UNIVERSITY OF EDUCATION, WINNEBA

COLLEGE OF TECHNOLOGY EDUCATION KUMASI

THE IMPACT OF SOFOKROM AND ESIPON QUARRY ON RIVER ANANKWARI AND ITS IMPLICATION ON THE PEOPLE WITHIN THE CATCHMENT AREA

BY

PETER MENSAH ABROAMPAH

JUNE, 2014

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JUNE, 2014

DECLARATION

STUDENT'S DECLARATION

I, Peter Mensah Abroampah declare that this, Dissertation with the exception of quotations which have all been identified and duly acknowledged, in entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

Signature: …………………………………

Date: ………………………………………..

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of Dissertation as laid down by the University of Education Winneba.

Name of supervisor: Dr. Peter P. K. Yalley.

Signature: ……………………………..

Date: ………………………………….

DEDICATION

This is specially dedication to my parents, Mr. J. F. Mensah and Madam Theresa Nuako Mensah who have been tremendous help throughout my education.

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ABSTRACT

Availability of water is steadily decreasing at the same time as demand for water exceeds supply in the Sekondi -Takoradi Metropolitan as the population continues to rise due to commercial production of oil, existence of Harbour and expansion of other business in the region. This project seeks to assess the impact of Sofokrom and Esipon quarry on Anankwari River and its implication on the people within the catchment area, in the Sekondi-Takoradi Metropolitan. Simple random sampling techniques were used to select the respondents in the two communities for the administration of the questionnaire. This was followed by Purposive sampling to select the medical personnel for the interview in order to ascertain the facts. Hundred questionnaires were distributed to the two quarry mining communities (Sofokrom and Esipon) and 98% were retrieved. The questionnaire consists of both ended and open ended. A questionnaire guide was used for interview and water quality analysis conducted at the Ghana Water Company limited laboratory. It was revealed that, stone quarry activities in the river basin have resulted in the residue of chemicals in the rivers and had led to drying up of rivers and streams in the area which has culminated into insufficient water for households and inflicted infections of skin diseases and prolonged and chronic cough. The study also revealed that annual discharge of the river has decreased from 574796m^3 in 2010 to 480252m^3 in 2014 and could be attributed to the quarrying of stones in the river basin. All physico-chemical parameters such as pH, turbidity, colour, conductivity, temperature, total dissolved solids, and total suspended solids of the downstream of the river Anankwari were found not meeting the WHO standards for drinking water except chloride, manganese and total hardness and this pollution may be attributed to contamination from quarry activities. The finding support the conclusion that the water quality of the river at the

downstream is below the desirable level and this causes diseases like cough, skin diseases on the inhabitant. The practical implication was that public awareness with respect to the need to boil and filter the water before drinking is significant in the area. It is thus recommended that a hydrological monitoring network station be established within the sub-catchment area to record these hydrological parameters for a longer time period, in order to establish the required parameters so as to inform the right time of treatment for the water in the area.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Surface water has been the major sources of drinking water across the globe since ages. According to Degrĕmont (2007), water is the most widespread mineral substance on the earth‟s surface. On earth, it is found mostly in oceans and other large water bodies, with only 1.6% of water below ground in aquifers and 0.001% in the air as vapor, clouds. Clean drinking water is essential to humans and other life forms.

Ghana and most particularly the Western Region has abundant and numerous water resources. Many experts have expressed serious concerned about rapid deterioration of the water resources, especially the mismanagement of water resources in Western Region. These water resources are utilized by man in various ways to satisfy his felt needs which are related to water usage. In his quest to fully utilize these resources, man uses all means to exploit them, resulting into water resources deteriorations, excessive evaporation, reduction in the quality and quantity of water supply and water pollution, diseases and increasing cost of water treatment. Stock (1978).

Rivers, streams and other water bodies are being dried off and polluted with poisonous chemicals through surface mining and querry activities. The situation is very serious for the people of Sofokrom and Esipong on River Anankwari which supply water to the people of Aboso, Aboadzi, in Sekondi-Takoradi Metropolis.

1.2 Problem Statement

Undoubtedly, access to potable water is a pre-requisite for sustainable human development and has significantly been recognized by the international community with litany of interventions. Despite the prominence given to the issue of water availability, many developing countries are faced with the difficulty of sustainability, especially in Ghana. The pressure to provide water service to people, particularly in Sekondi-Takoradi is intense as there is inadequate water supply for people within the area. The situation is even worse when reference is made to Aboasi, Aboadzi, Inchaban in Sekondi – Takoradi Metropolitan.

Water availability, accessibility and sustainability are a seriously becoming a concern for the people of Sekondi, Aboasi, Inchaban, Sofokrom and Esipon who depends on the river Anankwari for their daily water consumption, due to the activities of quarrying mining in the area. The only treatment plant in the area which takes its source from river Anankwari, has also be been affected by the activities of quarrying. Most streams which feed rural communities and river Anankwari apart from the possibility of being dried off and polluted their continuous existence are unkown.

Availability of water at households are steadily decreasing at the same time as demand for water exceeds supply in these communities as the population continues to rise due to the commercial production of oil, existence of Harbour and expansion of other business in the region. It is therefore important to assess the impacts of Sofokrom and Esipon quarry on River Anankwari and it implications on water distributions, water availability with particular attention to Sekondi and it environment.

1.3 Aim

The aim of this study is to assess the impact of Sofokrom and Esipon quarry on river Anankwari and its implication on the people within catchment area in the Sekondi – Takoradi – Metropolitan Assembly (STMA).

1.4 Objectives

The specific objectives of the research include:

1. To evaluate the activities of the quarry.
2. To determine the effects of the quarry on the quality of the river.
3. To determine the effects of the quarry in the discharge of the river.
4. To ascertain the implications of quarry on the inhabitants within the catchment

1.5 Research Questions

In embarking upon such study, certain questions should be answered before any credible conclusions can be drawn. Some of the questions raised in this study are as follows:

1. What is the quality of water in the river upstream and downstream?
2. How has the quarry influenced the discharge of the quality?
3. What was the rainfall pattern in the area before the inception of the quarry?
4. What has been the discharge of the river?
5. What is the current state of the river, and implication on the inhabitant within the area?

1.6 Significance of the Study

This study is essential in the sense that it would not only contribute to knowledge and theory, but intended to highlights the impact of Sofokrom and Esipon quarry on river Anankwari and its implication on the people within catchment.

1.7 Limitation of the Study

The study was only limited to the impacts of Sofokrom and Esipon quarry on river Anankwari with particular attention to Sekondi-Takoradi Metropolitan Assembly (STMA).

1.8 General Layout

This thesis is comprised of five chapters. Chapter one deals with background to the study, the problem, objectives and the significance of the study. Other aspects of this chapter are the limitation and delimitation of the study.

Chapter Two focuses on the review of related literature while the methodology and description of study area is the subject of chapter three. The chapter on the methodology describes the sampling procedures, data gathering instruments and data collection procedures of the study. In chapter four, results and discussion of the findings are presented. Finally, the summary of findings, conclusions, recommendations and suggestion for further research form the concluding chapter of the thesis.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This section deals with reviewing of available literature that is relevant to the subject matter. Specific areas reviewed include, General over view of water, sources of surface water, rural water supply, water contaminants and the challenges imposed on users, water elements and influences on water, water quality parameters, Method of quarry mining, Environmental impact of quarry mining, Effect of quarry on water bodies and so forth.

2.1 General Overview of Water

Water is a chemical substance with the chemical formula H_2o which means there are two mole of hydrogen and one mole of oxygen. The first decomposition of water into hydrogen and oxygen, by electrolysis, was done in 1800 by an English chemist William Nicholson. In 1805, Joseph Louis Gay-Lussac and Alexander von Humboldt showed that water is composed of two parts hydrogen and one part oxygen. Gilbert Newton Lewis isolated the first sample of pure heavy water in 1933 (http://home.comcast.net/-igpl/temperature html).

2.2 Sources of Water

There are several collection sources as water falls to Earth in the form of precipitation.

2.2.1 Surface Water

Water that gathers on the surface is called surface water. Lakes, rivers, and streams are examples of fresh surface water that can be used as sources of drinking water.

Dams are often constructed in a river to form an impoundment, allowing for storage of water. Approximately two thirds of the U.S. population consumes water from surface-water sources (American Water Works Association, 1999).

Groundwater

Water found in water-bearing sediment of rock formation beneath the ground surface in known as groundwater. Groundwater is a major drinking water source in the rural areas in Ghana, and is obtained by water well or clusters of wells. Almost all domestic supplies are groundwater wells.

Springs

Where a water-bearing formation intercepts the ground surface, usually on a hillside, a spring emerges. A spring can be captured for a water supply source as either surface water or groundwater.

There are many types of different springs, classified according to the conditions under which water flows to them. The most important distinction in between gravity and artesian springs. Gravity springs occur in unconfined aquifers, where the ground surface dips below, (Bell, 2007). If the spring water in captured inside the hillside before it emerges it in considered groundwater. If the spring water in allowed to flow on the surface, it becomes surface water Fabrizi (2011).

Rainwater

Rainwater does not contains contamination but many only be infected by other element in the air or atmosphere and therefore need to be disinfected before used. It is soft and lathers well; however rain water is not dependable because it cannot be harvested to meet requirement at all times. The surface where the rain is collected, usually a roof, must be clean and frequently. Rainwater is most commonly used as a source of supply where other sources are scare (US Environmental Protection Agency, 1999)

2.3 Water Uses

Water has a vast use on the earth. It is the source for life for living organisms residing on the surface of the earth. According to Alan (2000), public water use is categorized into domestic use, trade and industry, agricultural and public use. The domestic water use has been grouped into two; in-house which is for drinking, cooking, ablution etc. and out-of-house use which are for garden watering, lawn sprinkling and bathing pools.

The trade and industry comprises of water used for factories, industries, power stations, hostels, hotels, hospitals among others while the agriculture and public use are for crops, livestock, street watering, fire fighting and others.

2.4 The Physical State of Impurities in Water

Water found in the natural world is never pure and this is even more so in the case of untreated water. The impurities mainly come under two states;

2.4.1 Suspended Solids

Minerals or organic materials that remain suspended due to waters turbidity or because of their density is too close to that of water. They do not offer any major interference in relation to the water surrounding them (except for buoyant force which is a major factor of clarification and flotation phenomena)

Of these, colloidal suspension features very finely-divided solids (0.01 to 5µm) characterized by a major specific surface area ($cm^2.g^1$) and an electrostatic charge that is generally negative and which builds up at the solid/liquid interface. The suspensions which are often solids can also consist of liquid that is non-miscible in water and these are called mechanical emulsion, according to Degrĕmont (2007), if the emulsifiers at the water interface prevent any coalescing of droplets and therefore make the emulsion highly stable. Example is soluble oil.

2.4.2 Dissolved Substances or True Solutions

Dissolved substances involve mineral compounds or organic compounds, whether or not they have macromolecules as well as gases that are often highly water-soluble. Example is CO_2.

According to Alton (1998), six minerals make up about 90% of what is dissolved in water and these are calcium, magnesium, carbonate, sulfate, chlorides and sodium.

Also, all dissolved minerals are present in the form of electrically charged particles called ions. He continues to explain that calcium and magnesium ions in water are actually dissolved rock and are associated with hard water. When water is said to be soft, then it contains sodium as predominant metallic ion available.

2.5 Water Supply in Ghana

2.5.1 Access

The water supply infrastructure is insufficient, especially in rural areas and concerning sanitation. There are substantial discrepancies between access data from various sources, partially because of different definitions being used by different institutions that are providing access data (Joint Monitoring Program „"2008).

However, according to the multi-donor Africa MDG assessment, access to improved water sources is much lower (56%), (A Status Overview of Sixteen African Countries, 2006). The share of non-functional supply systems in Ghana is estimated at almost one third, with many others operating substantially below designed capacity (African economic outlook 2007). (OECD 2007).

2.5.2 Continuity of Supply

According to one estimate, only one quarter of the residents in Sekondi-Takoradi receive a continuous water supply, whereas approximately 30% are provided for 12 hours each day, five days a week. Another 35% are supplied for two days each week. The remaining 10% who mainly live on the outskirts of the capital are completely without access to piped water (Water Aid, 2008).

According to the water company Aqua Vitens Rand Limited. (AVRL), a joint venture of the Dutch Vitens Rand water services BV and Aqua Vitra Limited, residing in Accra, the situation is even worse: In February 2008, some communities within the Accra-Tema metropolis were served either once in a week, once in a fortnight or once in a month.

If even in the case of the capital city of Ghana, water supply is not sustainable, then the rural areas would probably suffer a great challenge in just the water supply let alone its quality and Anwiafutu community cannot be left out.

2.7 Challenges in Rural Water Supply

Water remains one of the most important sources of water supply in the rural communities and small towns in Ghana. Currently, over 95% of water provided to small communities and towns for domestic use is extracted from surface water source. However, the occurrence of high levels of minerals including metal compounds, especially ion and Manganese in most of these surface water sources has been identified as a challenge limiting the extent to which this resource can be exploited.

Drilling records have revealed that on the average, about 20% of surface water drilled for domestic water supplies contain high concentrations of Manganese or ion, or both metal compounds above the Ghana Standards Board permissible limits of 0-0.1 mg/L (Manganese) and 0-0.3mg/L (ion) for domestic water supply in some regions in the country including Eastern, Greater Accra, Central, Northern, Ashanti, Volta and Western. Low PH (Water Acidity) levels are also associated with surface water in most of the geological formations in these regions (CWSA, 2004).

Manganese and ion occur naturally in most of the geological formations in Ghana. In the Eastern Region for instance, the Togo Series, Voltaian and Birimian formations are noted for high levels of ion and Manganese.

Up to 41.5mg/L of ion and about 10.0mg/L of Manganese levels were detected in some boreholes. Drilling reports from CWSA also indicated that water quality of drilled wells have varied over severe cases water table fluctuation, weathering and geothermal changes in the geological formations are considered as major factors.

Research further shows that about 40% of drilled wells high ion or Manganese levels have been abandoned by user communities whiles about 60% are used only marginally for purposes other than drinking, cooking and laundry.

2.8 Water Pollution

Water pollution results when the level of the contaminant concentration restricts the potential uses of the water (Kuma, 2009).

According to Peirce, Weiner, and Vesilind (1998), "water is said to be polluted when it is altered in composition or condition directly or indirectly as result of human activities, so that it can become non unsuitable for its use in it natural form" Pollution of water as defined by GESAMP (1988), occurs when human introduce either by direct discharge to water or indirectly substances or energy that results in deleterious effects such as:

1. Harm to human health
2. Harm to living resources
3. Hindrance to aquatic activities such as fish
4. Impairment of water quality use in agriculture, industrial and economic reduction of amenity value Peirce et al (1998).

However, water pollution can result from two main types of action. These include

1. Introduction of substances into natural water causing physical or and chemical change.
2. Interception of all or part of a water resource Peirce et al (1978)

Also effect of these action results in the quality of the water being extremely affected render it less (or wholly) unsuited for human consumption or industrial use.

2.9 Surface Water Pollution

According to Hiscock et al; (2011), pollution can be defined as an impairment of water quality by chemicals, heat or bacterial to a degree that does not necessarily create an actual public health hazard, but does adversely affect waters for domestic, farm, municipal, commercial or industrial use. Bell, (2007) also defined pollution as the impairment through chemicals, heat or bacterial of water, either surface or ground water to the extent or degree which negatively affect the waters to be used for domestic, farm and others.

Andrews et al, (1998), also confirmed that a list of potential surface water pollutions would be almost endless, although one of the most common sources is sewerage sludge. This material arises from the separation and concentration of the waste materials found in sewage. Chilton et al, (1998), further gives detail sources of contamination to surface water and explains that the widespread use of chemical and organic pesticides or herbicide is another source.

The disposal of wastes in landfill sites lead to the production of leachate and gases which may present health hazards as a consequence of pollution of surface water supply. „"Municipal and industrial waste entering an aquifer(which may be classified as confined or unconfined depending on whether or not a water table or free water surface exists under atmospheric pressure) are major source of organic and inorganic pollution""(Warren et al; (2005).

2.9.2 Sources of Water Contamination.

The three important attributes distinguish sources of water contamination are:

1. Their degree of localization,
2. The type of contamination emanating from them and

3. Loading history

The term point and non-point sources describe the degree of localization of the source. The point source is characterized by the presence of an identifiable small-scale source such as leaking storage tank, one or more disposal pond and sanitary landfill. These may carry dissolved organic and inorganic solids, DOD, pathogenic organisms Kuma (2009).

A non-point source refers to large scale relatively defuse contamination originating from smaller sources, whose locations are often poorly defined. Examples of non-point contamination could include: nitrate that originates as a effluents from household disposal systems, ground or surface runoff of herbicides or pesticides that are used from agricultural sites, salt derived from highways in winter and acid rain, surface run off from urban areas, ground or surface runoff from construction sites, and areas of mining activities. (Kuma, 2009).

Again the major groups of contaminants include nutrients, trace elements, and inorganic species, organic and microbial contaminants Kuma (2004).

2.11 Water Quality

Water quality is a significant dimension of water to the health and the productive life of all living things.

Water quality is the closeness of water resources to their natural state, undisturbed by human activity. Kenneth (2002).

2.11.1 Features of Water Quality

The principal features of water qualities in Streams, Rivers, and Lakes with which the water engineer is most concern may be considered in the three groups Telbultt (1977)

1. Physical
2. Chemical
3. Biological

2.11.2 Physical

Solids form the most obvious extraneous matter to be carried along by a flowing river. The quantity and the types of solids depend on the discharge and flow velocity. The range from three trunks, boulders and other trash dislodge and carry away by flood to minute particle suspended in tranquilly flooding streams. The solids pollutant of rivers is derived from organic and inorganic sources. When evaluating quality for the potential use of water suspended in solids (SS) are measured in mg/L Shaw (2004).

Color, Tastes, and Odour are aesthetic properties of water that are judge subjectively and are caused dissolved impurities either natural sources or from the discharge of noxious substances into the water caused by man Shaw (2004).

Turbidity is the term for the cloudiness of water due to fine suspended colloidal particles of clay or silt, waste effluents or micro-organisms and is measured in turbidity units (NTU) based on the comparison scattering of light by a water sample with that of a standard suspension of formation Shaw (2004)

Electrical conductivity is a physical property of water that is dependent on the dissolved salts thus its measurement in micro-siemens per centimeter (US/cm) gives a good estimate of the dissolved solids content of a river Shaw (2004).

Temperature is a standard physical property characteristic that is important in the consideration of the chemical properties of water. Its measurement in ^{0}C, in natural rivers, also necessary for assessing effects of temperature changes on living organisms Shaw (2004). Also the temperature follows a diurnal variation, increases in day time and decreases during night.

2.11.3 Chemical Features

Hydrogen Concentration (pH) is a measure of the concentration of hydrogen ions (H+) and indicates the degree of acidity or alkalinity of water, pH=log 1/(H^+) and on the scale of 0 to 14. A pH of 7 is indicative of a natural solution. If the pH is less than 7 then the water is acidic, and if the pH is greater than 7, the water is alkaline Shaw (2004).

Dissolve Oxygen (DO) plays a large part in the assessment of water quality. It affects the taste of water, and a high concentration of dissolved oxygen in domestic supplies is encouraged by aeration. Values of dissolved oxygen are given in mg/L (O_2) (Shaw, 2004).

Total Dissolved Solids (DTS) is the measure of the amount of solids dissolved in water. It is obtained in mg/L as a chemical feature of water quality.

Biochemical Oxygen Demand (**BOD)** is a measure of the consumption of oxygen by micro-organisms (Bacteria) in the oxidation of organic matter. Thus a high BOD [mg/L (O_2)] indicates a high concentration of organic matter usually from waste water discharged (Shaw, 2004).

Nitrogen may be present in water in several forms in organic compounds (usually from domestic waste), as ammonia or ammonia salts, in nitrites or fully oxidized nitrates. Measures of nitrogen [mg/L (N)] gives indication of the state of pollution by organic wastes either larger quantity in the nitrate from being an indication of oxidation (Shaw, 2004).

Chlorides most often occurring in the NaCl common salt form are found in the brackish water bodies contaminated by seawater or groundwater aquifers with high salt content. The presence of chlorides (mg/L Cl) in a river is also indicative of sewerage pollution from other chloride compound Shaw (2004).

2.11.4 Biological Features

The existence of plant and animal life in rivers and other water bodies is a prime indicator of water quality and it has a different significance for the river engineer and the water supply engineer (Shaw, 2004). The growths of algae and populations of small aquatic animals can cause serious problems in pipes, reservoirs and other control works.

The content of micro-organics in water is of greater importance in the assessment of water quality for domestic supplies. Many harmful diseases are transmitted by water-borne organisms either within parasitic carriers like schistosoma causing billharzia, or as frees-swimming pathogenic bacteria and viruses. These can be isolated and identified only by microscopic examination of water samples. On a routine basis, the common organism found in all human excreta, Escherichia coli (E.coli), it is taken as an indicator of sewerage pollution. The measure of concentration in a water sample is the most probable number MPN per 100ml which is derived statistically from a number of samples. All supplies of water destined for human consumption must have regular bacteriological examination. (Shaw, 2004).

2.11.5 Surface Water Contamination

If a river is turbid, or coloured, or contains visible suspended matter or has an objectionable smell, it is rightly regarded by the average person as „polluted". The word pollution is derived from the Latin word *pollutes, which means* to soil, or to defile (Klein et al 1962).

Contamination is the impairment of water quality by sewage or industrial waste causing risk to public health. But pollution involves the introduction of anything which adversely and unreasonable impairs the beneficial use of water even though actual health risk may not be involved. (klein et al ,1962).

Water resources have been the most exploited natural system since man. On the other hand, rapid population growth, increasing living standards, wide spheres of human activities and industrialization have resulted in greater demand of good quality water while on the other, pollution of water resources is increasing steadily. (Peirce et al 1998).

It is part of the natural scheme of things that should cause environmental pollution in almost all what he does. Man-made pollution of water is divided mainly into two kinds; namely point and non-point sources (Fish 1995).Some water pollution comes from diffuse or "non-point" sources. For instance, airborne pollutants (from automobiles, factories, and power plants) and waterborne pollutants (from croplands, feed lots, logged forest and urban areas) can contribute significantly to river basin pollution (WRI 1992).

Apart from industrial and municipal wastes which represent specific point sources other specific sources of pollutants are bad land-use practices leading to soil erosion, the use of agricultural chemicals to increase yields, and livestock and human waste in rural areas adding to the organic pollution of water bodies. Jones, and White (1984).Fecal pollution of rivers largely comes from humans, animals and birds. The main fecal pollutants are coliforns, fecal streptococci and miscellaneous organisms. The cause disease such as dysentery, typhoid fever, cholera and gastroenteritis

Natural pollution of rivers may take place as a result of natural causes not necessarily associated with human activities. Pollution of this kind is generally small and intermittent, often connected with adverse weather conditions. Thus it may consist of runoff from land carrying silt, vegetable, manure, and many more. Washed into the river during a storm (klein et al 1962)

2.11.6 Physicochemical Parameters on Water

Water for drinking and food preparation must be free from organisms capable of causing disease and from mineral and organic substance producing adverse physiological effects. Smethurst (1979). The adverse effects of waste materials became acute in inland water systems due to their traditional role as receiving bodies‟ for effuents. Simultaneously, more areas have become dependent on surface water for their water supply due to depletion of natural groundwater reserves and the difficulty in exploiting new sources. At the same this precarious situation is not limited to inland waters since rivers carry their load of pollutants either in dissolved, colloidal or particulate form, to oceans. In many cases harmful substances also enter the food chain and concentrated in fish and other edible organisms particularly in near shore areas. (Alloway and Aryes 1993).

2.11.7 Hydrogen Ion Concentration (Ph) of Streams and Rivers

Acidity is the measurement of the base neutralization capacity of a volume of water. These are three types of acidity associated with pH; organic acidity associated with dissolved organic compounds and minerals acidity associated with dissolved metals. The sulphuric acid produced from the oxidation decrease the pH of water thus polluting the surrounding surface water Prowse, (1987). Where sulphate deposition is highest mineral-organic acidity is an important factor affecting the acidity of a water body. Where sulphate deposited is highest mineral-organic acidity is a more important factor affecting the acidity of a water body (Mattson et al, 2007). Although there are natural causes, the most common concern for changes in pH of water is that discharge from industrial effluent. Substance with pH less than 7 or more than 7 are acidity and basic respectively and the pH in most natural water ranges from 6.5 to 8.5. Michaud (1995). A low pH value in rivers (Morrison et al 2001) could impair recreational uses of the water; affect aquatic life and decreases solubility of certain essential element such as selenium and increase solubility of Aluminum, Boron, calcium, Cadmium, Mercury, manganese and ion.

2.11.8 Effect of Turbidity on River Water Quality

Turbidity measures the amount of light scattered from a sample (more suspended particles cause greater scattering). Michaud (1995) Water is normally transparent and clourless, but the environment water that we see is turbid in many cases. Turbidity is divided broadly into the following turbidity from soil particles, turbidity by organic pollutants drained from homes and factories, and turbidity caused by the growth of phytoplankton occurring in the stagnant water such as lakes and wetlands, many cases of turbidity from the soil particles are attributed to soil erosion, and are closely related to the destruction of forest. High turbidity, apart from seriously detracting aesthetic characteristics of water, may render the water unsuitable from domestic, industrial, agricultural and recreational uses. Excessive turbidity in water causes water purification problems with processes such as flocculation and filtration. Elevated turbidities are often associated the possibilities of microbiological contamination, as high turbidity makes it difficult to disinfect water property. As a rule when sewage is continuously discharge into river, turbidity levels increase and this affect the water quality of river. The degree of turbidity of stream water is, therefore often taken to be an approximate measure of the intensity of pollution. Indeed measurement of turbidity of rivers can be used to evaluate the effects of water pollution by waste waters and even to follow the course of self-purification of streams (Klein et al.,2001)

2.11.9 Conductivity as an Indicator of Salinity in Rivers

Conductivity is a measure of ability of eater to conduct an electric current. It is sensitive to variations of dissolved solids mostly minerals salts, and is also affected by temperature. The warmer the water, the higher the conductivity and for this reason conductivity is reported as conductivity at 25 ^{o}C. It is used to judge presence of metals. A high conductivity value indicates a high level of metals. The high conductivities could be attributed to high mineral salt concentration which becomes the dissolution of minerals in the soil or by run- off from dumps at the source of the stream or by effluent discharges into stream. The presence of inorganic compounds water makes to exhibit high conductivities (Ntengwe , 2006).

High salt concentration in waste effluents can increase the salinity of the receiving water, which may result in adverse ecological effects on aquatic biota.

Very high salt concentration (>1000mg/1) imparts a brackish salty taste to water and this causes health risk. For this reason electrical conductivity can serve as a useful salinity indicator when considered with other factors and when a natural geological origin does not apply in terms of source of dissolved salts (Morrison et al, 2001) (Barnes et al 1996) indicated that concentration of dissolved salts of a single body of water varies systematically with evaporation (causing increased conductivity) or rainfall (causing decreased conductivity)

Effect of Total Suspended Solids on Water Quality of Rivers

Inorganic solids such as clay and silt constitute total suspended solids (TSS). Total suspended solids are particles of different materials that remain suspended in water. Water human‟s beings and reduces the growth rate of fish. The TSS also provides adsorption sites for chemical biological agents. It is related to turbidity in that if TSS is high, turbidity will also be high (Ntengwe, 2006).

As levels of TSS increase, a water body begins to lose its ability to support diversity of aquatic life. Subsequently decreases levels of dissolved oxygen (warmer water holds less oxygen than cooler water). Photosynthesis also decreases, since less light penetrate the water. As less oxygen is produced by plants and algae, there is a further drop in dissolved oxygen levels. TSS can also destroy fish habitat because suspended solids settle to bottom and can eventually blanket the river bed. Suspended solids can smother the eggs of fish and aquatic insects and can suffocate newly-hatched growth rates and lowering resistance to disease. Changes to the aquatic environment may result in diminished food sources, and increased difficult in finding food. Natural movements and migrations of aquatic populations may be disrupted (carlon, 2005). TSS and turbidity values vary naturally for two main reasons- one physical, the other biological. Heavy rains and fast-moving water are erosive. They can pick up and carry enough dirt and debris to make any stream look dirty. So heavy rainfall may cause higher TSS concentration or turbidity, unless the additional particles are dispersed throughout large volumes of flood water. Michaud, (1995).

Total Dissolved Solids as a Measure of Water Quality

The total dissolved solids (TDS) in water comprise inorganic salts and small amounts of organic matter which could be filtered through a sieve of mesh size 2µm. the principal ions contributing to TDS are carbonate, bicarbonate, chloride, sulphate, nitrate, sodium, potassium, calcium and magnesium. The total dissolved solids originate from natural sources, sewage effluent discharge, urban run-off or industrial waste discharge (Ntengwe, 2006). A high TDS (Ntengwe, 2006) has high concentration of mineral salts which is not for human consumption. Increased levels of dissolved solids also results in reduction of dissolved oxygen in water and fish die of sudden lowering of oxygen in streams/rivers. It was also noted that the amount of dissolved material in a sample correlates to electrical conductivity.

Biochemical Oxygen Demand in Rivers

The biochemical oxygen demand (BOD) is an approximate measure of amount of degradable organic matter in water. It is defined as the amount oxygen required by aerobic microorganisms to oxidize the organic matter to stable inorganic from (Ntengwe, 2006). When the river basin is covered with rainforest, that is a big reservoir of plants and animal wastes in substantial quantity, this can account for large amounts of organic matter in a river and high values of BOD .Most of the organic compounds and materials can be broken down by micro-organisms presents in river, water, and dissolved oxygen is used up in these biochemical reactions. If the organic pollution load is small and the dilution by well oxygenated stream water is high, sufficient dissolved oxygen (DO) may be present to enable certain bacteria , thus aerobic bacteria which require free oxygen to break down the organic matter completely to relatively harmless , satbleamd odorless end products. The river thus recovers naturally from the effects of pollution and is said to have undergone‟ self-purification‟ (klein, 1962). Typical BOD values are<3mg/1 for class 1A river in the Uk(the least polluted), < 5mg/1 for class 1B, < 9mg/1 for class 2 (more polluted and only suitable for portable supply after advanced treatment) and < 17mg/1 for class.

2.12 Basic Water Quality Test Parameters

According to Mackenzie (2008), basic Water Portability Test packages include tests for, Coliform Bacteria, Nitrate, pH, Sodium, Chloride, Fluoride, Sulphate, Ion, Manganese, Total Dissolved Solids and Hardness

Coliform bacteria tests are used as an indicator test for the presence of microorganisms in the water that are potentially harmful to human health. Nitrate is a common contaminant found mainly in groundwater. High nitrate concentrations can be particularly dangerous for babies under six months, since nitrate interferes with ability of blood to carry oxygen. Ions such as sodium, chloride, sulphate, ion and manganese can impart objectionable taste or odor to water.

Excessive amounts of sulfate can cause a laxative effect or gastrointestinal irritation, along with a noticeable taste. Fluoride is an essential micro-nutrient, but excessive amounts can cause dental problems.

Total dissolved solids represent the amount of inorganic substances (e.g. ion, salts) that are dissolved in the water. High total dissolved solids (TDS) can reduce the palatability of water.

Other tests may be appropriate if there is a particular reason to suspect that a specific contaminant may be present or if additional background information is desired. Groundwater sources are sometimes tested for parameters such as arsenic, selenium and uranium. Both surface and groundwater sources are also sometimes tested for pesticide contamination.

Private drinking water supplies should undergo basic testing annually at a minimum. Drinking water supplies obtained from shallow wells and surface water sources should be tested more frequently, such as seasonally as they are highly susceptible to contamination.

Mackenzie (2008) highlights on various characteristics of water test parameters;

Microbiological Characteristics

2.12.1 Microbiological Indicator

Laboratory results may provide information on the levels of Total Coli forms, Escherichia coli (E-Coil), and Heterotrophic Plate Count (HPC) which are used as microbiological indicators of the microbiological quality of the water. This section will briefly outline the rationale for including these indicators and their significance.

2.12.2 Total Coli form (TC)

The presence of Total Coli form bacteria may indicate contamination in a water supply. The presence of only Total Coli forms is not necessarily a health risk, but it does require a further investigation of the water system. The presence of any coli form bacteria indicates that the drinking water is potentially unsafe and unsatisfactory.

The absence of coli forms in water supply is usually interpreted as evidence of safe drinking water. This indicates that the water is free of pathogens and contains a low risk of waterborne infectious disease.

2.12.3 Escherichia Coli (EC/E.Coli)

E. coli has been demonstrated to be a specific indicator for the presence of fecal (human or animal waste) contamination. This is a potentially dangerous situation. Immediate steps need to be taken to disinfect the water, remove the source of contamination or find an appropriate alternate source. Water containing E. Coil bacteria must not be consumed or used where the water could be a health hazard. Even brushing your teeth with this water can pose a significant health risk.

2.12.4 Heterotrophic Plate Count (HPC)

Although this test is not normally part of the standard testing for homeowners it can provide some useful information regarding the microbiological quality of our water.

The HPC bacteria enumerate both aerobic and facultative aerobic bacteria found in water. These bacteria are not normally used as an indicator of disease, and bacteria in this group are not usually directly associated with a specific illness or disease. However bacteria within the HPC can cause disease, both as primary pathogens and opportunistic pathogens.

The HPC is useful for measuring changes during water treatment and distribution. It is valuable for checking quality of finished water in a distribution system as an indicator of microbial re-growth and sediment build-up in slow-flow sections and dead ends.

Physical Characteristics

2.12.5 Fluoride and Ion

"The major problems associated with groundwater quality are the occurrence of fluoride and ion. Fluoride occurs mainly in the Eastern corridors of the region." (Daily Graphic, February 2006).

If that is the case, then any groundwater containing fluoride and ion more than the specified range by the Ghana standard board would have adverse effect on the people.

According to Joint department of army and Joint department of army and air force Manual (2008), an excessive fluoride concentration will damage the teeth of children using the water for extended periods. On the other hand, moderate concentrations, 0.7 – 1.2mg/l are beneficial to their teeth. Fluoride is one of the most reactive non-metal compounds that are common in groundwater in Ghana. The most affected parts of Ghana are the Upper East, Upper West and Northern regions.
Studies indicate that the proportion of water sources (boreholes) with fluoride levels higher than 1.5mg/L (WHO/Ghana Standards Boards Permissible Limit) is in the range 20 – 30%.

Because the element is reactive, it forms many complexes with several other elements and makes it difficult to remove using physical treatment methods. Fluoride is also one of few chemicals known to cause significant health effects through drinking water. High levels of fluoride compounds are available in igneous, sedimentary rocks and some metamorphic rocks.

2.12.7 Ion and Manganese

Dissolved ions and manganese is enumerated principal in groundwater devoid of dissolved oxygen. Stagnant water found in the bottom of thermally – stratified reservoirs, sometimes contains dissolved ion and manganese (Joint department of army and air force Manual, 1985).

The levels of ion as low as 0.2 to 0.3 mg/L will usually cause the staining of laundry and plumbing fixtures. The presence of ion bacteria in water supplies will often cause these symptoms at even lower levels. Ion gives water a metallic taste that may be objectionable to some at 1 to 2 mg/L. most water contains less than 5 mg/L ion, but occasionally, levels over 30 mg/L are found.

2.12.8 Color

According to Karikari and Asare (2006), color is often due to natural organics or dissolved inorganic compound such as ion and manganese.

Mackenzie, (2008) explains that, some color is caused by colloidal ion or manganese completes, although the most common cause of color is from complex organic compounds that originate from decomposition of organic matter. Color is a combination of dissolved and colloidal materials. An increase in the colour of water in reservoirs results in increases in treatment cost. Karikari et al. (2006).

2.12.9 Turbidity

As Degrĕmont 2007, specified from the table comparing surface water to ground water as related to suspended solids, Mallevialle, (1992), describes turbidity as related to organic contents in water. Particles of matter are naturally suspended in water.

These particles can be clay, slit, finely divided organic and inorganic matter, plankton and other microscopic organisms. Turbidity is a measurement of how light scatters when it is aimed at water bounces off the suspended particles. It is not a measurement of the particles themselves.

In general terms the cloudier the water, the more the light scatters and the higher the turbidity. The treated water turbidity target is 0.1 NTI (nephelometric turbidity units).

2.14 Water-Related Diseases

According to Adombire (1996), a water-borne disease is transmitted when the pathogen in water is drunk by an animal or human and may then become infected. Water borne diseases include cholera and typhoid, infectious hepatitis and bacillary dysentery.

The strategies to adopt to prevent water borne diseases include all measures to improve water quality and prevent casual use of unimproved sources of water.

Adombire, continued to explain that when the prevalence of a disease falls owing to increases in the volume of water used for other purposes, irrespective of the quality of that water, then the diseases is said to be water-washed.

Water-washed diseases are of three main types. The first is infections of the intestinal tract such as diarrhea and are all fecal-oral in their transmission route. The second is infections of the skin and eye. Bacterial skin sepsis, scabies and cuteness fungal infections cause morbidity in hot climates and eye infections may lead to blindness.

The third is those infections carried by fleas, lice, mites or ticks. For a water-based disease, the pathogens spend part of its life cycle in an intermediate aquatic host or hosts.

One example is schist is in which water polluted by excreta contains aquatic snails in which the schist some larvae develop until infective cercariae are shed into the water and infect man through the skin.

In 1989, Ghana had 179,556 cases of guinea worm (which is also another example of water washed disease) from a 6,515 villages. By 1994, the number of cases dropped by 95% to 8,400.

However, as at the end of 2003, a period of 9 years, Ghana still had 8,253 cases, making it second to the Sudan as the most endemic in the world (Adombire, 1996). Hence, there is the need to work hard on water consumed by users of the country so as to fight these diseases. Whether the source of particular water seems to be potable (by observation) or not, tests must be conducted to reinforce the fact.

2.15 Water Diseases via Chemical Elements

Certain diseases are not caused by fecal or other contaminable means. They are caused by over-intake or presence of overdose chemical substances in water. Such chemical elements are aluminum, fluoride and so forth. From lenntech.com, various chemical elements and their health implications have been elaborated as outlined below;

2.15.1 Aluminum (Al)

Health Effects of Aluminum in Water

Daily aluminum intake is approximately 5 mg, of which only a small fraction is absorbed. This leads to relatively low acute toxicity. Absorption is about 10 µg per day. These amounts are considered harmless to humans. Silicon may decrease aluminum uptake. However, once the element is taken up in the body it is not easily removed. Large aluminum intake may negatively influence health. This was connected with nerve damage. Particularly people with kidney damage are susceptible to aluminum toxicity. There is a risk of allergies. Aluminum is probably mutagenic and carcinogenic. A correlation between aluminum uptake and an increase number of Alzheimer cases is suspected. However, this is uncertain because aluminum concentrations always increase with age. Increased aluminum intake may also cause osteomalacia (vitamin D and calcium deficits).

Aluminum intake mainly occurs through food and drinking water. The most recent standards were between 50 and 200 µg/L. aluminum particles may cause functional lung disorder. According to WHO and Ghana standard board, GS (175-part 1 : 1998), the range of aluminum content in water should not exceed 0.2mg/L.

2.15.2 Arsenic (As)

Health Effects of Arsenic in Water

Arsenic related illness is usually caused by consumption of contaminated drinking water. In the old days it was applied as a poison, because symptoms of arsenic poisoning resemble cholera symptoms, and therefore the international factor was shaded.

A possible safe dose for humans was calculated. If arsenic is a dietary mineral, this does would be 15-25 µg. this amount could be absorbed from food without any trouble. The total amount of arsenic in a human body is about 0.5-15 mg.

Humans can develop resistance to certain arsenic concentrations. Shortly after absorption arsenic can be found in liver, spleen, lungs and digestive tract. Most arsenic is excreted, and residues may be found in skin, hair, nails, legs and teeth. Under conditions of prolonged exposure, many organs may be damaged, skin pigmentation may occur, hair may fall out and nail growth may stop. Arsenic in drinking water is an issue of global importance; therefore the legal limit was decreased to 10 µg/L. this legal limit is not met to countries such as Vietnam and Bangladesh, where millions of people consume drinking water with an arsenic content of over 50 µg/L. this problem results in long-term chronic health effects, such as skin disease, skin cancer, and tumors in lungs, bladder, kidneys and liver.

2.15.3 Calcium (Ca) Health Effect S of Calcium in Water

Calcium is naturally present in water. It may dissolve from rocks such as limestone, marble, calcite, dolomite, gypsum, fluorite and apatite. Calcium is a determinant of water hardness, because it can be found in water as Ca^{2+} ions. Magnesium is the other hardness determinant (Alton, 1998).

Examples of calcium applications are calcium hypo chloride as bleach and for disinfection, calcium phosphate in glass and porcelain industries, calcium poly-sulphate and hydroxide as flocculants in wastewater treatment, and calcium fluoride as turbidity agent in enamel industries, in UV-spectroscopy, and as a raw material for fluid acid production. According to WHO (Geneva 2009) and the GSB (175-part 1: 1998), the range of calcium in water was not specified. This might be as a result of calcium required in large quantities. Calcium is a dietary mineral that is present in the human body in amounts of about 1.2 kg. no other element is more abundant in the body.

Calcium phosphate is a supporting substance, and it causes bone and tooth growth, together with vitamin D. calcium is also present in muscle tissue and in the blood. It required for cell membrane development and cell division, and it is partially responsible for muscle contractions and blood clotting. Calcium carbonate works as a stomach acid remedy and may be applied to resolve digestive failure. Calcium lactate may aid the body during periods of calcium deficiency, and calcium chloride is a diuretic. Hard water may assist in strengthening bones and teeth because of its high calcium concentration. It may also decrease the risk of heart conditions. Drinking water hardness must be above 8.4 ^{o}dH. Calcium carbonate has a positive effect on lead water pipes, because it forms a protective lead (II) carbonate coating. This prevents lead from dissolving in drinking water, and thereby prevents it from entering the human body. When one takes up large amounts of calcium this may negatively influence human health.

2.15.4 Ion (Fe)

The total amount of ion in the human body is approximately 4 g, of which 70% is present in the red blood colouring agents. Ion is a dietary requirement for humans, just as it is for many other organisms. Men require approximately 7 mg ion of a daily basis, whereas women require 11 mg. the difference is determined by menstrual cycles. When people feed normally these amounts can be obtained rapidly.

The body absorbs approximately 25% of all ions present in food. When some is ion deficit feed ion intake may be increased by means of vitamin C tablets, because this vitamin reduces tertiary ion. Phosphates and phytates decrease the amount of binary ion.

In food ion is present as binary ion bound hemoglobin and myoglobin, or as tertiary ion. The food may particularly absorb the binary form of ion. Ion is a central component of hemoglobin. It binds oxygen and transports it from lungs to other body parts. It than transports CO_2 back to the lungs, where it can be breathed out. Oxygen storage also requires ion. Ion is a part of several essential enzymes, and is involved in

DNA synthesis. Normal brain functions are ion dependent. In the body ion is strongly bound to transferring, which enables exchange of the metal between cells. The compound is a strong antibiotic, and it prevents bacteria from growing on the vital element. When one is infected by bacteria, the body produces high amounts of transferring. When ion exceeds the required amount, it is stored in the liver. The bone marrow contains high amounts of ion, because it produces hemoglobin. The total ion content required in water according to Ghana Standards board, (GS 175-part 1: 1998) must not exceed 0.3 mg/L.

Health Effect of Ion in Water

Ion deficits lead to anemia, causing tiredness, headaches and loss of concentration. The immune system is also affected. In young children this negatively affects mental development, leads to irritability, and causes concentration disorder.

2.15.5 Lead (Pb)

The World Health Organization (WHO) stated a limit of 50 ppb for lead in 1995, which is decreased to 10 ppb or 0.01 mg/L in 2010.

Health Effects of Lead in Water

The human body contains approximately 120 mg of lead. About 10-20% of lead is absorbed by the intestines. Symptoms over overexposure to lead include colics, skin pigmentation and paralysis. Generally effects of lead poisoning are neurological or teratogenic. Organic lead causes necrosis or neurons. Inorganic lead causes axonal degeneration and demyelization. Both species of lead may cause cerebral edema and congestion. Organic lead compounds are absorbed quicker, and therefore pose a greater risk.

Lead causes menstrual disorder, infertility and spontaneous abortion, and it increases the risk of stillbirth. Fetuses are more susceptible to lead poisoning than mothers, and generally fetuses even protect mothers from lead poisoning. A long time ago lead was applied as a measure of birth control, for example as a spermicidal, and to induce abortion.

Children may absorb a larger amount of lead per unit body weight than adults (up to 40%). Consequently, children are generally more susceptible for lead poisoning than adults. Symptoms include lower IQs, behavioral changes and concentration disorder. Lead accumulates in leg tissue. The most severe type of lead poisoning causes encephalopathy.

2.15.6 Magnesium (Mg)

Magnesium and other alkali earth metals are responsible for water hardness. Water containing large amounts of alkali earth ions is called hard water, and water containing low amounts of these ions is called soft water. Alton (1998).

Water hardness may differ per region, therefore adding softeners to detergents is unnecessary for regions that only contain soft water. In regions containing hard water higher doses of detergent may be applied, in order to add more softener. This causes other substances in detergents to be dosed to high, thereby complicating the wastewater treatment process. A possible solution to this problem is dosing different compounds in detergents yourself.

2.15.7 Potassium (K)

Health effects of potassium in water

Potassium shortages are relatively rare, but may lead to depression, muscle weakness, heart rhythm disorder and confusion. Potassium loss may be a consequence of chronic diarrhea or kidney disease, because the physical potassium balance is regulated by the kidneys. When kidneys operate insufficiently, potassium intake must be limited to prevent greater losses. Skin contact with potassium metals result in caustic potash corrosion. This is more hazardous than acid corrosion, because it continues unlimitedly.

Caustic potash drops are very damaging to the eyes. The intake of a number of potassium compounds may be particularly harmful. At high doses potassium chloride interferes with nerve impulses, which interrupts with virtually all bodily functions and mainly affects heart functioning.

2.15.8 Zinc

Health effects of zinc in water

Zinc is naturally present in water. The human body contains approximately 2.3 g zinc, and zinc has a dietary value as a trace element. Its functions involve mainly enzymatic processes. The human hormone insulin contains zinc, and it plays an important role in sexual development. Minimum daily intake is 2-3 g, this prevents deficiencies. The human body only absorbs 20-40% of zinc.

2.15.9 Sulphate

The sulphate easily precipitates and settles to the bottom sediment of the river as Mallevialle, (1992).

2.16 Water Quality Requirements

Water from river, streams, wells and borehole must meet specific quality requirement before they can be supplied to distribution centers of consumption. John (2005).

Water Quality Index (WQI)

Water Quality Index is a chemical index of water pollution that measures range of parameters in the natural waters and produces a score describing the water quality. Parameters chosen may include dissolved oxygen, BODs, phosphate, ammonia, nitrate chloride, phosphates suspended solids, temperature and coli form bacteria. WHO (2009).

2.16.1 Water Quality Standards

Water quality standards are regulations that set specific limitations on the quality of water that may be applied to a specific use Kuma (2004).

Human health is of prime concern when dealing with water quality. This has necessitated in the establishment of guidelines for water quality analysis by authorized organizations. The world health organization (WHO) recognizes the dangers on the internal scale and has published recommended standards for drinking water WHO (2009).

Table 2.1: International Water Quality Guidelines

INTERNATIONAL WATER QUALITY GUIDELINES WHO (2006)

PARAMETER	UNIT	WHO GUIDELINE
PH	Mg/l	6.5 – 8.5
COLOUR	H_z	0 – 15
TEMPERATURE	O°C	-
TDS	Mg/l	1000
TSS	Mg/l	1000
CONDUCTIVITY	Us/cm	1000
TURBIDITY	NTU	5
ALKALINITY	Mg/l	200
MANGANESE	Mg/l	0.1
CHLORIDE	Mg/l	250
TOTAL HARDNESS	Mg/l	500

WHO (2006)

ENVIRONMENTAL PROTECTION AGENCY WATER QUALITY GUIDELINES

PARAMETERS	UNITS	MAXIMUM PERMISSIBLE LEVEL
PH	Mg/l	6 – 9
COLOURE	H_z	2000
TEMPERATURE	^OC	<3 above ambient
TDS	Mg/l	100
TSS	Mg/l	50
CONDUCTIVITY	Us/cm	150
TURBIDITY	NTU	7.5
ALKALINITY	Mg/l	200
MANGANESE	Mg/l	0.1
CHLORIDE	Mg/l	250
TOTALHARDNESS	Mg/1	250

EPA GHANA (2006)

2.17 Water Consumption, Assess and Coping Costs

Wide differences exist between water consumption levels in industrialized and developing countries. Average per capita daily water consumption (l/c/d) for Switzerland, the least among industrialized counties, is 110/ 1/c/d, USA (668 1/c/d) and Japan (342 1/c/d((World Bank, 1997b as cited by Rosen and Vincent, 1999). In comparison, although at the village level, an average of 11.1 1/c/d is observed for a village in Mozambique with a centrally located standpipe 300 metres away. Consumption averaged only 4.1 1/c/d (ibid, 1987) in another village in the same country with similar water source located 4 km away from home. It was reported an average of 232 lites per day household or 1/c/d for two wetland communities in northern Nigeria. In Madagascar, a survey of 180 households in 8 villages reveals that on the average households consume 31 liters of water daily in the dry season (Minten et al., 2002) No such documented information exists for rural communities in Ghana. What is available is a survey conducted by London Economics (1999) on behalf of the Ministry of Works and Housing (MWH) in major urban areas to justify the introduction of Private Sector Participation (PSP) in urban water sector. They report an average of 105.1 1/c/d for those using other means, with an average domestic water demand estimated at 52 1/c/d for urban sector. For example, a national water supply and sanitation survey conducted in 1993 showed that only 46% of the rural population had access to potable water while the urban population had 76% coverage (Ministry of Works and Housing 1998). Many households therefore depend on multiple water sources, including rainwater for multiple uses. Because in rural areas most of the water used comes from unimproved or traditional sources, their level of quality is questionable. Households cope with these prevailing conditions by undertaking water storage measures, which have time and financial implications.

It was observe that in the Chiduku communal area in Zimbabwe approximately 91% of total time devoted to water collection is carried out by women and girls whilst in Arusha, Tanzania, they account for 75% of this time. In 8 rural communities in Madagascar, Minten et al., (2002) indicate that women constitute 87% water carriers and spend an average of 12 minutes (one-way) undertaking this daily activity.

In a village in Mozambique, indicate that about 5 hours is devoted to water collection (return trip) from a public standpipe located 4 kilometers (average of 131 minutes per carrier per day) whilst a similar source located 300 meters takes an average of 25 minutes per carrier per day. Women in Oyo State, Nigeria spend about 58 minutes daily collecting water at an average distance of 537 meters.

Locating improved water supplies within reasonable distances to households saves time and possibly increases total water consumption. Although the World Health Organization (WHO) considers 200 meters as a convenient distance, Sharma et al., (1996) as cited by Rosen and Vincent (1999) points out that when rural households‟ perceptions of accessibility are considered, the percentage of households with safe water supply access could substantially reduce and may approach zero in some cases. It was find that improving accessibility by constructing boreholes in villages in Nigeria reduced daily water fetching times from 360 minutes to 45 minutes. Through rain water harvesting, women in Sri Lanka saved 2 hours (opportunity costs) daily by a reduction in the number of trips to dug wells and springs from 8 to 3 per day. As a result, rainwater consumption increased in dry and wet seasons between to 50 to 70%. Such substantial amount of time saved could improve women‟s welfare through time and energy availability for education, high-status work and civic activities (WHO, 1995) when it has been estimated that as much as 25% of women‟s productive time in developing countries could be allocated to this task.

2.18 Methods of Quarry Mining

Quarrying is carried out by different methods and equipment, such as hand tools, explosives, or power saws, and by channeling and wedging, according to the purpose for which the stone is extracted Stock (1978), Hand tools alone may be used for quarrying stone that lies in easily accessible beds. The principal hand tools are the drill, hammer, and wedge. A row of holes several centimeters apart is made with the drill and the hand hammer, partly through the layer, or stratum, perpendicular to its plane of stratification and along the line at which it is desired to break the stone.

United Nations Conference on Trade and Development (UNCTAD) (2005) also provides that in quarry operations each hole in a long row is filled with three wedges, shaped so that one may be driven down through the others, the method being known as plug and feathers; by striking each plug a sharp blow with a hammer, hitting them in succession, and by repeating the operation several times, the combined splitting force of the plugs and feathers finally becomes great enough to rupture the rock.

Explosives are most commonly employed for detaching large blocks of stone, which are then split and broken into smaller stones by wedges or by the plug-and-feathers me.5t.5hod, or crushed by a heavy steel ball weighing several tons. In this method of quarrying, the drill holes are put down to the depth to which it is required to break the rock and are then partly filled with some explosive that is discharged by the usual methods of blasting (Redmond, 2005). To obtain finely crushed stones for concrete, primary crushers, of the jaw or gyratory type, and secondary crushers are used to reduce the size of the rocks Darimani,A. (2001).

Channeling is the process of cutting long, narrow channels in rock to free the sides of large blocks of stone. Channeling machines, or channelers, formerly steam driven have now been generally replaced by gasoline or electric engines. These are self-propelling and move a cutting edge back and forth along the line on a rock bed on which the channel cut is to be made. The channel cut is sunk deep enough to permit the insertion of wedges by which the rock is split, the cut or groove guiding the fracture (World Bank, 2003). The channeling and wedging process of quarrying is extensively used in quarrying marble, sandstone, limestone, and the other softer rocks, but is not successful for granite and other hard rocks.

Another method of cutting is by the combination of a power saw, an abrasive, and water as a lubricant and a coolant. The saw cuts a narrow channel, the primary or initial cut that is then either expanded by a wedge or is blasted. This method is used in slate, granite, and limestone quarries.

An automatic channel burner has recently come into commercial use in dimension-stone mining. It resembles a handheld burner held vertically in a frame, with an electric motor moving the whole unit slowly down a track. It makes a more even cut, does not require the presence of an operator, and wastes less rock. The unit is controlled by a computer (Killick, Kayizzi-Mugerwa, Savane&Nial White, 2001).

Uses of gravel

Construction purposes

Gravel and crushed rock, represents the main source of construction aggregates used throughout the world Kesse (1985). Gravels are used in constructing roads, buildings, bridges, dams etc. In construction, crushed stone is used as an aggregate in concrete mixes. The stone binds the mix together when it hardens. Almost 60% of all crushed stone is used as aggregate in highway concrete and asphalt.

Aquarium

Aquarium gravel and other substrate form the bed at the bottom of freshwater aquariums. In addition, it supports decorations and furnishings that act as habitat that you will be putting inside the aquarium. It also supports aquatic plant life providing an anchor for their roots. The aesthetic quality is not the only consideration though when choosing aquarium substrate for the bottom of your tank. There are certain things that should be kept in mind to make the appropriate choice of aquarium gravel or other substrate.

It is important to understand that the substrate bed plays a major role in the nitrogen cycle inside your aquarium as well as other chemical cycles. The nitrogen cycle is very important for the survival of your fish. Bacteria that that grow in the aquarium gravel or sand eradicate unwanted ammonia and nitrates from the aquarium. An understanding of the requirements for a good aquarium gravel bed must therefore be understood, at least at the basic level, for both the aesthetic and biological functions (Walker, 2009).

2.18.1 Environmental Impact of Quarry Mining

2.18.1.1 Air pollution

Down, Banez, Ajaon, Bilolo and Dailyn (2010) Potential health impacts are almost exclusively linked to the presence of airborne dusts, in particular reparable particles, *i.e*. those that are less than 10µm in diameter (also known as PM10), have the potential to affect human health, including effects on the respiratory and cardio-vascular systems . According to Down, et al (2010). In-halation of dusts can cause “pneumoconiosis” which is a term that refers to a group of lung diseases.

According to (Matt Kallman, 2008), outdoor air pollution alone causes an estimated 800,000 deaths each year (an additional 1.6 million premature deaths are attributable to indoor air pollution, the subject of a previous (Earth Trends Monthly Update). In many urban areas, especially in the developing world, air pollution is the single greatest environmental threat to human health (WDI, 2007).

Dust from mining sites is a major source of air pollution, although the severity will depend on factors like the local microclimate conditions, the concentration of dust particles in the ambient air, the size of the dust particles and their chemistry, for example limestone quarries produce highly alkaline (and reactive) dust. In Togo, most of the roads are not tarred, they are dusty and bumpy during transportation of sand and gravel a lot of dust particles which sometimes can lead to road accidents.

The air pollution is not only a nuisance (in terms of deposition on surfaces) and possible effects on health, in particular for those with respiratory problems but dust can also have physical effects on the surrounding plants, such as blocking and damaging their internal structures and abrasion of leaves and cuticles, as well as chemical effects which may affect long-term survival. Hence patients prone to heart disease may one day be told by physicians to avoid not only fatty foods and smoking but air pollution too (Science daily, 2008).

Noise pollution

Some countries more than others, some cities more than others, some streets more than others yet noise is everywhere and noise problems will continue to increase in time Anon, (1990) No one on earth can escape the sounds of noise- an unwanted, disturbing sound that causes a nuisance in the eye of the beholder. Noise is a disturbance to the human environment that is escalating at such a high rate that it will become a major threat to the quality of human lives, (Anon, 1990). Unfortunately, quarrying involves several activities that generate significant amounts of noise. It starts with the preparatory activities, such as establishing road or rail access, compound and even mineral processing facilities. Next is the process of exposing the mineral to be extracted and this is usually done by removing the top soil and other soft layers using a scraper, or hydraulic excavators and dump trucks. The excavation of the mineral itself will involve considerable noise. Following this, the use of powered machinery and dump trucks to transport the materials to the construction sites as well as possibly processing plants to crush and grade the minerals, all contribute even more noise to the environment.

Noise generated within the immediate surrounding area in the course of blasting, quarrying and crushing the rocks can do and does a lot of damages to some of the stakeholder groups. For instance rock blasting causes ground vibration

The vibration can give rise to other ugly developments such as land slide or earth tremors. Generally the noise frightens away part of the fauna in such a locality. The deliberate deforestation of an area for mine development may cause the elimination of some plants and exodus of some animal/bird species that feed on such plants or depend on them for Adepelumi et al, Although noise is a significant environmental problem, it is often difficult to quantify associated costs. An OECD report on the social costs of land transport identified four categories of impact from transport noise (OECD, 2001):

i. productivity losses due to poor concentration, communication difficulties or fatigue due to insufficient rest;
ii. health care costs to rectify loss of sleep, hearing problems or stress;
iii. lowered property values iv) loss of psychological well-being.

Damage to biodiversity

One of the biggest negative impacts of quarrying on the environment in Togo today is the damage to biodiversity. Biodiversity essentially refers to the range of living species, including fish, insects, invertebrates, reptiles, birds, mammals, plants, fungi and even micro-organisms. Biodiversity conservation is important as all species are interlinked, even if this is not immediately visible or even known, and our survival depends on this fine balance that exists within nature.

Aggregate mining carries the potential of destroying habitats and the species they support. It is causing such damage to the bio-diversity as well as catastrophically resulted into pollution, introduction of alien species, over-harvesting of natural resources and destruction of habitats Gbedzi, (2007). Even if the habitats are not directly removed by excavation, they can be indirectly affected and damaged by environmental impacts – such as changes to ground water or surface water these has caused some habitats to dry out and others has become flooded. Even noise pollution has had a significant impact on some species and affects their successful reproduction.

Quarry waste

Again, like many other man-made activities, gravel and sand mining involves the production of significant amounts of waste. Some types of quarries do not produce large amounts of permanent waste, such as sand and gravel quarries, whereas others will produce significant amounts of waste material such as clay and silt. The good news is that they are generally inert and non-hazardous, unlike the waste from many other processes. However, there is still potential for damage to the environment, particularly with water contamination. For example, suspended particles may imbalance freshwater ecosystems. Large amounts of solids can also exacerbate flooding, if it is dumped on the flood plains. The accumulation of waste by-products will still need to be stored and managed somewhere that will not affect the environment in an adverse manner. Furthermore, the treatment and disposal of the waste may produce more negative impacts on the environment.

While quarries can cause significant impact to the environment, with the right planning and management, many of the negative effects can be minimized or controlled and in many cases, there is great opportunity to protect and enhance the environment, such as with the translocation of existing habitats or the creation of new ones.

Sand mining in quarries on the outskirts has damaged in the landscape. It leaves a chaotic landscape with isolated knolls in some places. The vegetation is completely destroyed. The soil becomes vulnerable to erosion and runoff waters as a result of the destruction of layers this has also threaten rail tracks.

These quarries, mostly underground, remain as such after depletion. No filling process accompanies the post exploitation. This results in large areas which serve as points of accumulation for runoffs. These are potential breeding grounds for mosquito larvae during the rainy season; these mosquitoes can cause malaria which is a killer disease.

The exploitation further accentuates the problem of coastal erosion which continues to the Eastern Port. Indeed, the swell drops items which it carries towards Western Port. It became more violent beyond the dam and through breakers (waves) it proceeds in undermining the coast in the areas to the east of the port. This is the consequence of the deficit coastal sedimentary (sand and gravel) related to development work and sampling of materials on the rivers especially the Volta.

Quarry and Health

World Health Organization (2005) defined “Health” as a state of complete physical, mental and social well-being of an individual, and not merely the absence of disease and infirmity. A metamorphosis in the living cells of the body which jeopardizes survival in the environment leads to diseases. Health problems emerge from a variety of man"s activities including industrialization, farming, mining, migration and others.

Solid materials in the form of smoke, dust and also vapour generated during quarrying operations are usually suspended over a long period in the air. Moreover, particulate matter in the air are capable of being transported from the point of generation to areas far removed (UNEP, 1991b). Once particles of varying chemical compositions are inhaled, they lodge in human lungs; thereby causing lung damages and respiratory problems (Last, 1998). According to Deborah (1996) and National Industrial Sand Association (1997), dusts generated from granite quarrying contain 71 percent silica. Inhaling such dust results in silicosis which is capable of disabling an exposed person and subsequently, leads to death. Apart from silicosis, sandblasters, miners and quarry workers are to suffer from pneumoconiosis.

Olusegun, Adeniyi and Adeola (2009) contended that the most prevalent health problem of the nearby residents was nasal infection whiles cough, followed by catarrh, sinusitis and silicosis were prevalent among the quarry workers. Thus there are similarities in the health problems suffered by the residents living near quarry sites and quarry workers in the study area.

Musah (2009) looked at the sociological and ecological impacts of sand and gravel mining in East Gonja District and reported that abandoned pits serve as a source of breeding grounds for mosquitoes for example, and the resultant spread of malaria and other related diseases. Most sand and gravel mining activities take place very close to communities and are often abandoned after completion. During rainy seasons, the abandoned pits collect water and as a result attract malaria parasites resulting in infection of community people. Other diseases such as cholera, dysentery and diarrhea, among others, are associated with the mining activities, since mining sites are often used as rubbish dumping sites (Moody & Panos, 1997)

Effects of quarrying on Water bodies

Sand and gravel extraction can result in a number of physical, chemical, and biological effects on mined streams. Sand and gravel mining can change the geomorphic structure of streams (Kondolf 1994), often resulting in channel degradation and erosion from mining operations located either in or adjacent to a water-body. In-stream mining typically alters channel geometry, including local changes in stream gradient and width-to-depth ratios.

The removal of topsoil, overburden and aggregates may affect the quality of water recharging of an aquifer, and excavation below the water table may lead to de-watering of adjacent water courses and wells. The quantity, and physical and chemical quality, of ground waters may be affected by quarrying activities; flows can be increased or decreased and may be contaminated by runoff or dust from the quarry. River and sand stone quarry can impact the ecology of a stream from the base of the food chain. Quarrying can destroy in-stream and river reserve habitats for a broad range of species as well as indirectly impair the functioning of the aquatic ecosystem in the affected nearby areas. The extensive mining of these building materials in the emirate naturally results in fluctuation of ground water level which in turn, according to Martin (2003), leads to considerable variations in the concentration of geo-chemical and bacteriological pathogens in the water. Very importantly, according to Kondolf et al (2001), this extensive mining brings about the lowering of alluvial water tables, channel destabilization and loss of aquatic and riparian habitat

Aside from the direct loss of habitat, increased stream turbidity as a result of the quarrying activity may temporarily reduce light penetration within the river, which will impact rates of photosynthesis and therefore primary production rates. The act also prevents longitudinal and lateral migration of fishes in the flood plain and obstruction may also occur in movement of fishes onto natural feeding and breeding grounds in the flood plain.

Little is known about changes in chemistry as a result of in stream sand and gravel mining. Changes may be primarily local and subtle. Martin (2003) found that dissolved oxygen, temperature, acidity, and total hardness were similar in dredged and reference areas in the Chattahoochee River, Georgia. However, decreases in dissolved oxygen and increases in temperature have been reported downstream from dredging activity.

Effects Sand and Gravel Transportation on Water Bodies

According to Langer, Drew and Sachs (2004) aggregate can be transported by truck, train, barge, or freighter. The preferred mode of transporting aggregate depends on a variety of factors including delivery-schedule requirements, distance, volume of material, loading and unloading facilities, and the availability of transportation methods. Transportation decisions also involve trade-offs between expenditures of investment capital and operating expenses.

Langer et al. (2004) further added that ninety-three percent of aggregate is transported by truck. Trucks can move throughout most areas of an aggregate operation. They can be loaded quickly at points of origin and can dump or drop their loads unassisted at the destination. Trucks can deliver practically anywhere there is a road. From small pickups to rigs that carry 28 tons (25 metric tons), trucks can be matched to requirements and, thus, make cost effective deliveries.

The effects of transporting aggregate are very immense. Firstly, aggregate and stone mining leads to increased traffic congestion and safety hazards in both small rural communities and urban areas. Unlike metals or coal mines where most of the truck traffic occurs on private mine property, aggregate, stone, and industrial mineral mines create traffic on public highways. Wherever such mines are located, it is common to note traffic hazards as trucks enter and leave public highways dozens of times each day. In rural areas, the trucks may have to navigate narrow, twisting roads to the construction site. Ultimately, truck traffic must intermingle with automobile traffic Bachelor, (1999).

The second effect is air pollution. Large trucks generally generate a lot of fumes and dust especially on the road. Thus with a lot of trucks transporting aggregates from the mine dust and diesel fumes are generated on the haul road to and from the mine. This pollutes the air. Apart from the fumes and dust it generates, the fugitive sand blowing from the uncovered or partially covered dump trucks also pollutes the environment Bachelor, (1999). Noise pollution is another effect of construction aggregate transportation. Large trucks of any type, including those transporting aggregate, create a lot of nuisances of noise. When they are in traffic, they try to announce their presence tooting. The tooting generates a lot of noise that disturbs the communities (Langer et. al., 2004).

Finally, Large trucks of any type, including those transporting aggregate, create trucks create a potential danger to motorists on local streets and highways (Langer et. al., 2004).

(Langer et. al. , 2004) further suggested that the environmental impacts and hazards of trucks can be minimized when the trucks are well-maintained and operated, and when automobile drivers yield reasonable space so that truck drivers can maneuver and stop safely. Trucks that haul aggregate are typically equipped with mud flaps and load covers to prevent loose material from being thrown from wheels and off of loads. Loads can be wetted to reduce.

Negative Impact of Quarry on Water Bodies

Sand and gravels extraction can results in number of physical, chemical and biological effects on mined streams. Sand and gravel mining changes the geomorphology structure or streams (Kondolf 1994), often resulting in channel degradation and erosion from mining operations located either in or adjacent water-body. In stream mining typically alters channel geometry including local changes in streams gradient and width-to-depth ratios.

The removal of topsoil overburden and aggregate may affects the quality of water recharging of an aquifer, and excavation below the water table may lead to de-watering of adjacent water courses and wells. The quantity, and physical and chemical quality, of ground waters may be affected by quarrying activities; discharge can be increased or decrease and may be contaminated by runoff or dust from the quarry. (http://www.lawyersnjuries.com).

Rivers and stone quarrying can impact the ecology of stream from the base of food chain. Quarrying can destroy in-stream and river reserve habitats for a broad range of species as well as indirectly impair the functioning of the aquatic ecosystem in the affected nearby areas. The extensive mining of these building materials in the emirate naturally results in fluctuation of ground water level which in turn (Martin, 2003; Bashir and Adebayo, 2002) leads to considerable variations in the concentration of geo-chemical and bacteriological pathogens in the water. Very importantly (Kondolf et al, 2001), this extensive mining brings about the lowering of alluvial water tables, channel destabilization and loss of aquatic and riparian habitat.

CHAPTER THREE

RESEARCH AND METHOD

3.1 The Target Population

The study targeted teachers, Assemblymen, school children, chief and opinion leaders who are 18 years and above in the case study areas.

3.2 Research Design

The study employed both quantitative and qualitative techniques in sequential manner in the collection of data. It also employed laboratory analysis to determine the quality of water in the study area.

3.3 Data Collection and Analysis

The research involves the collection and analysis of data from both primary and secondary sources. The first source was obtained from field study undertaken in Sofokrom and Esipon using questionnaires, structured interview and direct observation and water quality analysis conducted at the Ghana Water Company limited laboratory. Statistical product for service student (SPSS) shall be used to analysis the data.

Sampling Procedure

Simple random sampling techniques were used to select the respondents in the two communities for the administration of the questionnaire. This was followed by Purposive sampling to select the medical personnel for the interview in order to ascertain the facts. Hundred questionnaires were distributed to the two quarry mining communities (Sofokrom and Esipon) and 98% were retrieved. The questionnaire consist of both closed ended and open ended. According to the 2000 housing and population census, the population of the study area was 2000 household was recorded. The study focus on 20% of the household in the study.

Owning to the population different among the various communities, the sample population was shared on the basic of the population sizes.

3.4.1 Laboratory methods and procedures

A reconnaissance survey of the sampling point was carried out in Esipong and Sofokrom. Two sampling sites were ear marked, namely upstream and downstream. Upstream site was the point before any major activities of the quarrying operation whilst downstream point was where most of the major activities of the quarrying are currently taken place.

Water samples were collected both downstream and upstream. At each sampling point, a clean 1litre polyethylene sample bottle was filled with water. This was, subsequently, used in the laboratory for offsite analysis.

The water samples were kept at 4^{o}C in ice chest and transported to the laboratory of the field station of the (Takoradi) Ghana water and sewage company GWSC Takoradi laboratory on the same day of collection for analysis. Sampling bottles had appropriate labels on them and record was made of each bottle. The samples were refrigerated upon receipt in the laboratory to avoid external contamination or deterioration, until the time of the analysis. The tests conducted were: Turbidity, Colour, Suspended Solids, Alkalinity, Hardness, Manganese, PH, Chloride, dissolved solids

3.7 Water Parameter Tests Procedures

The laboratory tests were conducted 2 hours after fetching the water samples by the researcher and two other chemists. Below are the procedures.

Key Equipments

The key equipments are Turbidity meter, measuring cell, flask, multimeter, spectrophotometer, Erlenmeyer flask, pipette, and beakers.

3.7.1 Turbidity (Field Test Method)

Sample was poured into flask and stirred gently to dissolve sediment materials. Measuring cylinder was filled with normal amount of sample. The turbidity meter was plugged and switched to on, following calibration to the salinity. After pressing the read, sample was placed on the machine and the reading was taken.

Colour (Field Test Method)

Sample of water was poured into the flask, stirred and normal amount placed in the cell. Color was selected on the machine and sample of the distilled water was fetched, put into the spectrophotometer machine which set to zero scale. After zeroing, sample of the water was placed in the machine and the result was recorded after the machine has stopped reading.

3.7.3 Total Suspended Solids (Field Test Method)

Sample was poured into Erlenmeyer flask, stirred slowly and normal quantity placed in the cell. After plugging, spectrophotometer was switched to on to allow self calibration. After self calibration, TSS was chosen. Distilled water was poured into measuring cell and placed in the machine followed by zeroing. After zeroing, the sample was put into the machine ensuring that the arrow on the measuring cell is in line with that of the machine. Result was recorded after the machine has stopped reading. After determining the total suspended solids and the total dissolved solids of the sample, the total solid was determined as the total of their values.

3.7.4 Total Alkalinity (titration method)

Reagent:

Standard Sulpheric Acid or Hydrochloric acid, 0.02N and Methyl Orange indicator solution.

Procedures

50ml of the sample was measured into Erlenmeyer flask. Three drops of methyl was then added to the sample. Hydrochloric Acid was sucked into the pipette after the sample has shown yellow colour. The titration was done with 0.02N hydrochloric acid against the sample until the colour changed from yellow to orange. The amount of 0.02N HCL sample used for titration was multiplied by 20 to obtain the alkalinity value.

3.7.5 Total Hardness (Edta Titration Method)

Reagent: Erichrom Black T, Ammoniun Buffer Solution and Ethlene Diamine Tetra asetic acid (EDTA).

Procedure

50ml of the sample was measured into a beaker and 0.5ml buffer solution added. Few drops of powered Meurexide indicator was also added. 0.02N EDTA solution was titrated against the sample until the colour changed from red to blue. The total hardness value was recorded by adding the titre value by 20.

3.7.12 Manganese (Persulphate Method)

Procedure

10ml sample was added into a flask and Ascorbic acid pan reagent were added. Select Nitrite and the program number on the spectrophotometer. Following the instruction on the screen, the wave length was pan to 560nm. Ascorbic acid and pan reagent were added to an amount of distilled water, put into the cell and finally placed into the machine to zero it. After zeroing, sample with reagent was placed in the cell and put into the machine. This time, alignment was taken into consideration. Result was recorded after machine reading and sample remove.

3.7.13 pH (Comparator Method)

Procedure

10ml tube was filled with water sample.0.5ml of reagent solution was added, about 9-10 drops, swirled gentle and placed it in the right hand compartment. The comparator was held before a uniform source white light. The two color produced were then compared, that is the one produced in the test solution and that of the standard disc. The disc was then rotated until the two colors became the same. Result was recorded after the color match.

3.7.14 Chloride (Argerto Metric Method)

Reagent: chloride ion, standard silver nitrate and potassium chromate indicator solution.

Procedure

50ml of raw water sample was measured into the flask. Chloride ion was added. Three drops of potassium chromate (K_2CrO_4) solution was added to turn it yellow. The sample was titrated against silver nitrate solution until it changed to reddish brown in color. The titer value was multiplied by 10 to get the chloride value.

3.7.15 Total dissolved solids

Procedure

Water was placed in flask, swirled gently and put into measuring cell. Total suspended solid was selected multimeter after it has been switched to on. Sample was placed in a machine and value, after the machine has stopped reading was recorded.

CHAPTER FOUR

RESULTS

4.1 Questionnaire

4.1.1 Demographic Characteristics of respondents

Out of 100 questionnaire sent out 98 were retrieved after one month, making a recovery rate of 98%. Forty eight of the respondents are male and 50 of them being female. The respondents were of the age range between 25 and 50 years, with 63% within the age bracket of 25 and 35 years. Four percent of the respondents were between 45 and 50 years old. Out of the 98 respondents 33% have Tertiary education and 44% have completed second cycle education.

4.1.1 Sex of sampled population

Table 4.1: Sex of sampled population

Gender	Frequency	Percentage
Male	48	49.0
Female	50	51.0
Total	98	100

Source: ***Field Work, 2014***

Table 4. 2. Age of sampled population

Aged	Frequency	Percentage
25-29	43	43.0
30-34	20	20.9
35-39	19	19.4
40-44	12	12.2
45-49	4	4.1
Total	98	100

Source: ***Field Work, 2014***

Table 4.3 Educational Status

Level	Frequency	Percentage
Middle /JHS	23	23.5
SHS/Voc/Tech	43	43.9
Tertiary	32	32.7
Total	98	100

Source: *Field Work, 2014*

4.1.2 Activities of the quarry at Sofokrom and Esipon

It was found out the quarry has been in existence for over 21 years with an intense activity since 2011.

4.1.3 The effect of quarry activity on river bodies in the catchment area

All the respondents perceived that the activities of the quarry had an effect on the river. Leaving quarry residue and chemicals in the river as indicated in Table 4.6. They lamented that dust from the quarry dirties the water from the river and also the rivers and streams in the area are drying up as a result of such quarry activities.

Table 4.4: Effects of the Quarry Activities on the Use of River Anankwari

Effects	Frequency	Percent
Dirties water	24	30.4
Deposits chemicals	35	44.3
Dries up river	20	25.3
Total	79	100

Source: *Field Work, 2014*

4.1.4. Change of River Waters Colour As A Result Of Quarry Activities

From the sampled population, 82.2 % responded that the colour of the water from the river had changed due to the quarrying activities within the Esipon and Sofokrom communities and had resulted into discoloring the river Anankwari.

4.1.4 The effect of quarry activity on the health of the people

As shown in Table 4.7 all the respondents claimed that, they have contracted infectious diseases such as skin diseases and cough from bathing or drinking from the river. Furthermore, about 63 % of the respondents indicated that they have been infected by prolonged coughing due to drinking of water from the steams in the area. Again, 82 % responded that the water from the stream has been discoloured due to the quarrying activities within the Esipong and Sofokrom communities.

Table 4. 5: Outbreak of Diseases from Drinking Contaminated Water from the River

Time of Event	Frequency	Percentage
2 years ago	4	5.7
4 years ago	27	38.6
10 years ago	39	55.7
Total	70	100

Source: *Field Work, 2014*

Out Break of Diseases Resulting From Drinking Contamination Water From The Anankwari River

Table 4.6: Effect of the quarry activity on the health of the residents in Esipon and Sofokrom

Disease	Frequency	Percentage
Skin Diseases	16	37.2
Prolonged Cough	27	62.8
Total	43	100.0

Source: *Field Work, 2014*

All the respondents reported that there has been an incident of an outbreak of diseases as a result of the drinking contaminated water from the river. The respondents indicated that such incident occurred about 10.4 and 2 years ago.

4.2 Interview

3.2.1 Health issues

Based on the responses from the questionnaire survey, interviewed were granted to personnel from the health centre in the case study areas. The respondents were medical assistant, two nurses from disease control unit, and two nurses from community nursing unit all from Essikado Polyclinic. Also a medical Doctor from private hospital at Inchaban, a town closer to the catchment area, was also interviewed.

All the respondents confirmed that the common reported cases of the people from Sofokrom and Esipon beside malaria are skill rashes, coughing and diarrhea

Table 4.7: The Group of Inhabitants Affected by the Outbreak of Diseases Resulting from Drinking Contaminated Water from the River

Group	Frequency	Percentage
Adults	4	36.4
Children	7	63.6
Total	11	100.0

Source: *Field Work, 2014*

It also came to light that children are mostly affected during outbreak of disease as indicated in table 4.10

4.3 Field Survey

The researchers wanted to find out the methods of operation of the quarry firms and to ascertain whether their activities have adverse effect on the streams in their catchment area.

During the survey and interview with the dozer operators, it was discovered that the main method been carried in the quarry site are blasting and drilling with blasting being predominant method of quarrying.

Table 4.8. Method and operation of Quarry

	Method of quarrying					
	Manual		Blasting		Total	
Occurrence	**Frequency**	**Percent**	**Frequency**	**Percent**	**Frequency**	**Percent**
Seldom	0	0.0	7	7.1	7	7.1
Very Often	0	0.0	71	72.4	71	72.4
No Blasting	20	20.4	0	0.0	20	20.4
Total	20	20.4	78	79.6	98	100.0

Source: *Field Work, 2014*

Rainfall Analysis

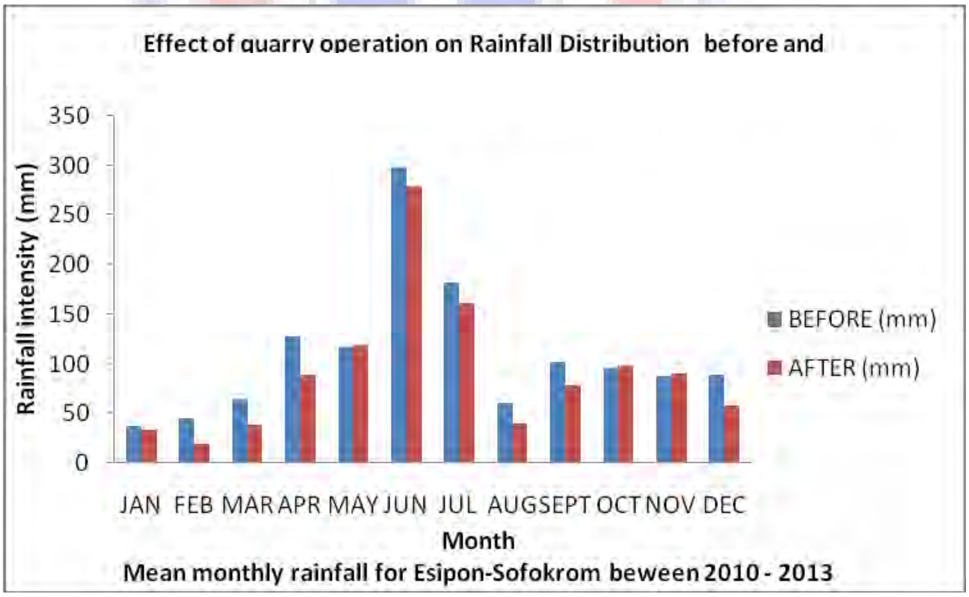

Figure 1.0: Histogram of monthly rainfall for Esipong-Sofokrom from 2010 - 2013

The average monthly rainfall for the Esipong-Sofokrom sub-catchment two years before and after the establishment of the quarry operation is shown in figure 3.0. The result depicts a perfect normal distribution for a typical tropical rainforest area such as Ghana. Although the result generally depicts a gradual decrease in the rainfall, it does not show a clear trend in the decline. The average rainfall from February to April showed a difference of about 30 mm/month after the establishment of the quarry operation. The average rainfall for the month of May did not change two years after the operation of the quarry activities. It however decreased gradually and continuously from June through to September with an intensity of about 21 mm/month. It then remained constant from to October to November and eventually decreased in December with an average intensity of about 30 mm/month. The operation of the quarry involves extensive clearing of vegetation in order to have access to the geological formation (quarry material). This activity can influence the average annual transpiration within the catchment area by reducing the humidity. The relative reduction in humidity might eventually reduce the average annual rainfall within the catchment area. Moreover, since changes in climatic variables are long term it is evident that short term rainfall data cannot effectively show a significant impact of the operational activities of the quarry company. It is however recommended that a monitoring hydrological network station be established within the sub-catchment or basin to record these parameters for a time period of at least ten years.

Discharge of River Analysis

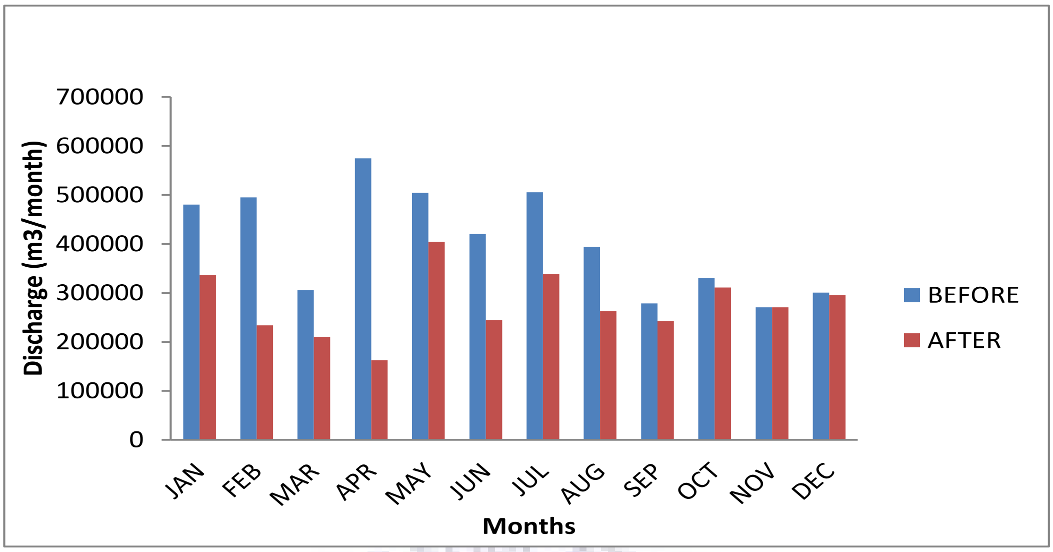

Figure 2.0: The Discharge of River Analysis

The average monthly discharge of river Anankwari before and after the operation of the quarry activities is presented in figure 4.3 above. It can be seen that the average monthly discharge before the operation of the quarry activities was higher than after the operation with an average difference in discharge of 128852 m^3/month.

Discharge of River Anankwari

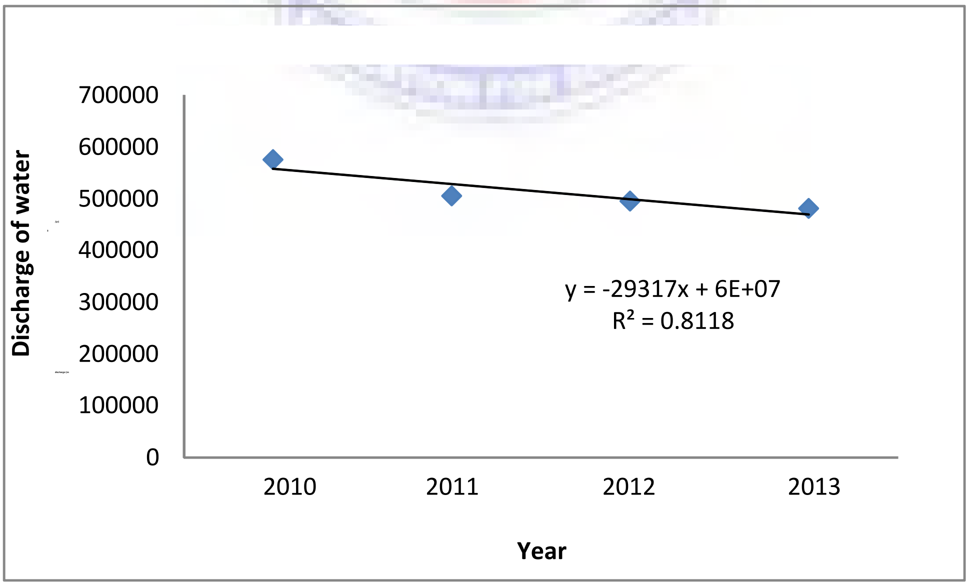

Figure 3.0: Annual Discharge of River for the Period of Study

The regression equation:

$y = 29317x + 6x10^7$

Where y is the dependent variable, that is the water discharge and x is the independent variable, years.

From the equation as the years go by, there is a reduction of 29317 lm^3 of water in the river.

The regression coefficient. R^2 has a significant value of 0.8118 which means that 80% of the reduction in the water discharged is dependent on the years of operation. This implies that the longer the quarry operation the reduction of the greater water discharge will be.

The average annual discharge of river Anankwari for the four year period regarding the activities of quarry indicated that, total discharge before the quarry activities on the river was 1079.174 m^3 whilst the discharge during the activities with 798.089 m^3. In generally, the discharges for 2010 and 2011 were higher compared to 2012 and 2013.

The average monthly discharge after the establishment and operation of the quarry company was generally lower than that before the establishment of the quarry company.

4.9.: Physicochemical Parameters Assessment of River Anankwari

PARAMETER	UNIT		SAMPLE VALUE (RESULT)		EPA	WHO
			UP STREAM	DOWN STREAM		
PH			9.20 – 9.90	6.60 – 7.80	6 - 9	6.5 -8.5
COLOUR	Mg/l	H_2	12.5 – 19.7	24.9 – 30.6	200	0 - 15
TEMPERATURE	O°C	o °C	25.2 – 25.5	26.5 – 29.5	<3 above ambient	-
TDS	Mg/l	mg	54.8 – 73.9	64.40 – 78.4	1000	1000
TSS	Mg/l		54.67 – 68.5	61.25 – 87.5	50	1000
CONDUCTIVITY	Us/cm		114.10 - 132.7	119.8 - 224.0	1500	1000
TURBIDITY	NTU		7.45 –12.83	7.9 – 15.56	7.5	5
ALKALINITY	Mg/l		201.2-219.10	256.10-569.10	200	200
MANGANESE	Mg/l		0.4 – 0.93	0.60 – 1.3	0.1	0.1
CHLORIDE	Mg/l		12.4 – 18.0	23.0 – 30.0	250	250
TOTAL HARDNESS	Mg/l		56.4 – 69.4	86.8 – 100.8	500	500

Table: Shows the EPA and WHO standard for drinking water compared to the obtained value from sample analysis

Statistical Analysis

Differences between sampling sites and within period of sampling (months) were determined using Analysis of Variance (ANOVA) using data analysis in Microsoft Excel 2007. Comparison of each parameter level between the upstream and downstream of the river was made using paired *t*- test. Additionally, each parameter level at both the up and down streams was compared using paired *t*- test. The results were used to assess the influence of the quarry on the River within the area.

$$LSD = t\sqrt{\frac{2MSE}{n}}$$

Where:

t critical value of the t- distribution with a degree of freedom (df) of the f – statistic

MSE mean square error, obtained from the ANOVA test

n number of scores used to calculate the means

LSD Lest Significant Difference

Using the equation

$$LSD = t\sqrt{\frac{2MSE}{n}}$$

Where:

$P = 1.8$ which is $p > 0.05$

Details of arithmetic are in the Appendix for cross reference.

4.5.0 Physicochemical Parameters Assessment of River Anankwari

The mean pH values at both the up and down streams of Anankwari river recorded within the three month period were 7.80, 6.60 and 6.80 for up streams and 9.20, 8.9 and 9.9 for down streams respectively. The downstream recorded the highest values for the all water samples for the entire period than the upstream. Significant differences ($p < 0.05$) between at least two treatments means existed within the upstream and downstream sampled values. However there were no significant differences ($r = 1.18$, $p > 0.05$) among the samples within the same stream for the three months period.

The colour determined for the sampled water from the respective upstream and downstream locations indicated that the samples from the downstream recorded the highest colour values throughout the three months. Colour of the water samples was clear, slightly turbid and odour was unobjectionable. The mean colour from upstream ranged from 12.5 to 19.7 Hz. The downstream also recorded a ranged of higher mean values of 24.9 to 30.6 Hz. There was substantial variance ($p < 0.05$) between at least two treatments means within the data.

The mean temperature determined for the samples from the respective location proved that the downstream water sampled recorded the highest mean temperature values. The temperatures of the upstream were in the range of 25.2 – 25.5 °C. The downstream water sampled recorded an average ranged of 26.5 - 29.5°C. There was significant difference ($p < 0.05$) between the upstream and downstream mean values for the entire sample period.

Total suspended solids (TSS) recorded for the water from the Anankwari indicated that the downstream sampled water obtained the highest mean range of 61.25 mg/l to 87.5 mg/l as against upstream of mean range of 54.67 mg/l to 68.5 mg/l during the three months period. There was significant differences ($p < 0.05$) between at least two treatments mean within the data.

Total Dissolved solids (TDS) recorded for the water from the Anankwari indicated that the downstream untreated water obtained the highest mean range of 54.8 mg/l to 73.9 mg/l as against upstream of mean range 64.40 mg/l to 78.4 mg/l of during the three months period. There was significant differences ($p < 0.05$) between at least two treatments mean within the data.

Alkalinity recorded from the Anankwari river indicated that the downstream water had the highest mean range of 256.10 mg/l in January to 569.10 mg/l in

February as against upstream of mean range of 201.2 mg/l in December to 219.10 mg/l in February. There was significant differences ($p < 0.05$) between at least two treatments mean within the data.

Manganese recorded for the water from the Anankwari indicated that the downstream untreated water obtained the highest mean range of 0.60 mg/l to 1.3 mg/l as against upstream of mean range 0.4 mg/l to 0.94 mg/l of during the three months period.

The average chloride level recorded from the Anankwari river indicated that the downstream recorded the highest mean range values from 23.0 mg/l in December to 30.0 mg/l in February as against upstream of mean range from 12.4 mg/l in January to 18.0 mg/l in December during the three months. There was significant differences ($p < 0.05$) between at least two treatments mean within the data

The total hardness recorded for the water from the Anankwari indicated that the downstream water recorded the highest mean range from 86.8 mg/l in February to 100.8 mg/l in January as against upstream of mean range from 56.4 mg/l in February to 69.4 mg/l in January during the three months There was significant differences ($p < 0.05$) between at least two treatments mean within the data

Conductivity recorded for the water from the Anankwari showed that the downstream untreated water obtained the highest mean range of 119.8 to 224.0 as against upstream of mean range 114.10 to 132.7 of during the three months period. There was significant differences ($p < 0.05$) between at least two treatments mean within the data.

Turbidity determined for the water from the respective locations indicated that the downstream untreated water recorded the highest mean values of 7.90, 16.62 and 6.66 against upstream of mean values of 7.45, 12.83, and 5.26 during the three months period. There was significant differences ($p < 0.05$) between at least two treatments mean within the data.

4.6 Perception of sample population about activities and impacts of quarry

The existence of quarry activities in the area has been operating for more than 21 years with an intense activity since 2011. The main method carried in the quarry site was manual and blasting. 79.6 % of the sampled population contended that the blasting has been the main method of quarrying and is done very often (72.4%). All the sampled population perceived that the activities of the quarry had an effect on the river. They leave quarry residue of chemicals in the river, dust from the quarry pollutes the water from the river and finally, rivers and streams in the area dry up as a result of such quarry activities.

Again, all the inhabitants sampled during the study perceived to be contracted infections diseases such as skin diseases and cough from bathing or drinking from the river. However, 62.8 % of the respondents indicated that the river water gives users in the area a prolonged or chronic cough and whilst 37.2% confirmed skin diseases. From the sampled population, 82.2 % responded that the colour of the water from the river had changed due to the quarrying activities within the Esipong and Sofokrom communities had resulted in discoloring of the water from River Anankwari. The entire household sampled reported that there has been an incident of an outbreak of diseases as a result of the drinking contaminated water from the river. 57 % of sampled population indicated that such incident occurred about 10 years ago. 38.6 % reported that it happened about 4 years ago and 6 % of the respondents also reported that the incident happened just 2 years ago.

4.7. Discharge of River Anankwari

The average annual discharge of the river for the four year period has showed a decreasing strand. Total discharge before the active quarries activities on the river was 1079174 m^3 whilst the discharge during the active quarry activities recorded 798089 m^3. It is evidently that the average monthly discharge after the establishment and operation of the quarry company was generally higher than that before the establishment of the quarry company. The reduction in the volume of water in the river could be attributed the activities of quarry which has impacted negatively on the quality and quantity of water distribution in the communities as perceived by the sampled population. From regression equation, every year there is a reduction of 29, 317m^3 of water from the river.

The annual water consumption requirement for Sekondi-Takoradi Metropolitan Assembly (STMA) is (1,620,000m^3) million gallons. It implies that consumption requirement of STMA is reduce by 2% in water supply. In 50 years time the will be a reduction of 100%. The practical implication is that if the trend continues than STMA will import water or look for other alternatives of water source. The practiced water requirements for STMA in the next 50 years will 3,24600 due to expected population increase in the city.

4.7.0 Rainfall Pattern

The average rainfall from February to April showed a difference of about 30 mm after the establishment of the quarry operation. The average rainfall for the month of May did not change two years after the operation of the quarry activities. It however decreased gradually and continuously from June through to September with an intensity of about 21 mm. It then remained constant from to October to November and eventually decreased in December with an average intensity of about 30 mm. The operation of the quarry involves extensive clearing of vegetation in order to have access to the geological formation (quarry material). The reduction of rainfall pattern, though cannot be solely attributed to the quarry activities, it contributes to certain extent. From section 5.2 the annual water requirement STMA reduces by 2% every year, all things being equal. If the rainfall pattern continues to reduce than the 50 years project, that stipulate time STMA will import water, will come early than projected.

4.7.1 Physicochemical Assessment of River Anankwari

The Physico-chemical parameters of both upstream and downstream have been given in Table 4.12. The pH values for the downstream are above the prescribed limit given by WHO. Concerning the drinking water pH, the WHO (2010) standard is 6.5 – 8.5, this means that the drinking water for the entire downstream under study was higher than the standard and could be attributed to the quarry activities in the area. Water contamination as a result of quarry activities can have serious effects on living things, including man and animals (Armah*et al.,* 1998). Hydrogen ion concentration (pH) has the most marked effect upon the growth of bacteria. The rate at which a polluted stream undergoes self-purification is decreased due to the reduction in bacterial numbers caused by changes in pH of the river. The optimum pH value for good growth usually lies around pH of 7 (Klein *et al.,* 1962). A change in pH in rivers as indicated by Morrison *et al.* (2001), could impair recreational uses of water, affect aquatic life and decrease the solubility of certain essential elements such as Selenium and increase harmful metals as Cadmium, Mercury and Aluminum.

Temperature is one of the important factors in environment since it regulates the various physico-chemical as well as biological activities (Kumar *et al*., 1996). The water temperature follows a diurnal variation, increases in day time and decreases during night. The temperatures of the upstream were in the range of 25.2 – 25.5 °C. The downstream water sampled recorded an average ranged of 26.5 - 29.5°C. Increase in temperature accelerates the chemical reactions in water and thereby reduces the solubility of gases and imparts taste and odour to the water. This indicates that the downstream mean temperatures fall above the WHO and Ghana EPA recommended standard (15 – 25°C) for drinking water. The high temperature recorded for the downstream may be due to high turbidity and conductivity value (suspended materials) in the stream (DWAF, 1998).

Colour of the water samples in the upstream were clear, slightly turbid and less odour than the downstream. The values of the drinking water for downstream water supply were above <15 Hz which is WHO recommended limit for no risk. This goes to indicate that the downstream water is not very suitable for drinking. The values of upstream supply fell within the WHO recommended limit for no risk indicating that all the drinking water for upstream supply areas were suitable for drinking. According to Karikari *et al.* (2006), increase in the colour of water in reservoirs results in increases in treatment cost. Highly coloured water observed in the samples and perceived by sampled population may be due to decaying quarrying.

The background limit for turbidity is 5FTU (WRC, 2003). All the turbidity values recorded in the downstream do not met the WRC and the WHO (2010) standard (5FTU) and therefore showed a higher level of turbidity. High turbidity levels in water causes problems with water purification processes such as flocculation and filtration, which may increase treatment cost (DWAF, 1998). Though high turbidity is often a sign of poor water quality and land management, crystal clear water does not always guarantee healthy water. Elevated turbid water, according to DWAF (1998), is often associated with the possibility of microbiological pollution as high turbidity makes it difficult to disinfect water properly. The high level of turbidity recorded in this study for the downstream water may have been strongly influenced by soil erosion and decay of organic matter from improper disposal of quarry activities within the catchment. The high turbidity could be due to the increased amount of precipitates in the water from corrosion, the amount of particulate matter (and thus turbidity) increases (Juhna and Klavins, 2001). As a result, microbes may attach and aggregate onto these particles and be protected from disinfection (Besner *et al*., 2002), rendering a disinfection residual less effective.

The conductivity levels at all the sampling sites are within the maximum WHO drinking water guideline limit. High conductivities in water could be attributed to high mineral salt concentration which comes from the dissolution of minerals in the soil (Ntengwe, 2006; Morrison *et al.,* 2001). When a riverbed is disturbed, for instance, by mining within a river, absorbed ions are released from the riverbed into the water (Prowse, 1987). Although quarrying activities within the river were in the form of crashing the bedrock and blasting, the conductivity levels met the minimum WHO guideline limit. Thus, inorganic or metal levels are very low in the river and according to Ntengwe, (2006) the presence of inorganic compounds or metals makes water exhibit high conductivities.

Total dissolved solids (TDS) level at all the sampling sites was below the minimum WHO guideline limit. These areas experienced low rainfall due to the dry season and probably there was not enough mineralization of the bedrock which could result in low concentration of mineral salts. According to Davies, (1996) both heavy rainfall and the consequent rapid erosion of soil and leaching of associated bedrock can dramatically raise the dissolved solids content in a river. A high TDS (Ntengwe, 2006) has high concentration of mineral salts which is not good for human consumption. Increased levels of dissolve solids also result in reduction of dissolved oxygen in water.

The total hardness levels determined were found to be within the WHO standards range for both upstream and downstream values recorded during the three month period.

The chloride levels in the water are well within the WHO guidelines. There are therefore no health concerns from chloride as per the portability of this water since all the levels recorded were within the World Health Organization guideline values.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

The study revealed that, the existence of quarry activities in the area has been operating for more than 21 years with an intense activity since 2011. The main method carried in the quarry site was manual and blasting. The research discovered that, blasting has been the main method of quarrying and is done very often which has had an effect on the river and the inhabitants. It was also discovered that, after querying, they leave quarry residue of chemicals in the river, dust from the quarry pollutes the water from the river and finally, rivers and streams in the area dry up as a result of such quarry activities.

Again, the study revealed that, the people who live along the river have contracted infectious diseases such as skin diseases and cough from bathing or drinking from the river. It was obviously seen from the research that, the average monthly discharge after the establishment and operation of the quarry company was generally higher than that before the establishment of the quarry company, which implies that consumption requirement of STMA is reduce by 2% in water supply which indicate that in 50 years time there will be a reduction of 100%.

5.2. Conclusion

From the results obtained and discussed in the preceding section, the following conclusions have been drawn:

Sand and stone quarry activities in the river basin have resulted in the residue of chemicals in the river and drying up of rivers and streams in the area are culminated into insufficient water for households and infections of skin diseases and prolonged and chronic cough.

The average annual discharge of the river has decreased from 574796 m^3 in 2009 to 480252 m^3 in 2012 and could be attributed to the quarrying of stones and sand in the river basin.

The average rainfall within the catchment area has decrease gradually and continuously from June through to September with an intensity of about 21 mm/month. This has occurred as a result of quarrying operations which involve extensive clearing of vegetation in order to have access to the geological formation (quarry material). This activity can influence the average annual transpiration within the catchment area by reducing the humidity

The physical and chemical parameters of all sampled water in the downstream showed appreciably statistically different values from respective downstream sampling locations. All physico-chemical parameters such as pH, turbidity, colour, conductivity, temperature, total dissolved solids, and total suspended solids of the downstream of the river Anankwari did not meet the WHO standards except chloride, manganese and total hardness and this pollution may be attributed to contamination from quarry activities. Again, upstream values among all the selected samples, almost all of them were within the WHO standards which may be good and safer drinking water than the downstream.

5.3. Recommendations

From the result obtained and actual field observations made during the study, the following recommendations are made:

1. The Sekondi – Takoradi Metropolitan Assembly (STMA) and other stakeholders should provide drainage facilities in the area to control river pollution.
2. Appropriate water treatments and safe potable water sources such as groundwater resources should be harnessed in the area to enhance the water distribution.
3. Education on efficient water use and locally treatment of water for domestic use.

4. The rules and regulation governing the operations of quarry activities should be review carefully in order to at least reduce its negatives impact on Anankwari River and ecosystems.
5. Monitoring hydrological Network station be established within the sub-catchment area or basin to record the parameters for a time period at least ten years.

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APPENDIX A

Mean Rainfall Distribution

MONTH	BEFORE (mm) 2010 – 2011	DURING (mm) 2012 - 2013
JAN	37.7	33.1
FEB	45	19.9
MAR	64	38.9
APR	127.8	88.9
MAY	117.9	118.2
JUN	298.2	279.5
JUL	182.3	161.6
AUG	60.1	40.3
SEPT	102.3	78.4
OCT	96.1	98.4
NOV	88.1	90.3
DEC	88.5	57.6

Mean rainfall distribution from 2010 - 2013

Discharge of River Anankwari

BEFORE QUARRY OPERATION			
Month	Discharge	Before	During
JAN	475533.3	480252	335908
FEB		494837	233799
MAR		305578	210116
APRIL		574796	162594
MAY		504378	404378
JUN		4``20501	244499
JUL		505614	338856
AUG		393905	263182
SEP		278178	242843
OCT		329993	310778
NOV		270332	270259
DEC		300397	295316

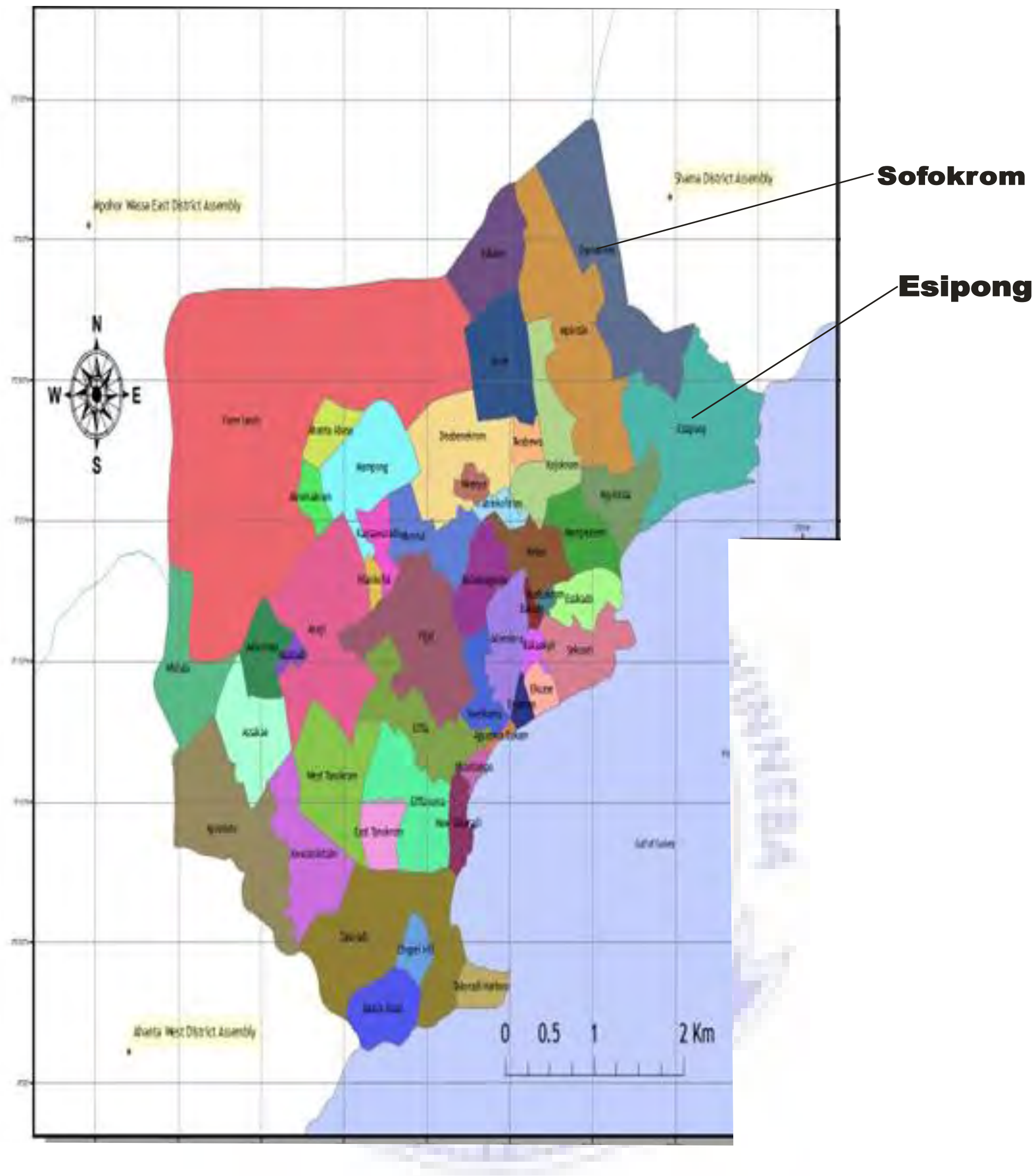
ANOVA of Water Quality Parameters Among the Sampling Methods for Anankwari River

Sources of variation		Sum of Squares	df	Mean Square	F	P-Value	F-Critical
PH	Between Groups	42.61267	5	8.546701	.4976.900	1.18	2.263709
	Within groups	0.16346	62	0.001915			
	Total	42.77613	67				
Colour	Between Group	278104.8	5	49726.68	.532.6354	6.53	2.63709
	Within groups	6234.608	62	92.36347			
	Total	284339.40	67				
Temperature	Between Group	123.2280	5	28.12378	.158.0463	3.86	2.63709
	Within groups	10.7272	62	0.162493			
	Total	133.9552	67				
TDS	Between Group	24.69724	5	11.24631	532.134	0.002136	2.63909
	Within groups	51.69943	62	14.1693			
	Total	76.39667	67				
TSS	Between Group	6.000	5	6.000	.088	.781	2.63709
	Within groups	272.000	62	68.000			
	Total	278.000	67				

Conductivity	Between Group	35.042	5	35.042	0.372	.575	2.63709
	Within groups	376.893	62	94.223			
	Total	411.935	67				
Turbidity	Between Group	674.000	5	196	2.732426	0.069244	2.63709
	Within groups	6548.677	62	72.012111			
	Total	7222.677	67				
Alkalinity	Between group	16. 667	5	16. 667	.342	.590	2.63709
	Within group	194.667	62	48. 667			
	Total	211.333	67				
Manganese	Between group	0. 240	5	.240	.024	.880	2.35309
	Within group	39. 413	62	9.853			
	Total	39. 653	67				
Chloride	Between group	1.500	5	1.500	.150	.718	2.35309
	Within group	40. 000	62	10.00			
	Total	41. 500	67				
Total	Between group	0.0386824	5	0.041385	1.947 .51	3.18	2.35309
Hardness	Within group	0.00483	62	3.218			
	Total	0.0435124	67				

Anankwari Dam

Figure 4.0 Map showing the Anankwari River at Inchaban



The Map of Sekondi-Takoradi Metropolis Showing Esipon and Sofokrom

APPENDIX B

UNIVERSITY OF EDUCATION WINNEBA, GHANA

KUMASI CAMPUS

MASTERS IN CONSTRUCTION TECHNOLOGY

Department of Design and Technology Education

A Questionnaire for workers or management at quarry site at Esipon and Sofokrom

The general objective of this study is to evaluate the impact of quarrying activities on river Anankwari at Esipon and Sofokrom . I would be grateful if you would respond to the questions asked to the best of your ability. This study is solely for academic purposes and you are assured of your anonymity and confidentiality.

Section A

Workers in Quarry

Respondent's background characteristics

1. Sex: Male ( ) Female ( )
2. Age:……………………………………
3. Level of education: No education ( ) Primary ( ) Middle/JHS ( ) SHS/Voc/Tech ( ) Tertiary ( )
4. Marital status: Single ( ) Married ( ) Divorced ( ) Separated ( ) Widowed ( )
5. Hospital workers: Doctors ( ) Nurses ( ) Pharmacies ( )
6. Profession: Engineer ( ) Labourer ( ) Others (specify)……………
7. Working experience: 1 - 4yrs ( ) 5 – 9yrs ( ) 10yrs and above ( )

Section B

Quarrying activities

8. How long has quarrying activities existed here in sofokrom?

   5yrs ( ) 10yrs ( ) 15yrs ( ) 20yrs ( ) 25yrs ( ) 30yrs ( )

9. What method do they use stone quarrying? Manuel ( ) Blasting ( )

   If blasting ( )

10. How often do hear the blast of quarries here?

    Seldom ( ) Very often ( )

11. What kind of chemical do you use for blasting?..

12. How long have you been using these chemicals for blasting?

    5yrs ( ) 10yrs ( ) 15yrs ( ) 20yrs ( ) 25yrs ( ) 30yrs ( )

13. Do you know of any side effect of using these chemicals? Yes ( ) No ( )

    I f yes; mention some of the side effects…………………………………………

14. How do you depose off waste chemicals after using them for blasting?

    Bury them

15. Do you treat the waste chemicals before you dispose? Yes ( ) No ( )

16. How far is the quarrying site from Anankwari River?

    Very close ( ) close ( ) far ( ) very far ( )

Section C

Effects of quarrying activities on river Anankwari

17. Do your quarrying activities affect the use of river Anankwari? Yes ( ) No ( )

If yes:

18. Do the chemicals kill fish and other living organisms in the river? Yes ( ) No ( )

19. Do people get infections or diseases from bathing or drinking water from the Anankwari River? Yes ( ) No ( )

If yes, what is the cause?..

20. Has the colour and taste of the river changed as a result of the quarrying activities? Yes ( ) No ( )

21. What measures have you put in place to ensure the safest way of discharging waste chemicals?..

22. What have you done or is being done to compensate the community of the effects of your quarrying activities on the Anankwari river?

....

....

Thank you.

UNIVERSITY OF EDUCATION WINNEBA, GHANA.

KUMASI CAMPUS

MASTERS IN CONSTRUCTION TECHNOLOGY

Department of Design and Technology Education

A Questionnaire for inhabitants of Esipon and Sofokrom

The general objective of this study is to evaluate the impact of quarrying actives on river Anankwari at Esipon and Sofokrom. I would be grateful if you respond to the questions asked to the best of your ability. This study is solely for academic purpose and you are assured of your anonymity and confidentiality.

Section A

Respondent's background characteristics

1. Sex: Male ( ) Female ( )
2. Age…………………………..
3. Level of education: No education ( ) Primary ( ) Middle/JHS ( ) SHS/Voc/Tech ( ) Tertiary ( )
4. Marital status: Single ( ) Married ( ) Divorced ( ) Separated ( ) Widowed ( )
5. Occupation: Farming ( ) Trading ( ) Artisan ( ) Public Servant ( ) Civil Servant ( ) Unemployed ( )
6. Hospital workers: Doctors ( ) Nurses ( ) Pharmacies ( )

Section B

Quarrying activities

7. How long has quarrying activities existed here in sofokron?

   5yrs ( ) 10yrs ( ) 15yrs ( )

   20yrs ( ) 25yrs ( ) 30yrs ( )

8. What method do they use stone quarrying? Manuel ( ) Blasting ( )

   If blasting

9. How often do hear the blast of quarries here?

   Seldom ( ) Very often ( )

Section C

Effects of quarrying activities affect the use of river

10. Do quarrying activities affect the use river Anankwari? Yes ( ) No ( )

    If yes;

11. Do the chemicals kill fish and other living organisms in the river?

    Yes ( ) No ( )

12. Do people gel infection or diseases from bathing or drinking water from the Anankwari River? Yes ( ) No ( )

13. If yes, what type of diseases?..

14. Has the colour and taste of the river change as a result of the quarrying activities? Yes ( ) No ( )

15. Has there been any history of an outbreak of diseases as a result of drinking contaminated water from the Anankwari river? Yes ( ) No ( )

16. I yes, when was that?...

17. Did a lot of people die as a result of this outbreak? Yes ( ) No ( )

18. Was it children, adult or the aged who were dying most?

    Children ( ) Adults ( ) Aged ( )

19. What do you think the quarry company should do for the inhabitants of Sofokrom to avoid contaminating the Anankwari river? ....

20. What do you think the quarry company should do for the inhabitants of Sofokrom to prevent the outbreak of diseases as a result of drinking polluted water from the Anankwari river? ....

Thank you.