultivated with cassava, maize and cowpea to test the soil's productive capability. Complete results of laboratory analysis to determine the wholesomeness of the crops cultivated on the spent heap was not ready at the time of this research work. IGM pursues a vigorous revegetation policy, and in the year 2003 alone, 51.3 hectares of mined-out areas were revegetated. This

practice by IGM is consistent with the requirements for reclamation, which requires mined-out areas to be returned to a similar land use capability prior to the mine. With reference to the guidelines on mine reclamation and decommissioning, it can be concluded that the rehabilitation practices of IGM is not a deviation from the recommended practice for surface mining operation.

However, a critical look at Table 12, which records some environmental incidents in the mine, raises some questions with regards to IGM's environmental stewardship. For the month of August 2003 alone, there were as many as five recorded cases of spillages of oil, cyanide solution slurry an tailings. In less than forty-five days from 11th July to 22nd August, 2003 there were two recorded environmental incidents involving cyanide. Even though all the recorded incidents as shown by Table 12 occurred within the company's operational area, the frequency of the incidents and the causes of their occurrences (due mainly to faulty equipments and negligence on the part of employees), perhaps give credence to the claim by some members of communities within the concession area of IGM that the company was polluting their environment. It is important to mention also that the causes of the environmental incident as recorded in Table 12, supports the argument by Alexander and Cohen (1998), as stated in the conceptual framework that environmental violations by public trading firms are due mainly to negligence and employee shirking responsibility, and not as a deliberate corporate policy.

Table 12: Environmental incident statistics for 2003

Date	Type of Incident	Causes of Incident	Location
03/02/03	Tailings spillage	Busting of tailing discharge line at joint	Near salvage yard
03/02/03	Slurry spillage from SAG mill 1	Tripping of SAG mill 1 sump pump and resultant stoppage as well as changeover difficulties	SAG mill 1 area
13/05/03	Hydraulic oil spillage	Bust of hydraulic hose	Teberebie ROM pad area
14/05/03	Fuel leakage	Faulty fuel tank breather / shut valve causing leakage.	Taywood workshop
17/05/03	Spillage of dirty oil into drain	Overfilling of bulk waste oil separator valve	Lube oil and waste oil area
08/07/03	Spillage of diesel fuel to the ground	Rusty delivery pipeline, which for a time, has not been used.	Teberebie East ADR
11/07/03	Spillage of gold bearing and cyanide solution	Failure of barren strip pump in the gold room	Teberebie East ADR
12/08/03	Spillage of dilute hydrochloric acid	Breaking of PVC pipe joined to the acid mixing tank	Acid mixing area
22/08/03	Raw water leakage into cyanide mixing area	Faulty valve of raw water pump	Cyanide mixing area

Table 12 continued

28/08/03	Oil leakage into absorption tank	Non functioning seal in the gear box on the Kemix screen	Absorption tank area
30/08/03	Tailings material spillage	Joint between two flanges coming off	Stockpile area near CVR 6
31/08/03	Slurry spillage from SAG mill 1	Non-functioning of mill discharge pumps and inadequate bounded	SAG Mill 1 and discharge hopper

Source: IGM annual report, 2003

Community members' perception on the environmental stewardship of Iduapriem gold mine

This sub-section looks at the perception of community members about IGM's environmental performance. A total of 82 out of 100 questionnaires distributed to respondents at Teberebie, Adieyie and Adisakrom were answered and returned giving a response rate of 82%.

Analysis and discussions of responses

The age distribution of respondents is represented in Table 13.

Table 13: Age distribution of respondents

Age groups	Teberebie		Adieyie		Adisakrom		Total Respondents	
	No.	%	No.	%	No.	%	No.	%
18-24	8	23.6	9	32.2	5	25	22	26.8
25-44	16	47.0	11	39.3	9	45	36	43.9
45 and above	10	29.4	8	8.5	6	30	24	29.3
Total	34	100	28	100	20	100	82	100

Source: Field data, 2004.

From Table 13, it could be observed that the total percentage of respondents within the various age groups of 18-24, 25-44, and 45 and above are 26.8%, 43.9% and 29.3% respectively. This means that majority of the respondents were in the 25-44 age bracket. The sex of the respondents was 50 males and 32 females representing 61% and 39% respectively. On the highest level of formal educational attainment, Table 14 presents the responses of respondents.

Table 14: Level of formal education of respondents

Education	Teberebie		Adieyie		Adisakrom		Total respondents	
	No.	%	No.	%	No.	%	No.	%
First Cycle	15	44.2	14	50	12	60	41	50
Secondary	8	23.5	4	14.3	2	10	14	17.1
Tertiary	3	8.8	1	3.6	-	-	4	4.9
No formal	8	23.5	9	32.1	6	30	23	28
Total	34	100	28	100	20	100	82	100

Source: Field data, 2004.

The responses as shown in Table 14 show that 50% of the respondents had first cycle education (Primary, JSS, and Middle), 17.1% had had secondary education and 4.9% had attained tertiary education. 28% had no formal education. Respondents were asked about their occupations and their responses are presented in Table 15.

Table 15: Occupation of respondents

Occupation	Teberebie		Adieyie		Adisakrom		Total Respondents	
	No.	%	No.	%	No.	%	No.	%
Farming	14	41.2	10	35.7	13	65	37	45.1
Mine Work	8	23.5	5	17.9	2	10	15	18.3
Self employed	5	14.7	4	14.3	4	20	13	15.9
Civil/public Servant	2	5.9	2	7.1	-	-	4	4.9
Student	3	8.8	2	7.1	-	-	5	6.0
Any other	2	5.9	5	17.9	1	5	8	9.8
Total	34	100	28	100	20	100	82	100

Source: Field data, 2004.

From Table 15 it is observed that majority of the respondents are farmers (45.1%). 18.3% are miners, 15.9% of them are self employed and they engage in activities such as trading, oil palm extraction, and hewing of fire wood. Civil/ Public servants, students and Any Other occupation (artisinal mining included) constituted 4.9%, 6.0% and 9.8% respectively. Respondents were also asked whether they had any knowledge of IGM's environmental management practices

and whether they had in any way suffered any negative impact as a result of the company's operation and their responses are presented in Table 16.

Table 16: Respondents knowledge on IGM's environmental practices

Communities	Do you have any knowledge of IGM's environmental management Practices?						Has the Operations of IGM in any way negatively affected you?					
	Yes	%	No	%	Total No.	%	Yes	%	No	%	Total No.	%
Teberebie	10	29.4	24	70.6	34	100	34	100	-	-	34	100
Adieyie	6	21.4	22	78.6	28	100	28	100	-	-	28	100
Adisakrom	4	20	16	80	20	100	20	100	-	-	20	100
Total	20	24.4	62	5.6	82	100	82	100	-	-	82	100

Source: Field data, 2004.

From Table 16 it could be noticed that whereas all the respondents have in one way or the other suffered from the operations of IGM, 75.6% of the respondents do not have any knowledge of the environmental management practices of the company. 20% of the respondents said that they have knowledge of the company's environmental activities. Majority of the people making up this 20% are mine workers (as shown in Table 15, with 18.3% respondents being mine workers) most of whom have been employed as casual labourers on the company's revegetation programme. Respondents who said they had suffered any negative impact were asked about the kind of negative impact they had suffered and their responses are presented in Table 17.

Table 17: Nature of negative impact suffered by respondents

Communities	Respondents	What kind of impact have you suffered from the operations of the company?											
		WP	%	DE	%	VB	%	NP	%	WG	%	AO	%
Teberebie	34	10	24.9	25	73.5	30	88.2	15	44.1	9	26.5	4	11.8
Adieyie	28	20	71.4	12	42.9	22	78.6	10	35.7	5	17.9	5	17.9
Adisakrom	20	15	75	10	50	11	55	11	55%	5	25	4	20
Total	82	45	54.9	47	57.3	63	76.8	36	43.9	19	23.1	13	15.9

Note: *W.P = Water Pollution, D.E = Dust Emission, V.B= Vibration Due to Blasting N.P= Noise pollution, W.G= Waste Generation, AO= Any Other*

Source: Field data, 2004.

From Table 17 it could be observed that 54.9% of the total number of respondents said that they have suffered water pollution due to the activities of IGM. 57.3% complained of dust emission and 76.8% of vibration due to blasting. 43.9% and 23.1% of the respondents also complained of noise pollution and waste generation respectively. 15.9% of the respondents also said they had suffered other negative impacts such as human right violation, non-payment and/or low payment of compensation and taking over of farmlands. Respondents were finally asked their opinions about the environmental stewardship of IGM and their responses are presented in Table 18.

Table 18: Respondents opinions about IGM's environmental stewardship

Opinion	Teberebie		Adieyie		Adisakrom		Total Respondents	
	No.	%	No.	%	No.	%	No.	%
Satisfactory	-	-	-	-	-	-	-	-
Unsatisfactory	34	100	27	96.4	20	100	81	98.8
Can't tell	-	-	1	3.6	-	-	1	1.2
Total	34	100	28	100	20	100	82	100

Source: Field data, 2004.

From Table 18 it could be observed that with the exception of one respondent from Adieyie who said he could not tell whether or not the company was doing the right thing, the rest of the respondents were not pleased with IGM's environmental management practices. Even though majority of the respondents do not know anything about the company's environmental management practices as shown by Table 16 (75.6%). The fact that they negatively suffer from the operations of the company coupled with the fact that majority of them are farmers and depend on the environment for subsistence gives them a basis to make judgment.

Again, the fact that 18.3% of the respondents are mine workers (as shown in Table 15) and yet no respondent seems to be speaking in favour of the company's environmental management performance, is an indication that, perhaps, the environmental management requirements of surface mining in Ghana of which IGM does not fall short in her adherence to them, do not favour people living in mining communities.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

The focus of the study was to examine the environmental stewardship of Iduapriem Gold Mine. The researcher was motivated by the many peaceful demonstrations by mining communities in the Wassa West District against mining companies to undertake this study in order to make public the efforts mining companies are making to mitigate the negative impacts of their operations on the environment. This chapter summarizes the entire project work as well as the findings and makes recommendations.

Summary

Data for the study were gathered from field trips to the company's environmental monitoring stations, waste dump sites as well as reclaimed and revegetated areas. Monitoring reports collated from various sampling stations by the company's environmental department provided values for comparison and analysis. Parameters of assessment were particulate matter monitoring, noise monitoring, vibration due to blasting, water monitoring, waste management

practices and land reclamation issues. The thresholds used for analysis were those of EPA Ambient Quality Standards, EU, WHO and USA threshold levels.

Findings of the study

- Iduapriem Gold Mine has a proactive approach towards environmental management. Its environmental agenda does not operate in isolation, but brings on board all departments and employees unto the environmental action plan.
- The company's environmental management practices with regards to waste management, water and particulate matter monitoring are standard. The land rehabilitation practice that involves the cultivation of plants belonging to the family of Leguminosae such as Acacia auriculiformis and Acacia siamia is an outstanding practice. This is because not only do such plants have the ability to colonize newly cleared lands, but they also provide the soil with nitrogen, hence helping to further enrich the soil.
- The company has introduced an agro-forestry trail plots system to test the agricultural potentials of reclaimed lands. This practice is consistent with the ideals of sustainable development.
- During the research it was discovered that water from the processing plant was contained in a raw water dam and recycled for use for other purposes within the mine. This prevents the potential accumulation of the environment with water that might contain pollutants due to mining operations.

- Ghana has not developed enough allowable thresholds for the regulation of pollution. Because of this, the nation depends mostly on the EU, WHO and USA for the allowable limits of pollutants concentration.
- From the literature review, it was observed that some of the regulations that control surface mining activities in Ghana are not specific in their demands. Some of them give broad-spectrum regulations with no specific demands. The subjective nature of regulatory requirements is a potential cause for community-company conflict.
- Field observation also revealed that local communities who are the direct recipients of the negative impacts of gold mining activities have no supervisory authority whatsoever over the environmental performance of gold mining companies operating in their area. The fact that enforcement of mining regulations cut-off affected communities in their enforcement can provoke the displeasure of community members.

Conclusions

Data collected for this project work gives the impression that Iduapriem Gold Mine is an environmentally proactive company. This is because in addition to operating within the confines of the regulations governing mining operations in Ghana, it is also responsive to the dictates of international environmental regulatory bodies membership of which is voluntary. This gives an indication that the company perhaps believes in the notion that environmental improvement is a good business practice as postulated by Downing and Kimball (1982) in the

conceptual framework. There is a commitment to upholding all corporate environmental standards. This commitment is evident in its emphasis on working towards minimizing the impact of mining and mineral processing on adjacent communities and on the physical environment. The environmental section of the company carries out a regular and a periodic monitoring of the air, water, noise and soil in-and-around the operational areas of the mine to ensure that the environment does not unnecessarily suffer from the company's operation. To fulfill corporate environmental standards, management of Iduapriem Mine makes a conscious effort to:

- identify and evaluate potential environmental impact associated with its operations,
- comply with corporate environmental policy and all applicable laws, regulations, standards, code, and guidelines, and
- Carry out ecologically sustainable land rehabilitation programmes.

Iduapriem Gold Mine at the time of this work had achieved a National Organization of Safety Association (NOSA) 4-STAR integrated certification and International Organization of Standardization (ISO) 14001 Environmental Management System Certification. These accreditations are indications of employee safety and good environmental management practices.

However, this notwithstanding, the perception of residents of communities in-and-around the concession area of the mine is an important factor in assessing the company's environmental performance. In November 2004, some farmers from Teberebie village organized a protest march against Iduapriem Mine over a

disagreement in the payment of compensation for farmlands that had been taken over by the company. The farmers held placards some of which read "GAG (former name for Iduapriem Mine) is cheating poor farmers", "GAG has polluted our drinking water, the air we breathe and is now twisting our hands for the small lands on which we feed" and "Don't entertain mining companies into your environment, they have nothing good to offer".

Though these placards may appear unjustifiable, but the fact that they carry the impressions of some members of communities who are the direct recipients of the impact of the company's operation on the environment, should not be overlooked. Information gathered from WACAM, an environmental NGO in Tarkwa, on the environmental stewardship of Iduapriem Gold Mine gives an indication that the company is doing well, but a lot more needs to be done.

Recommendations

To help address some of the problems identified, the following recommendations are proposed:

- State institutions that are responsible for the monitoring of the activities of mining companies such as the EPA and the Minerals Commission should be well resourced to carry out frequent monitoring of the environment in mining areas.
- A study should be done on the extent to which blasting by mining companies impacts on structures in communities surrounding their operations. Researches of this nature will persuade the government to take steps to

develop blasting standards that would better protect structures in mining communities.

- Regular medical screening (at least once every two years) for residents in mining communities due to the negative impact of mining operations on the natural environment.
- Revegetation should be done with economically useful plants in addition to the nitrogen fixing plants.
- Inspection teams from the EPA and Mines Department to inspect the environmental performance of mining companies should include representatives from the affected communities who suffer the direct impact of the company's activities. So that members in mining communities would develop confidence in the inspection process.
- Mining companies should ensure an uninterrupted supply of potable water to communities in their catchments area. This is because mining operations lead to the pollution of natural water bodies.
- Environmental requirements that regulate the activities of surface mining in Ghana are inadequate and the few available are fragmented and scattered. The state should have a holistic and a comprehensive mineral and mining law that would address the social and the environmental concerns of surface mining .
- Environmental Impact Assessment document should be made accessible to people in mining communities in a language that they can easily understand so

that they can play an effective watch-dog role over the environmental management practices of mining companies.

- Mining companies should consider as a social responsibility educating community members on its environmental stewardship. This will help correct some of the misconceptions that some community members have about the activities of mining companies.

REFERENCES

Acquah, P. C. (1993). *Emerging trends in gold processing and some environmental issues in Ghana,* Proceedings of the 9th International Geological Conference. Geological Society of Africa and the Geological Society of Ghana, Accra, Ghana.

Addo, B. (1997). *Current environmental practices in the mining industry.* Proceedings of UST-IDRC 1997 National Symposium on the Mineral Industry and the Environment. Kumasi: UST/IDRC Environmental Research Group, Ghana. Pp 35-42

Agbesinyale, P. K. (2003). Ghana's gold rush and regional development, A case of Wassa West District. *Spring Research Series*. Dortmund: University of Dortmund.

Agra, G. Y. (1997). *Current environmental practices in the mining industry.* Iduapriem Gold Mine. Proceedings of UST-IDRC 1997 National Symposium on the Mineral Industry and the Environment. Kumasi: UST/IDRC Environmental Research Group, Ghana. Pp 18-27

Akabzaa, T. M. (2000). *Boom and dislocation: The environmental and social impact of mining in Ghana. A case of the Wassa West District.* Accra: Third World Network-Africa (TWN).

Akabzaa, T. M. and Darimani, A. (2001). *Impact of mining sector investment in Ghana: A study of the Tarkwa mining region.* (Draft report for SAPRI), Accra.

Akuffo, S. B. (1998). *Pollution control in developing economy: A study of the situation in Ghana*. Accra: Ghana Universities Press, Ghana.

Anon, (1994). *Ghana's mining and environmental guidelines*. Accra: Minerals Commission and the Environmental Protection Agency, Ghana.

Anon, (1997). Halt mine expansion. *African Agenda* (15).

Anon, (1999). *Environmental literacy in mineral education,* Perth: United Nations Environment Programme (UNEP) conference, Australia.

Arora, S. and Cason, T. N. (1995). Experiment in voluntary environmental regulations. Participation in EPA's 33/50 program. *Journal of Environmental Economics and Management*. 28(3), 271-286.

Arora, S. and Gangopaday, S. (1995). Toward a theoretical model of voluntary over compliance. *Journal of Economic Behavior and Organization*. 28, pp 289-310.

Aryee, B. N. A. (2001). *Ghana's mining sector, its contribution to the national economy*. Resource Policy, Pergamon.

Asamoah, K. (1996). Management of mine waste at Ashanti Goldfields limited. *Ghana Mining Journal*. 4. pp 37-40.

Bosson, R. and Varon, B. (1997). *The mining industry and the developing economies*. Oxford: Oxford University Press.

Bush, M. B. (2000). *Ecology of a changing planet.* 2nd ed, New Jersey: Prentice Hall, Upper Saddle River.

Cahill, E. (1994). Voluntary approaches, market structures and competition. *Policy Studies Journal*. 42. London: J. N Publications.

Charis, D. D. (1998). *Environmental science: A framework for decision making.* 2nd ed., California: Benjamin/Cummings inc. Menlo Park.

Cohen, M. A. and Alexander S. (1998). *Monitoring and enforcement of environmental policy.* (Working Paper). Nashville, TN: Owen Graduate School of Management, Vanderbilt University.

Cohen, M., A. (1999). Monitoring and enforcement of environmental policy. *International Yearbook of Environmental and Resource Economics 1999/2000.*Cheltenham: Edward Elgar Publishers., Cheltenham, UK.

Cunningham, S. and Saigo, A. (1999). *Environmental science, a global concern,* 5th ed. New York: McGraw Hill Companies.

Daily Graphic, (1996). *Wassa chiefs protest against environmental degradation,* Graphic Communication Group. Accra, Ghana. 7th Nov.

Daily Graphic, (2001). *Pollution is not an academic exercise.* Accra: Graphic Communication Group, Ghana. 30th Dec.

Daily Graphic, (2004). *AGC Pays $7m in royalties to government.* Accra: Graphic Communication Group, Ghana. 6th Oct.

Daily Graphic, (2004). *Help reverse degradation.* Accra: Graphic Communication Group, Ghana. 30th May.

Doonan, L (1998). Nature of voluntary approaches: Empirical evidence and national pattern. *Policy Studies Journal.* 33, J.N Publication, pp105-110.

Downing, P. and Kimball J (1982). Enforcing pollution control laws in the U.S.A. *Policy Studies Journal.* 40, J.N Publication, pp86-93.

Junner, N. R. (1973). *Gold in the Gold Coast*. Accra: Ghana Geological Survey Department.

Keatley, M (1992). *Africa's gold potential*. A speech delivered at the World Gold Conference, London.

Khanna, T. (1998). Mining and the environmental agenda. *Mining Magazine* 181 (3). *Mining Journal Ltd. South Africa.*

Konar, S. and. Cohen, M. (1998). Information as regulation, the effect of community right to know laws on toxic emissions. *Journal of Environmental Economics and Management.* 32, pp 109-124

Mensah, L and Boateng, A. (1998). Environmental guidelines for Ghana's mining industry. *Ghana Mining Journal,* 4. Kumasi/Tarkwa: IMME, Ghana. Pp 5-8.

Mensah, L. (1997). *The protection of the Ghanaian mining environment: The role of legislation.* Proceedings of UST-IDRC 1997 National Symposium on the Mineral Industry and the Environment, Kumasi: UST/IDRC Environmental Research Group, Ghana. pp 27-34.

Minerals Commission of Ghana, (1991). *A draft report on the study of effects of mining on the environment in Ghana.* Accra: Minerals Commission of Ghana.

Montgomery, C.W. (1995). *Environmental geology.* 4th ed. London: W.M.C. Brown Publishers.

Myers, N. (1989). *Deforestation rate in tropical forest, and its climatic conditions.* London: WMC Brown, Publishers.

Odeneho Gyapong Ababio V (1998). Mining and the environment, perspective of the Western Regional Traditional Council. *Ghana Mining Journal.* 4, pp 51-52.

Owusu-Koranteng, D. (2002). *Mining and agriculture: The experience of mining in the Wassa West District,* (Unpublished) WACAM, Tarkwa

Pagal, A. Wheeler, D. (1990). Environmental transition in developing countries. *Geographical Journal.* 163 (2), pp 206-215.

Pertzel, B. A. (1989). *Iduapriem gold project feasibility report.* Pertzel, Tahan and Associates Ltd. (Unpublished) Sydney Australia, pp 5-11

Pickering, K.T. and Owen, L.A. (1995). *An introduction to global environmental issues.* New York: Routledge, U.S.A.

Public Agenda, (1998). *Gold is killing us.* Accra: Public Agenda, Ghana. 14 -20 Sept.

Public Agenda, (2000). *WACAM protest against surface mining,* Accra: Public Agenda, Ghana. 30th Oct.

Republic of Ghana, (1996), *PNDC Law 154, Minerals Commission Law 1986.* Accra: Ghana Publishing Corporation, Ghana.

Sackey, E. A. (1998). Mining health and safety issues in Ghana. *Ghana Mining Journal,* 4, pp 18-20.

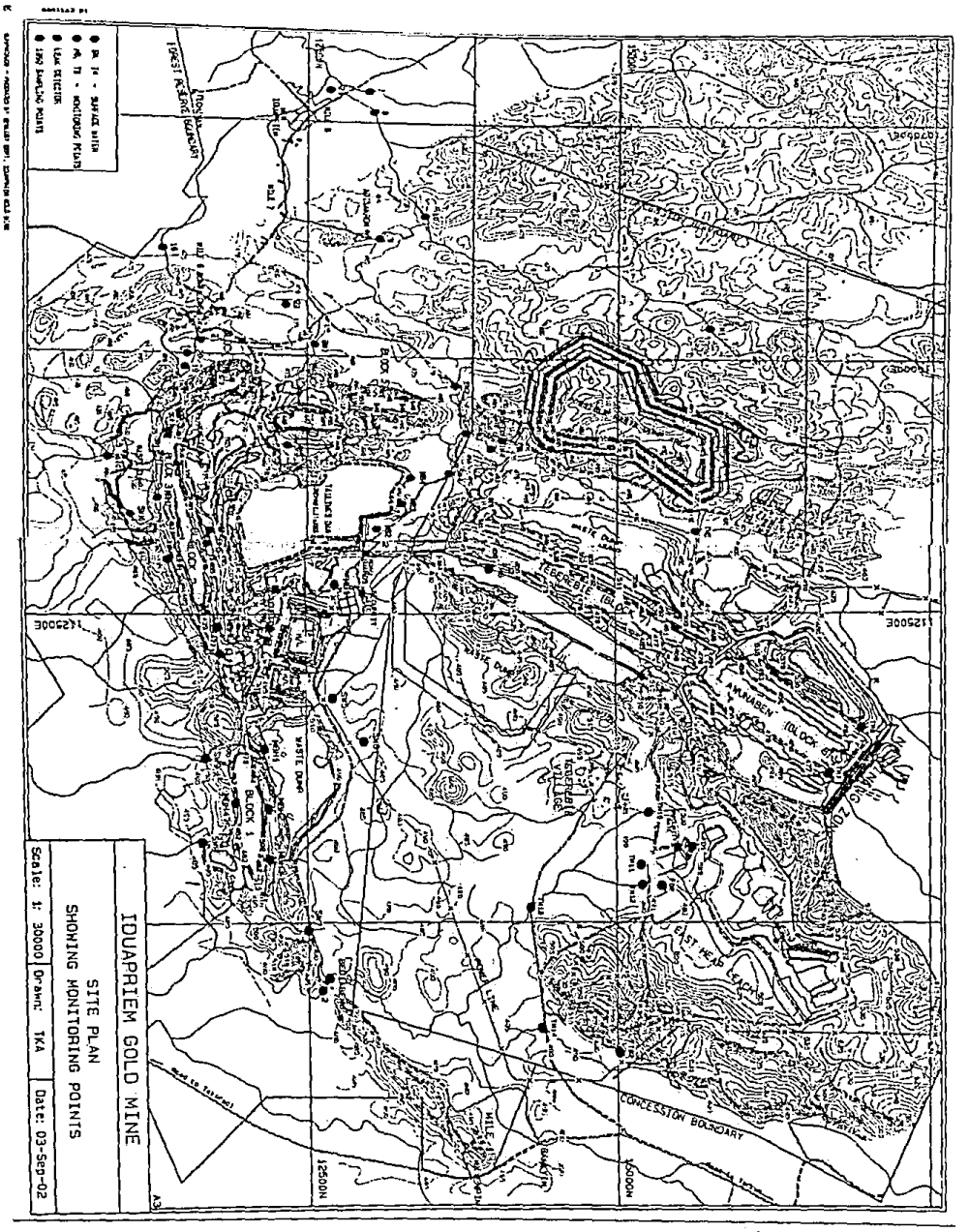
Wallace, D. (1976). *International regulation and multinational corporations.* New York: Praeger.

Wassa West District Assembly (2004). *Facts about Wassa West District, District Assembly.* Tarkwa, Ghana.

World Bank (1993). *Ghana, 2000 and beyond: Setting the pace for accelerated growth and poverty reduction.* Washington DC: World Bank Africa Regional Office, Western Africa Department.

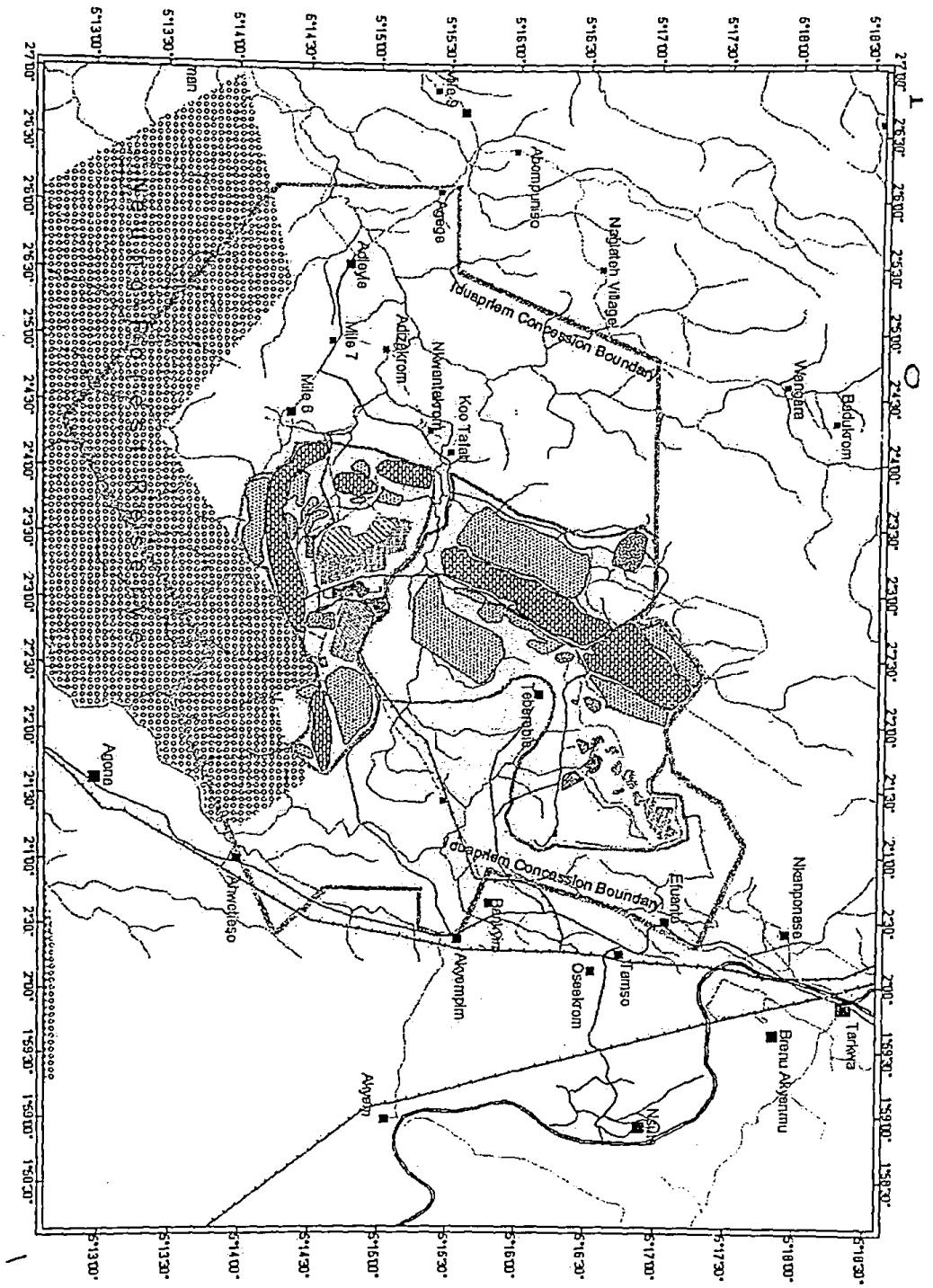
APPENDIX A

Map showing Boundaries of Iduapriem Concession



APPENDIX B

Map showing water monitoring points at Iduapriem gold mine



APPENDIX C

Description of IGM's water sampling points

Labeling	Description
Plant Site	Borehole at plant site
Mile 6	Borehole near the catering house, Mile 6 camp (drinking water)
RWD	Raw Water Dam
SW1	Tributary of Angonabeng Stream north-east of Block 3 pit (surface water)
SW2	Tributary of Angonabeng stream north Block 5 pit
SW3	Angonabeng stream at the south west exit from the Teberebie GoldFields Limited (TGL) property
SW4	Atsufoe stream before confluence with Angonabeng stream from GTL
SW 6	Asufoe stream at one of its sources, norh of Block 1 N waste Dump
SW 7	Bediabewu stream east of Block 1 N waste dump
SW 8	Tributary of Bediabewu stream south-east of Block 1 S waste dump
SW 10	Tributary of Angonabeng stream south east of Blocks 2 & 3 waste dump and coming through SW 1
Bediadewu	Bediabewu stream on the access road to Bankyim
MB 1	Monitoring borehole between RWD and leach pad
MB 2	Monitoring borehole north east of tailing dam

MB 3	Monitoring borehole north-northeast of tailing dam
MB 4	Monitoring borehole north of tailing dam
MB5	Monitoring borehole west of tailing dam and south-east of Block 4 pit
MB 6	Piezohole on the south-west of Block 1 pit
MB 7	Piezohole on the north of Block 1 pit
Mile 7	Well at Mile 7 village (drinking water source)
Mile 8 A	First well at Mile 8 village (drinking water source)
Mile 8 B	Second well at Mile 8 village (drinking water source)
TM 1	Tributary of Ahumabru stream south-east of south pad
LW 3	Tributary of Angonabeng flowing southwards onto the north of the south facility
TM 4	Spillway of the proposed south containment area
TM 5	Weir connecting the wetland southeast of the south facility to the south containment area.
TM 6	Tributary of Angonabeng southwest of the south pit.
TM 7	Inter-connector draining Mantriam stream into the diverted channel of Angonabeng stream at northeast of the south pit
TM 8	West interior connector draining mantraim wetland into the diverted channel Angonabeng stream
TM 9	Tributary of Angonabeng stream north east of Teberebie village
TM 10	Tributary of Bediabewu stream on the access road west of the cemetery

5. What is your occupation? Mine Worker [ ] Farmer [ ] self-employed [ ] Civil/Public Servant [ ] Student [ ] Any other (specify) .....

SECTION B: OPINION ABOUT THE ENVIRONMENTAL PERFORMANCE OF IDUAPRIEM GOLD MINE

7. Do you know anything about Idaupriem's environmental management practices? Yes [ ] No [ ]

8. If yes what do you know?

.....

.....

8. Has the operations of the company negatively affected you?

Yes [ ] No [ ]

9 If yes how has it affected your community? Water pollution [ ] Dust Emission [ ] Noise pollution [ ] Waste disposal [ ] Vibration due to blasting [ ] Any Other (Specify) .....

10. How would you assess the environmental performance of Iduapriem?

Satisfactory [ ] unsatisfactory [ ] I Can't tell [ ]