ENSIGN COLLEGE OF PUBLIC HEALTH,

KPONG EASTERN REGION, GHANA

Health Effects of Limestone Quarrying in Yilo Krobo and Lower Manya Krobo Municipalities

By

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Declaration & Certification

I hereby declare that excerpt for reference to other people's work, which I duly sited, the investigation submitted to Ensign College of Public Health, Kpong is the end result of my own investigation and not presented anywhere for any other degree.

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Abstract

The investigation conducted the health effects of limestone quarrying in the Yilo Krobo municipality at Klo-Begro and Manya Krobo municipality at Odugblase. The objectives were to assess possible clustering of respiratory disease cases around a putative pollution source, model possible correlation between exposure and respiratory disease cases and relative risk surface of upper respiratory disease cases in the two communities.

Secondary data was collected from Oborpah, Obenyemi and Oterkpolu in Yilo Krobo and Manya Krobo health facilities on people who reported upper respiratory and water related diseases. A total of 351 reported to the three health facilities in 2015.Those sampled were 329.The inclusion criteria were health records of people who lived in Klo-Begro and Odugblase and reported to the health facilities in 2015.The exclusion criteria were people who attended the three health facilities in 2015 and were not from those two communities. A response rate of 93% and no respondents of 7% were lost to follow up. It revealed that 72 % had upper respiratory diseases and 28% water related diseases. Clustering of upper respiratory diseases termed cases were found around the dusty haul roads of the quarrying communities. Test of clustering after thousand simulations based on Monte Carlo relabeling hypothesis produced a p-values less than 0.05. Water related diseases were reported more in 2003 when quarrying activities was not in operation but more people reported on upper respiratory tract infection from 2005 and beyond when quarrying activities started. The investigation supports other established findings on limestone quarry in other parts of the world and in line with the sustainable development goals.

ABREVIATIONS/ACRONYMS

agegmiddle	Middle age
agegold	Old age
agegyoung	Young age
Dist..aj..fanj	Distance to A.J.FAN
Dist..dust	Distance to dust road
Dist..love.ent	Distance to Love Enterprise
Dist..road	Distance to road
EPA	Environmental Protection Agency
GAM	Generalized Additive Model
GISTools	Geographic Information System Tools
GSCP	Ghana Statistical Census Report
IPP	Inhomogeneous Poison Process
KDE	kernel density estimate
LMK/YKM	Lower Manya Krobo and Yilo Krobo Municipalities
NGO	Non-Governmental Organization
owin	observation window in the two- dimensional plane
SDG	Sustainable Development Goal
spatstat	spatial statistics

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Definition of operational terms

Water related diseases: Malaria, Guinea worm, Cholera, Typhoid, Elephantiasis, Diarrhoea, Bilharzias (Schistomiasis)

Dust related /upper respiratory diseases: Cough, Sneezing, Catarrh, Sore throat, Asthma, Short breadth, Pneumonia, Heart problem, Headache, Eye problems, frequent bringing out of phlegm, and Wheezing or whistling of chest.

Environmental impacts: These are the resultant effects that come with the activity of quarry mining or any other mining activity. They may be positive or negative impact to the environment.

Quarry: A quarry is a type of open-pit mine from which rock material and sand are extracted.

Pollution: The process of introducing or adding materials to the environment. These materials, deliberately or accidentally introduced to the environment, are harmful and injurious to living systems.

Noise pollution: means the emission of uncontrolled noise that is likely to cause danger to human health or damage to the environment

Dust: is a fine powder that consist of very small pieces of a particular substance.

Noise: means any undesirable sound that is intrinsically objectionable or that may cause adverse effects on human health or the environment.

Quarry pit: This is a surface excavation allocated to an operator within a quarry site for extracting building stone, construction aggregate, sand and gravel.

CHAPTER ONE

1.0 Introduction

1.1 . Background of the study

Environmental concerns have gained prominence throughout the world recently with myriad of international protocols which was established by the global community in dealing with the emerging environmental and climate change issues per Sustainable Development Goal, 11. In line with these global changes coupled with sustainable development, the enactment of environmental laws (EPA ACT- 1994 ACT 490) which among other functions, is to monitor and evaluate development activities to ensure there is no threat to the environment and livelihood. Mining activities such as quarrying of limestone and air pollution is a major concern in Ghana.

Quarrying involves the process of obtaining quarry materials, usually rocks, found on or below the land surface (Banez et al, 2010). Mining and quarrying are different in that quarrying extracts nonmetallic rocks and aggregates while mining excavates the site for metallic mineral deposits. Types of stones extracted are marble, limestone, ironstone, slate, granite, perlite rock salt phosphate rock and sandstone**(s)**. The two major branches of the industry, notably the crushed-stone quarrying and dimension stone. In the dimension stone, blocks or sheets of stone, such as marble, are extracted in different shapes and sizes for different uses while in the crushed stone industry, limestone, granite, sandstone, or basaltic rocks are crushed for use mainly as road stone or concrete aggregates(s). The aim of Sustainable Development Goal,3 is to ensure healthy lives and promote wellbeing for all at all ages. The activities engaged in economic development should not have a negative impact on the livelihood of others but rather seek to improve reproductive, maternal and child health; ending the epidemics of major communicable diseases;

reducing non-communicable and environmental diseases; achieving universal health coverage; and ensuring access to safe, affordable and effective medicines and vaccines for all.

The activities of quarrying at the study sites started in 2005 in the study area when former president of Ghana J.H. Kufuor commissioned the operations of the mining companies in the Lower Manya Krobo and Yilo Krobo municipalities.

The Yilo Krobo and Lower Manya Krobo municipals have a total of three quarries namely, Love Enterprise close to Bueryonye, A.J. Fanj near Odugblase and Premium Terrazzo close to Klo-Begro. The population at the time of establishment of the quarries were 1200 people. The population has grown over the years to about 2300 people (GSCR, 2010) and this makes the effects of the quarrying activities felt by many who live in these communities. Quarrying activities affect our environment and livelihood in various ways. Both flora and fauna are affected by these activities. The negative effects far outweigh the benefits to the quarrying communities. Blasting of limestone from the quarry sites results in cracks in the houses or buildings and facilities leading to weakening and deteriorating of buildings and often collapse.

To achieve quality health, the Environmental Protection Agency of Ghana was constituted to control air quality and safety of people in communities especially where mining and quarrying activities take place. Air pollutants such as dust are unhealthy particles (solids, liquid gas mixtures) that are liable to harm both living and non-living things (Ward, 1989**).** Sources of airborne particulate matter include the following activities: site clearing, road construction, top soil stripping and dumping, open pit drilling and blasting, stripping, loading and haulage and dusty roads (Akabzaa, 2000)**.** Loss of biodiversity is influenced by the quarrying activities. The study identified how quarrying activities in Lower Manya Krobo and Yilo Krobo municipalities affect the people living in the quarrying communities with upper respiratory diseases.

1.2. Problem statement

Employment, infrastructural development and growth of communities has initiated the establishment of quarrying industries leading to environmental damage (Siachoono,2009). The industry has more negative effects than positives as written by other researches ((Adekoya, 2003; Ajakaiye, 1985; Kibet, 2004). The mining communities at Odugblase and Klo-Begro are located in the LMK/YK municipalities respectively. Odugblase is 102 meters to A.J. Fanj (Ghacem) associated with quarrying activities. Respondents affirmed biodiversity loss, loss of wildlife, reduced photosynthesis in plants, dust pollution, noise pollution, vibrations, cracks in buildings, standing water are associated with quarrying. The purpose of the industry is extraction of construction materials in the form of sand, gravel or rocks, stone ornaments and in the production of paint which constitutes the basis of the effects of quarrying activities. The quarries are located behind Yogwa Mountain about 600m away pollution has caused respiratory tract infections in the study area (Kissi,2012). Inhabitants are suffering from catarrh, cough, common cold, chest pains and other respiratory diseases. The indigenes in the area have confirmed the impacts and attributed them to quarrying activities in the area. These statements were made during the investigation of the health volunteer, and some elders of the quarry communities. Blasting vibrations have generated environmental problems such as cracks in buildings, which in some cases collapsed buildings and destroy life.

1.3. Rationale of the study

The investigation assessed the health effects and environmental problems of quarrying in Klo-Begro, and Odugblase. These quarries are located close to the communities, which make them susceptible to the negative effects of quarrying activities. The study unveiled the effects of quarrying activities on the communities. Several investigations (Musyoka 1997, Okafor 2006,

Azad and Ashish 2006) in other limestone quarrying communities have identified quarrying activities to have negative effects to the health of quarry workers and the people living near them. These communities suffer from a host of diseases ranging from non-water related diseases and water related diseases due to lack of basic knowledge, safety precautions, lack of clear quarrying legislation, environmental degradation, non-involvement in stakeholders' meetings and non-adherence to social responsibilities by the quarrying companies.

1.4. Hypothesis

Null Hypothesis: Dust concentration is likely to cause upper respiratory tract infections.

Null Hypothesis: Enforcement of safety environmental regulations can reduce health effects of quarrying

1.5. Research questions

i. What are the health effects of dust pollution on the health of the communities?

ii. Is there a spatial clustering of respiratory diseases in the communities.

Iii. Is distance to the quarries contributing to dust pollution?

1.6. General objective

The main objective of this research is to assess the health effects of quarrying activities on these communities and possible ways to mitigate them

1.7. Specific objectives

i. To compute a" relative risk" surface of respiratory disease cases in the communities.

ii To assess possible clustering of respiratory disease cases around a putative pollution source

iii. To model possible correlation between exposure and respiratory disease cases

1.8. Profile of study area

The study areas are located in Yilo Krobo and Lower Manya Krobo Municipalities. They are among the twenty-six districts in Eastern Region located in the eastern part of the Region along the south-western corner of the Volta River. Lower Manya Krobo lies between latitude 6.05S and 6.30N and longitude 0.08E and 0.20W. The municipality is surrounded by Yilo Krobo in the west, Upper Manya Krobo in the north, Asuogyaman in the east and Dangme West in the south. A range of mountains called Yogwa stretches across the municipality west-east. Lower Manya Krobo District covers a land area of71787.350 acres or 29,053 hectares (LMK District Profile). Lower Manya Krobo has a population of 89,246(Ghana Statistical Service, 2010). Females 47,776 and males 41,470. The two communities in the study area had a total population of 845 (Odugblase: 354, Klo-Begro: 491). The population includes 442 males and 403 females (Ghana Statistical Service, 2010). The study area has 126 houses (Odugblase: 41, Klo-Begoro: 85). Three construction companies are located in the study area. These are A. J. Fanj, Love Enterprise and Premium Terrazzo. The largest of the three, A. J. Fanj Company Limited, was contracted by Ghana Cement Factory (GHACEM) which was founded by the Government of Ghana in collaboration with Norcem A. S. of Norway, on 30 August 1967, to mine limestone on 17 November 2004.

Profile of Yilo Krobo Municipality

Location

The Yilo-Krobo Municipality is one of the twenty-six Municipals in the Eastern Region of Ghana and is strategically located in the south eastern part of the country. It shares boundaries with the Lower and Upper Manya-Krobo Municipals in the North and East, Dangbe West and

Akwapim North Municipals in the South, New Juabeng, East Akim and Fanteakwa Municipals in the West. The Municipality covers a land area of 805 square kilometers with Somanya as the Municipality capital

Demography The 2010 Housing and population Census indicates a population size of 86,107 comprising 41,830 males (48.6%) and 44,277 females (51.4%) with a growth rate of 3%.

The population density is 107 persons per square kilometer. Somanya Town Council has the highest population in the Municipality accounting for 38.4% of total population. This is followed by Nkurakan and Boti Area Councils, Nsutapong, Obawale, Oterkpolu and Klo-Agogo.

Economy The major economic activities in the Municipality are agriculture, services, trading and small scale Industrial activities, 58 percent of the working population is engaged in agricultural activities producing mainly staple food like maize, cassava, plantain and cocoyam. The Service Sector consists predominantly of government sector employees. There are huge deposits of limestone in the Municipality, which could be mined for the production of cement and other building materials for both local and international uses. Klo-Begro is situated in the municipality.

1.9. **Scope of the Study:**

The study covered two out of the three limestone quarrying communities, one in Lower Manya Municipality–Odugblase and the other Klo-Begro in Yilo municipality which have two active quarry sites. Active blasting and crashing is ongoing. Economic activities, social status, proximity to the quarries, morbidity cases on water and non-water related records from health facilities in the limestone catchment area, and dusty road in the community are some of the factors considered. A rugged and dusty road passes through the limestone mining communities

from Bueryonye, Odugblase to Klo-Begro. The dusty road is used by heavy-duty trucks of these companies to transport the limestone ore to their parent companies in Tema for final processing. The road generates a lot of dust daily as more than fifty of the heavy duty trucks ply it.

1.10 Organization of report

The paper is organized in six chapters. The preceding Chapter is an introductory part, which contains the background, problem statement, research questions, study objectives, profile of the study areas Chapter 2 is on Literature review, definitions of terms and process of dust generation and similar work done in other parts of the world, Chapter 3 methodology, Chapter 4 is on the results of the investigation, Chapter 5 highlights on discussions and finally the Conclusion and Recommendation are drawn from the overall study and presented in Chapter 6.

CHAPTER TWO

2.0 Literature Review

2.1 **Introduction**

The chapter presents what was done about the same work or a review of related literature on the subject under investigation by various scholars, authors and researchers. It gives an overview of what had been written or researched on different aspects of the subject. It also summarizes selected studies that would be relevant to organization and interpretation of data. Finally, it was guided by the statement of the problem, the aim and objectives of the study and the rationale.

2.**2 Quarry processes**

Activities in quarrying cause significant impact on the environment. A method used to extract the ore is blasting of rocks with explosives in order to extract materials for processing but this method of extraction gives rise to noise pollution, air pollution, land pollution, damage to biodiversity and habitat destruction. The first step of quarrying is prospecting an area to locate the ore.

Secondly, once the rock is blasted and removed from the working area, there will normally be some processing carried out at the site and in some cases transported on dusty roads to its final extraction. Some materials may need to be crushed further to reduce the size of individual pieces to a manageable size. Crushing machinery can be noisy, and for hard rock there is sometimes a need to use a pecker on the largest rocks before loading onto the dump truck, or a hydraulic breaker at the crush feed.

The extent of the impact of quarrying can range from those that can be seen, noticed and heard to highly noticeable and the nature of the impact can similarly vary widely depending upon the

mineral worked on, the method of mining and the characteristics of the quarry site and surrounding communities. One of the major complaints by communities to the crushed stone industry is location near rural communities. Blasting may occur frequently and unannounced.

2.3 Quarrying effects in other parts of the world

Limestone quarrying and stone crushing is a global phenomenon, and has been the cause of concern everywhere in the world, including the developed nations (Okafor,2006). Quarrying is an important activity because it provides much of the materials used in traditional hard flooring, such as granite, limestone, marble, sandstone, slate and even just clay to make ceramic tiles. However, like many other man-made activities, quarrying activities cause significant impact on the environment (Okafor, 2006). In particular, it is often necessary to blast rocks with explosives in order to extract material for processing but this method of extraction gives rise to noise pollution, air pollution, damage to biodiversity and habitat destruction.

Quarrying involves several activities that generate significant amounts of noise. The excavation of the mineral itself involves considerable noise, particularly if blasting methods are used and the use of powered machinery to transport the materials as well as possibly processing plants to crush and grade the minerals such extraction of raw materials from their natural habitats by mining, drilling and harvesting affect the natural environment considerably (Howard and Cameron, 1998). Dust from quarry 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 dusts, whereas coal mines produce acidic dust(Hsin-Yi, C.,2012**).** Air pollution is not only a nuisance in terms of deposition on surfaces and possible effects on photosynthesis, but with respiratory problems (W. C. Montgomery.1993). Dust can

also have physical effects on the surrounding plants, such as blocking and damaging their internal structures and abrasion of leaves and cuticles, (Guach, 2001).

One of the biggest negative impacts of quarrying on the environment is the damage to biodiversity (Anand, 2006). 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, as our survival depends on this fine balance that exists within nature (Anand, 2006).

In the crushed stone industry, dust is carcinogenic due to heavy metals found in them and long exposure to silica causes silicosis and deposition of dust on the skin and eyes can cause irritation and the eyes may develop conjunctivitis((NIOSH,2002)). The chemical compounds or elements that compose the rock compounds have effect on human health. Other factors that pose health risks to living near quarries or quarry workers include particle size, composition and concentration of dust, deposition location within the respiratory tract and the exposure duration (NIOSH, 2002) of the heavy mental. According to environmental experts the uncontrolled expansion of quarrying in Senegal has led to coastal erosion, a reduction in the area of available farmland, skin and lung problems for the quarry workers and people who live nearby, (Irin, 2003) Varying degrees of polluted air, water and land occur in the course of mineral development depending on the stage and scale of activities attained. While only minor pollution occurs during mineral exploration, more intense air and water pollution emanates from the exploitation stages, particularly if carried out on a large scale an example in Nigeria, the greatest pollution effect comes from a large scale exploitation of petroleum, limestone and rocks used in the construction works (Unesco-Mab, 1995). A common negative effect of quarrying minerals

from the earth's surface is the destruction of its natural landscape, creating open space in the ground and generating heaps of rock wastes that cannot be easily disposed (Bell FG ,2000). These phenomena are fully demonstrated in several parts of Nigeria, where commercial mining or quarrying had occurred in the past or is currently taking place with varied environmental issues comprising of land disturbance, emission of fugitive dust, noise pollution, and ground vibrations, which involves movement of machinery and rock blasting Quarrying poses danger to the workers due to rock fall and machinery, while the dust produced is harmful to their health ((Langer et al., 2004).

The dust particle size, concentration, mineral composition and long-term exposure are factors considered in evaluating the health risks involved. The inhalation of the dust causes severe health problems including respiratory and pulmonary problems, while dust deposition causes skin and eye problems (Ugbogu et al., 2009).

An investigation by (Azand et al.,2006) on the quarrying industry around Delhi has described three types of silicosis depending upon the airborne concentration of crystalline silica to which a worker is exposed: Chronic silicosis usually occurs after ten or more years of exposure, accelerated silicosis results from higher exposures and develops over a period of five to ten years and acute silicosis occurs where exposures are the highest and can cause symptoms to develop within a few weeks or up to five years.

2.3.1 Economic value of the quarrying industry

The quarry industry is important because of its positive impact on economic development of a country as source of construction materials, revenue for the government through taxation and royalties and employment especially of the rural population and the industry also provides employment opportunities for both skilled and unskilled workers thereby supporting many urban

and rural families as it contributes to their livelihood and socio-economic development (Divya et al., 2012).

2.3.2 Quarry management practices

Dust generated at the crushed stone quarries can be mitigated through the usage of protective instruments to reduce respiratory diseases, as most quarries in the advanced countries have developed quarry management plans or dust management plan or schemes (Aliyu AA & Shehu AU.,1993) Dust control measures including use of vegetative cover in the quarry perimeter, mulching of the ground, windbreaks, taping of haul vehicles, dust suppressors and sprinkling of the ground surface with water (Barret & Eck, 2012).

2.3.3 Health effects of quarry dust

(Ugbogu, et al., 2009) studied the occurrence of respiratory and skin problems among manual stone workers and found out that up to 85% of the workers had respiratory symptoms while 77% had skin infection. The study also observed that although there was high level of awareness of effect of dust on their health, use of protective clothing and gear was not popular According to (Aigbedion, 2005), also large amount of dust from the cement factories and mining operations in the Nigerian limestone quarries are discharged daily into the air. Similarly, a lot of air-borne particulate matter are generated by the numerous stone crushing industries in the country. When the air is laden with such dust, it causes health hazards for some people, for example, pollution studies around Sagamu and Ewekoro cement works in Ogun State have shown that several people are suffering from eye pain, and asthmatic attack due to the dust-laden air that prevails within a few kilometers radius of the factories(Aigbedion,2005)The major health concern is the

inhalation of crystalline silica, which lodges, in human lungs thereby causing respiratory and pulmonary damage such as silicosis, bronchitis, pneumonia and lung cancer (Last, 1998).

2.3.4 Lack of environmental consideration and mining communities

Development most often does not check the effects of resource utilization to the environment, (Oyaigheviven, 1998) The reason why there had been many environmental problems associated with the ore extraction in the case of quarrying, most activities lack environmental considerations in the planning stage. Investigation by (Ayodele, 2010) projects are usually sited and embarked upon to satisfy the social and economic needs of the company without meeting the need and aspirations of the people concerned at the quarrying communities and the impact on the primary environment. In open cast mining and quarrying, vast area of excavated land usually exists, leaving behind stagnant ponds where mosquitoes breed, Malaria and dengue fever are among the main dangers of stagnant water, which can become a breeding ground for mosquitoes that transmit these diseases. Stagnant water can be dangerous for drinking because it provides a better incubator than running water for many kinds of bacteria and parasites (Sharma S., 1993).

CHAPTER THREE

3.0 Methodology

Introduction

The Yilo Krobo Health Directorate in January 2017 had their Annual Review Meeting and Malaria was on top of the top ten diseases followed by Upper respiratory tract infections. In Lower Manya Krobo Health Directorate, the 2017 Annual Review meeting also had Malaria, HIV/AIDS and Upper respiratory diseases in that sequence indicating that upper respiratory tract infections are a major public health problem in both municipalities.

3.1 Study design:

Spatial retrospective case-control study design is selected for this investigation for feasibility considerations, it is less time consuming and less costly.

3.2 Data collection technique and tools

An observational study was done to collect environmental effects in the study areas with the youth leaders. Primary data was collected using structured questionnaire which was both open and closed ended questions on social survey. Age of respondents was18 and above. The questionnaire was self-administered or through an interviewer for literate and non-literate respondents respectively. Their locations were geo-referenced using Global Positioning System Space (GPS)device.

3.3.1 Secondary data

Secondary data was obtained from health records frequently patronized by the respondents in Oborpah, Obenyemi and Oterkpolu health facilities. The data was categorized into cases (those

who reported upper respiratory tract diseases) and controls (those who reported other diseases than respiratory diseases). They were followed up and their locations were geo-referenced using Garmin Global Positioning System Space (GPS) device. Health records were collected for the period of 2015.

3 .3.2 Exposure to quarrying activities

Geographic Information System (GIS) was used to compute distances (as proxy of exposure) of both cases and controls from the quarrying sites and road networks within the communities.

3.3.3 Study population

People who live in Klo-Begro and Odugblase in 2015 and reported to any of the three health facilities and aged from 18 years and above constitute the study population.

3.4 Study variable

Catarrh, Sore Throat, Asthma, Short breadth, Pneumonia, Heart Problem, frequent bringing out of phlegm, Wheezing or whistling of chest was considered as upper respiratory tract infection which constitute a case and the other variable is any other disease which include water related diseases such as Malaria, Guinea worm, Cholera, Typhoid, Elephantiasis, Diarrhea, and Bilharzias constitute control.

3.5 Sample size

A total number of 351 people attended the three health facilities in 2015.Inclusion criteria: people who lived in the two communities and experienced any of the health conditions. Exclusion criteria: people who reported of those conditions and are not from Odugblase and Klo-Begro for the specified year. People sampled represents 108 households, in most situations, some

of the household have more than two or three cases and controls and could not be geo-referenced separately. hence I grouped them into household for easy data analysis. Odugblase has 38 households and Klo-Begro has 70 households. Thirty-two people were lost to follow up either left the community, died or used a different name not known in the community or could not trace the location because of unnumbered houses.

3.6 Pretesting

Pretesting of data collection tool was done in Bueryonye which has similar characteristics. Respondents were tested on the comprehensiveness of the questionnaire and was able to modify its ambiguity. Corrections were made where necessary.

3.7 Data handling

Four research assistants were trained. The respondents' interviews were coded and double entered and cleaned in Excel

3.8 Data analysis

The data analysis was carried out using R version 3.3.1 (statistical computing environment)

3.8.1 Kernel Density Estimates

A common technique used to estimate probability density function $f(x)$ of a point pattern process is the kernel density estimate or KDE. KDEs operate by averaging a series of small "bumps" (probability distributions in two dimensions centered on each observed point. The approximation of probability density function $f(x)$ for any arbitrary location $x = (x, y)$, is given by:

$\hat{f}(x) = \hat{f}(x, y) = \frac{1}{nhxhy} \sum_i k \left(\frac{x-xi}{hx}, \frac{y-yi}{hy} \right)$ (Brunsdon and Comber, 2015).

Each of the "bumps" maps onto the kernel function $k\left(\frac{x-xi}{hx}, \frac{y-yi}{hy}\right)$ and the entire equation describes the "bumps averaging" process leading to the estimate of the probability density, h_x and h_y are bandwidths in the x and y directions(i.e. the radii of the bumps in each direction).

A bandwidth estimation approach: $h_{x=}\delta x \left(\frac{2}{3x}\right)^{\frac{1}{6}}$ (Brunsdon and Comber, 2015), where δx is the standard deviation, is a default bandwidth estimation procedure in the R package GIS Tools.

In this research, two different tools were used to estimate the Kernel density. The first kernel density was estimated using GISTools package of R statistical computing environment. The output depicts the spatial intensity of the cases.

The second kernel estimate was carried out for both cases and controls using spatstat statistical package of R statistical computing environment. In this case, the bandwidth was computed.

3.8.2 Spatial variation of relative risk (rr).

Using the spatstat package in R, spatial polygon object of the study area in shape file format was imported into R and coerced to a suitable "owin" object. The point locations of the case – control samples were divided into cases and controls and the intensities of each subset calculated for a grid cells lying within the area, using the bandwidth calculated for the sample. To assess departure from the null hypothesis of risk variation under inhomogeneous Poison process (IPP), the significance of risk variation was computed using the test statistics (Bivand, et al, 2013):

$$\mathbf{T= \int_A (P(x) - \widehat{P}(x))^2 \, dx}$$

The significance of the observed value of the test statistics was computed by means of Monte Carlo Test. In this case, thousand (1,000) values of the test statistics were computed by re-labelling cases and controls (keeping $\mathbf{n_1}$ **and** $\mathbf{n_0}$ fixed) and calculating a new risk ratio $\widehat{P}_i(x)$

i=1,2,…,n for each new set of cases and controls. This provided a series of values $T^1,\ldots,T^k$ under the null hypothesis.

Using T^0 to represent the value of T for the observed data set, the significance (P-value) was calculated by taking (t+1)/ (k+1), where t is the number of values of T^i, i=1,…, n greater than T^0.

The Monte Carlo test is based on the fact that cases and controls are equally distributed under the null hypothesis. In that case, if the label of a case is changed to a control (or vice versa), the new sets of cases (or controls) still have the same spatial distribution and will have the same risk function p(x). If that is not a case, then the relabeling of cases and controls will produce different risk functions (Waller and Gotway, 2004).

The probability map is calculated by repeating the relabeling process 1,000 times, and tallying the number of times that the observed kernel density ratio was less than the re-labelled ratios.

The results for the test with null hypothesis $P=P_0$ turned out to be significant (P-value of 0.000999001), which means that the observed risk ratio is not consistent with a constant risk ratio.

3.8.3 Binary Regression using Generalized Additive Models

The Generalized Additive Models formulation allows the inclusion of covariates in the models by means of standard logistic regression (Bivand et al., 2013). In addition, the residual spatial variation can be modelled by including a smooth spatial function (Bivand et al., 2013). Thus, if u is a vector of covariates observed at location x and g(x) is a smooth function not dependent on the covariates, the formulation is given by (Bivand et al., 2013)

$$\mathbf{logit(p(x)) = u' \beta + g(x)}$$

The R's package mgcv was used to fit the Generalized Additive Model (GAM) with the penalized spline approach (Bivand et al., 2013). The GAM was fitted using distances from the three quarry sites and the road, and controlling for known and possible risk factors such as gender, age, and occupation. The distances to the quarry sites and road were used as proxies of the actual exposure to any risk factors caused by the pollution sources

3.9 Ethical considerations

Permission and approval was obtained from Manya Krobo and Yilo Krobo Health Directorates and also from the Ethical Review Committee of Ensign College of Public Health, Kpong in the Eastern Region of Ghana. Informed consent from each of the respondents was obtained before questionnaire was administered in accordance with the Helsinki declaration of 1975. All procedures were adhered to. All records obtained are confidential and names of people in the investigation will not be sighted. Soft copies of the data are stored on the investigator computer. Feedback of the investigation was sent to the Lower Manya Krobo and Yilo Krobo Health Directorates.

3.10 Limitation of the study

Recall bias by respondents on cases reported to the health facilities. Air pollutants were not measured in the investigation.

CHAPTER FOUR

4.0 Results

4.1 Study area composition of cases and controls

Table1. No of cases and controls and number of households

Community	Cases	Controls	Households
Odugblase	122	37	38
Klo-Begro	114	56	70
Total	**236**	**93**	**108**

Source: Investigator, 2017

Out of 351health records collected ,329 were sampled with a response rate of 93%, cases constitute 72% and controls 28%. After geo-referencing their locations ,122 cases were found at Odugblase and 37 controls which represent a total of 38 households. At Klo-Begro 114 cases and 56 controls were sampled representing 70 households (Table 1)

4.2 Questionnaire distribution by sex

Sex	Number	%
Male	172	52.28
Female	157	47.72

Table 2: Questionnaire distribution

Male respondents represent 52.28% and Females 47.72% indicating 5% more males were sampled than females.

Age Group	Number	%
Young Age	92	27.96
Middle Age	137	41.64
Old Age	100	30.39
Total	329	100

Table 3: Age distribution of respondents

The age distribution of the respondents was young age 27.96%, middle age 41.82% and old age 30.39% and shows that middle age has a larger population size than the rest.

OCCUPATION	Number	%
Farming	309	93.52
Teaching	2	0.60
Trading	8	2.43
Dressmaking	4	1.61
Food vendors	6	1.82
Total	329	100

Table 4: Occupation of respondents

The predominant occupation of these rural communities are farmers that translate into 93.52%, teachers 0.60%, traders 2.43%, dressmakers 1.61% and food vendors 1.82%

Noise pollution/Vibration	%

Quarry noise	100
Hearing defects	35

Table 5: Noise pollution/vibration

All the respondents agreed that the main source of noise pollution was the activities of the quarries sited in the communities and 35% agreed to have hearing defects as a result of strong noise created as a result of blasting of the limestone.

Table 6: Environmental effects on houses

Crack in buildings because of blasting	80%
Collapsed buildings	10%

Respondents reported of cracks in the walls of their buildings due to blasting as 80% and collapsed buildings at 10%.

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Plate 1: Cracked building at Odugblase

The picture above is one of the several houses that developed cracks and is a confirmation of what the respondents said as a result of constant vibrations from blasting by the quarry companies which forms part of the observational study

Plate2: Collapsed building at Klo-Begro

This is one of the collapsed buildings suffered from constant vibration not too far from the quarry site

Table 7: Loss of flora & fauna

Activity	%
Plant and animals destroyed	100
Loss of domestic animals	76

Plants and animals get extinct was 100% and domestic animals dying 76%

Table 8: Sources of dust pollution

Sources	%
Quarries dust	100

stockpile	
Blasting	100
Crushing	100
Road haulage	100

Sources of dust in the communities was from the quarry activities and stockpile agreed by all the respondents 100%, blasting 100%, crushing of limestone at the quarries 100%, and dusty haulage road was 100%. The plate below shows a stockpile of dust gradually blown into the community

Plate 3: Stockpile of quarry dust at site.

Source: investigator,2017

Plate 4: Quarry pit

Livestock fall into the pits on some occasions

Source: investigator,2017

Table 9: Quarrying activities and water pollution

Flooding	%
Farmlands	40
Run – offs	95
Stagnant water breeding mosquitoes	100

The above table shows that run-offs from the quarries affect their land by 40%, run-offs actually enter the community by 95%and stagnant water breeding mosquitoes 100%.

Plate 5: Water accumulated in the quarry pit.

Source: investigator,2017

Water accumulated in the pit will be pumped to the community due to lack of drainage system and eventually source of surface and underground water bodies polluted and formation of stagnant water bodies as sites for breeding of mosquitoes.

Plate 6: Polluted drinking water at Klo-Begro(Kotuku)

Source: Investigator,2017

Source of drinking water and polluted by airborne dust and run-off from the quarries.

4.3 Human health and quarry effects

Activity	%
Dust is nuisance	100
Dust affect health	100
Rain water from roofs unclean	100
Ill – health due to dust/flood	100
Rainwater contain dust	90

100% of the respondents agreed that dust is a nuisance, dust affecting their health was 100%, rain water from their roofs contain dust 100%, ill health was the result of dust and flood 100% and rain water contain dust 90%

Table10: sources of pollution

Types of Health Service	%
Postnatal care	100
Health talk	5

Table 11: Health programmes

100% agreed to postnatal care service provided and 5% agreed to a health talk

Table12: Effects of quarry dust on plants

Activity	%
Dust reduces crop yield	75
Dust makes leaves stunted	40

75% agreed to dust deposition reduce crop yield and dust makes plants have a stunted growth

Plate 7: Dust deposit on mango tree at Odugblase.

Source: investigator,2017

This tree is polluted with dust from the haulage road and dust produced by the quarrying activities and similar conditions affect their crops which give rise to stunted growth and poor yield.

Plate 8: The above picture shows two handbags polluted with dust.

Source: investigator,2017

The person lives close to the dusty haulage road and said the fugitive dust from the haulage road is a curse to their health as they similarly inhale it daily at Odugblase

Plate 9: Quarry raw material to be transported

Source: investigator,2017

The crushed limestone is awaiting vehicles to be transported from the quarry site which is exposed to the wind.

Plate 10: Heavy duty vehicles that transport limestone from Klo-Begro.

Source:investigator,2017

Transportation of limestone is done by several of such vehicles to the mother company at Tema for the production of cement and generate much dust on the untarred haulage road

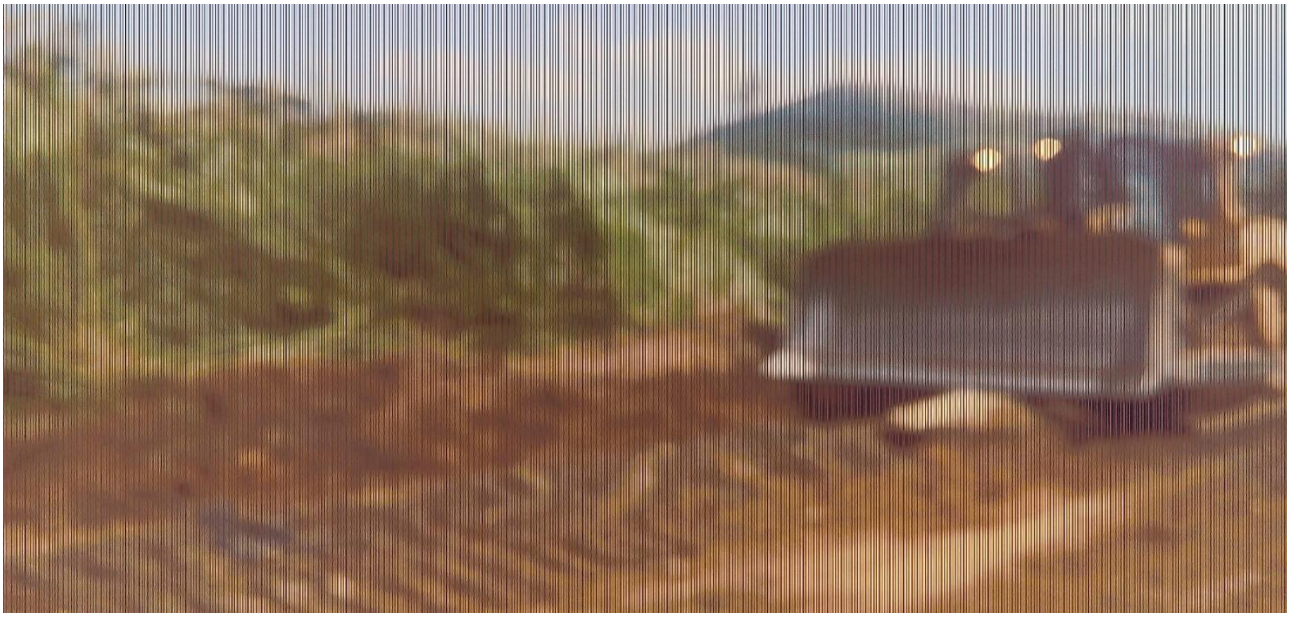


Plate 11: A Tractor clearing the vegetation at Odugblase

Source: investigator,2017

The vegetation is destroyed to pave way for quarry activities

Table 13: Mitigation measures

Activity	**%**
Health talk	100
Screening	90
Spray of dusty haul roads	100
Nose masks	40
Clinic	100
Blasting alarm	100
Relocation	90

Health talk, spraying of dusty road with water, siting of a clinic in the community and blasting alarm was 100% for each, wearing of nose masks 40% and relocation of the community 90%.

4.4 Study areas

Figure 1: Map of the study area depicting the quarry sites, road network, cases and controls

In Odugblase, A.J Fanj (Ghacem) and Love Enterprise shown in red boxes operate their quarrying activities and are sited in Lower Manya Krobo Municipality and Klo-Begro is shown also in red box where Premium Terrazzo operates and is found in the Yilo Krobo Municipality. Cases were distributed along the dusty road. The red stars represent cases and the pink rectangles represent controls.

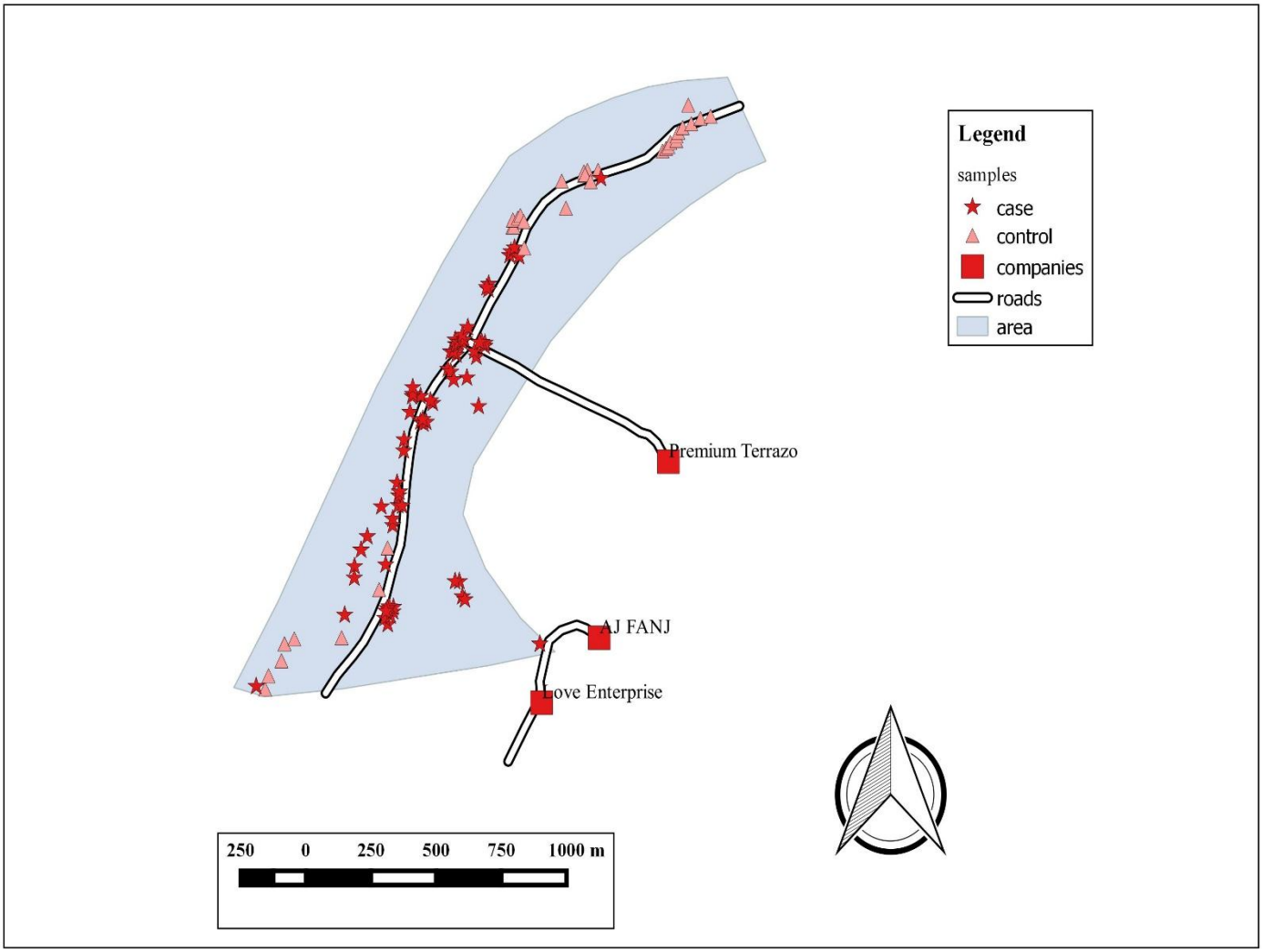
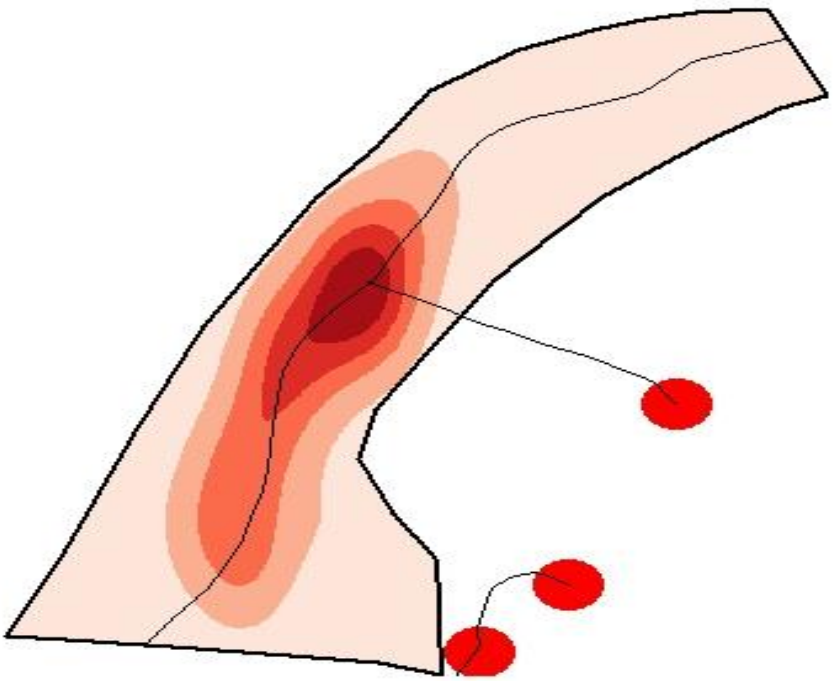


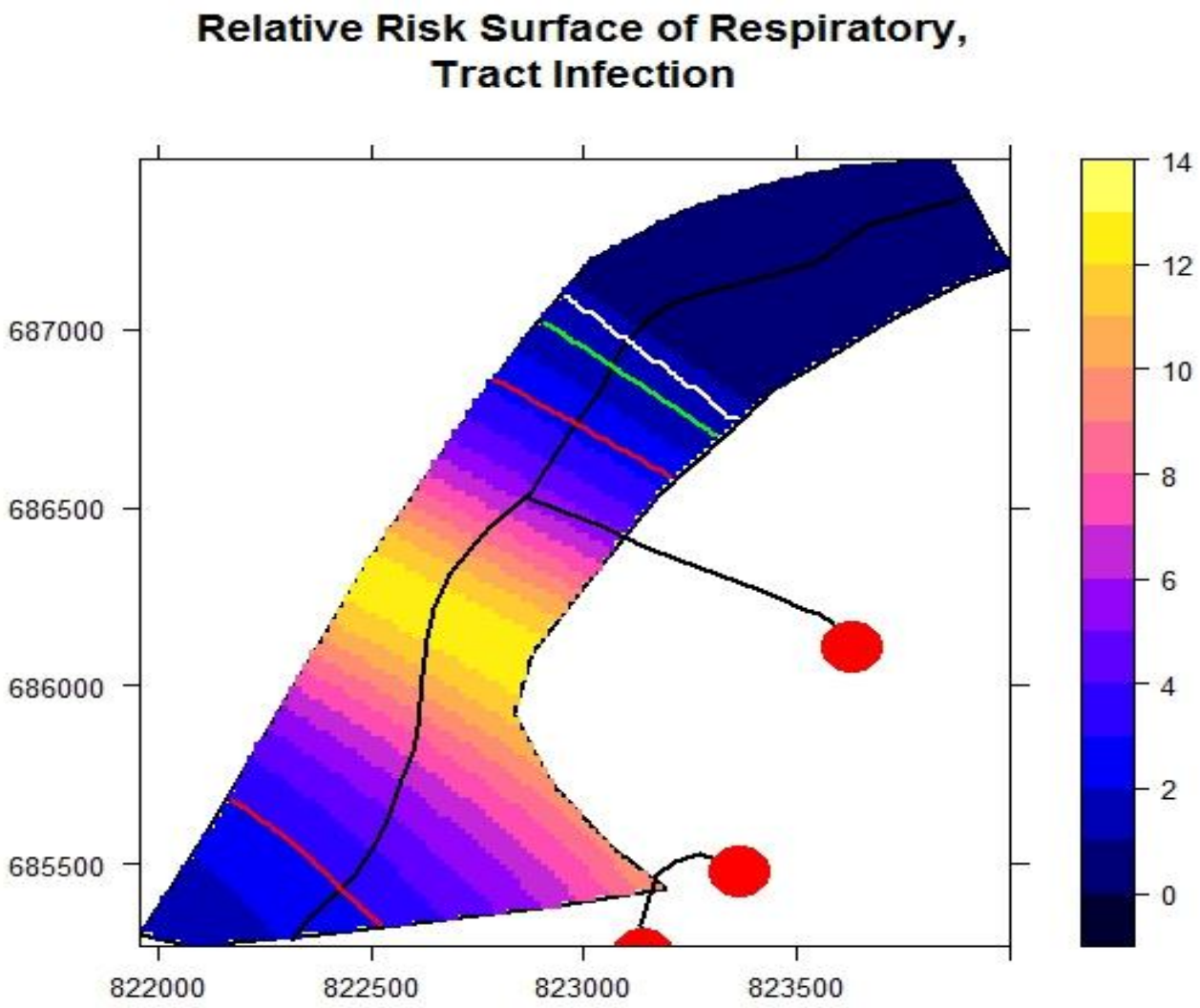
Figure 2: Kernel density plot of cases of respiratory tract infection (RTI) disease

Kernel density estimation (KDE) of the cases show very high cases of respiratory tract infection (RTI) in the middle portion of the study area that is Odugblase community, the intensity decrease



slightly southwards. Areas around Klo-Begro community showed very low upper respiratory tract infections (Figure 2).

Figure 3: Relative risk surface of respiratory tract infection generated from the kernel ratio of intensity of cases and controls. The red continuous lines in enclose areas show where the risk surface is so high with less than 0.05 p-values, the green line marks areas with 0.05 p-values and the white contour marks areas with very low relative risk with 0.95 p-values



Test of clustering of the relative risk surface after thousand simulations based on Monte Carlo relabeling hypothesis produced a p-value of 0.000999001 which is very significant around the dusty road. The log relative risk surface displays spatial variation of the respiratory tract infection, areas zero (0) risk surface means those areas constant risk ratio between cases and controls, areas below zero indicate they have very low risk of respiratory tract infection, and areas above zero between them have high risk ratio (Figure 4).

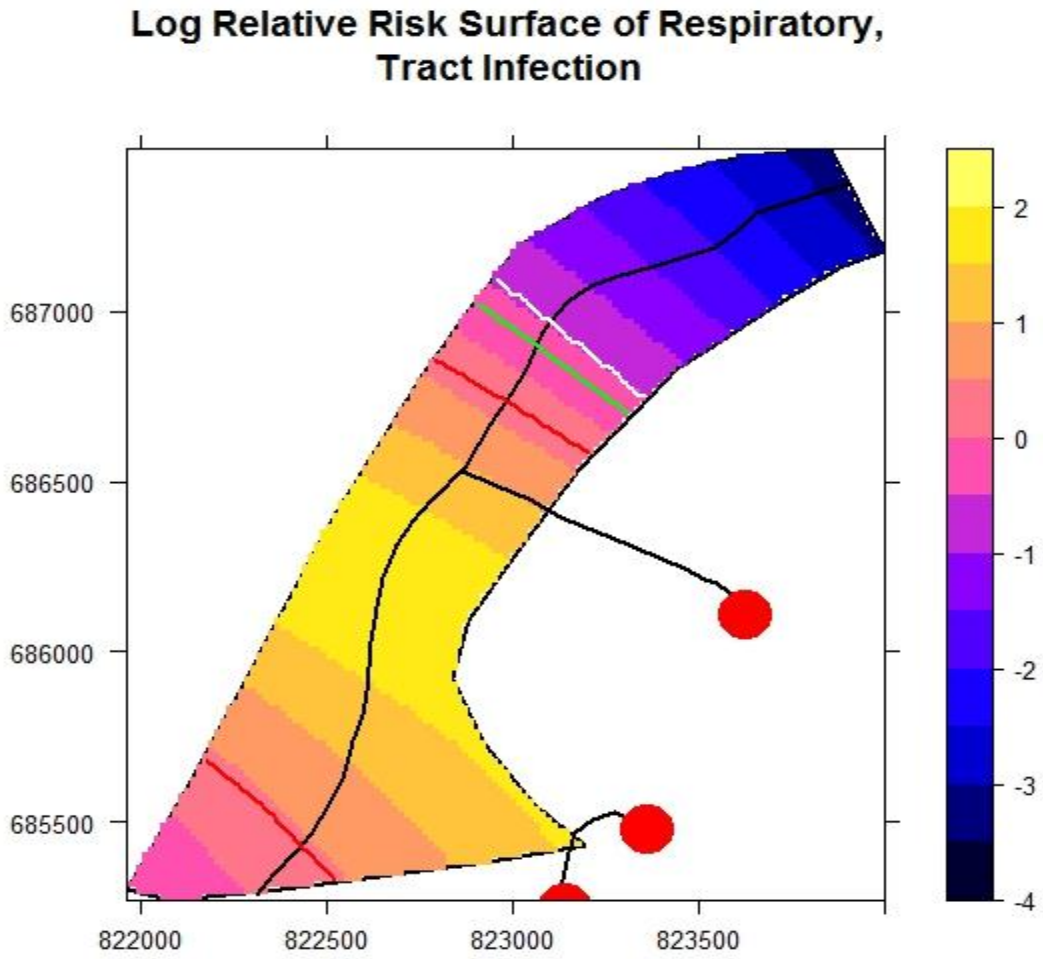
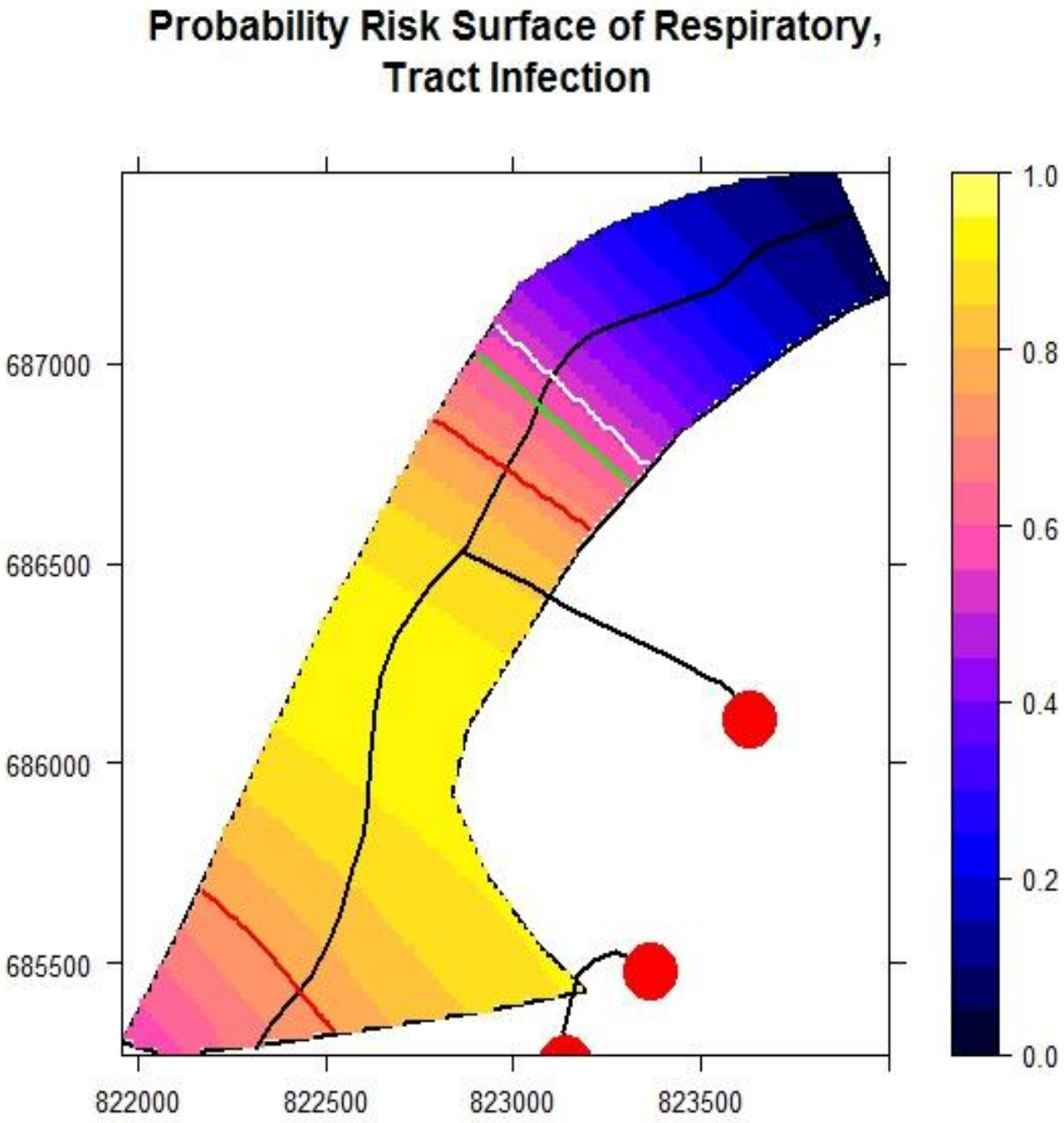


Figure 4: Log relative risk surface of respiratory tract infection of the study area

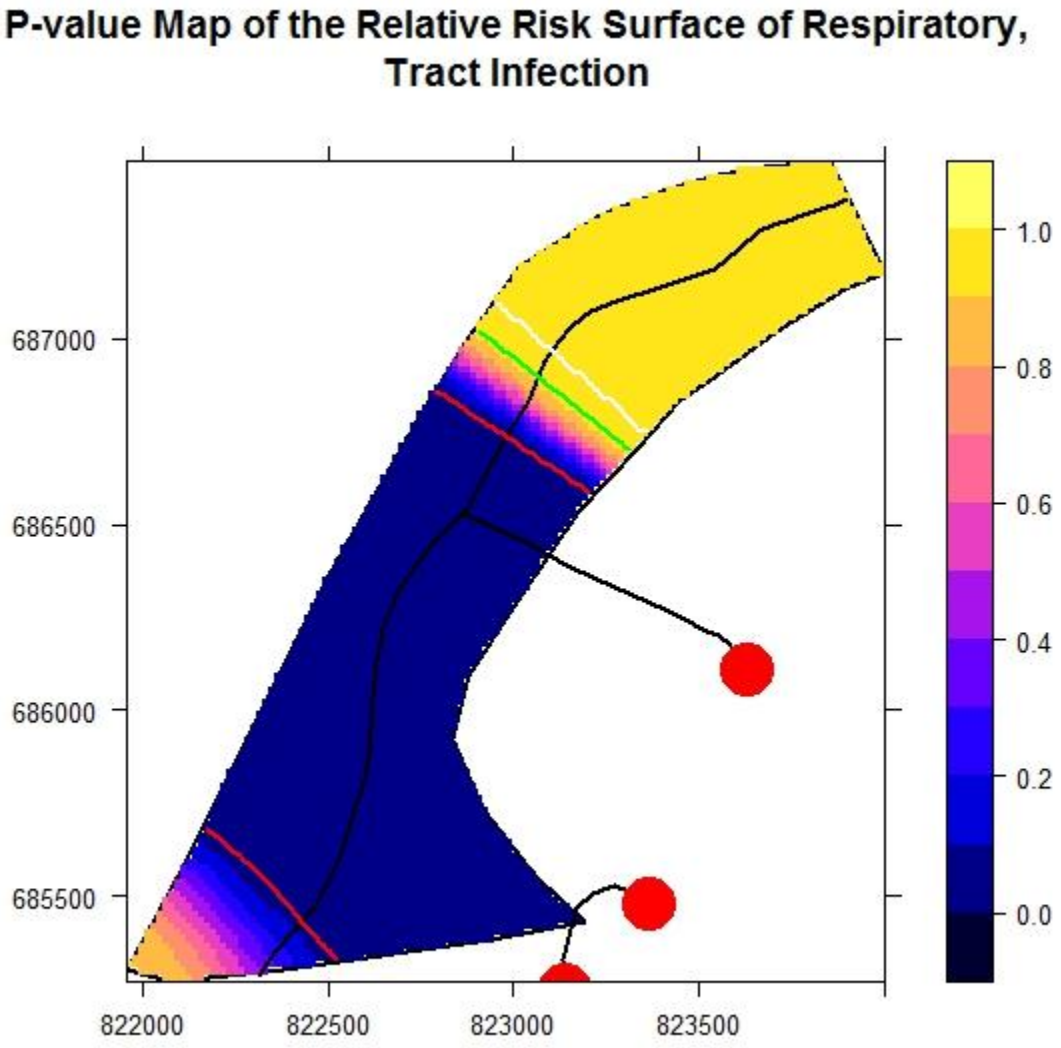
The probability of an individual living at Odugblase is one (1) and Klo-Begro of one developing a respiratory tract infection is 0.08. Areas around Odugblase depict very high probability close to



one (1) of being a case

Figure 5: Probability risk surface map of the respiratory tract infection at Odugblase and Klo-Begro communities.

The p-value map indicates significant risk areas around the dusty road from the middle to south-



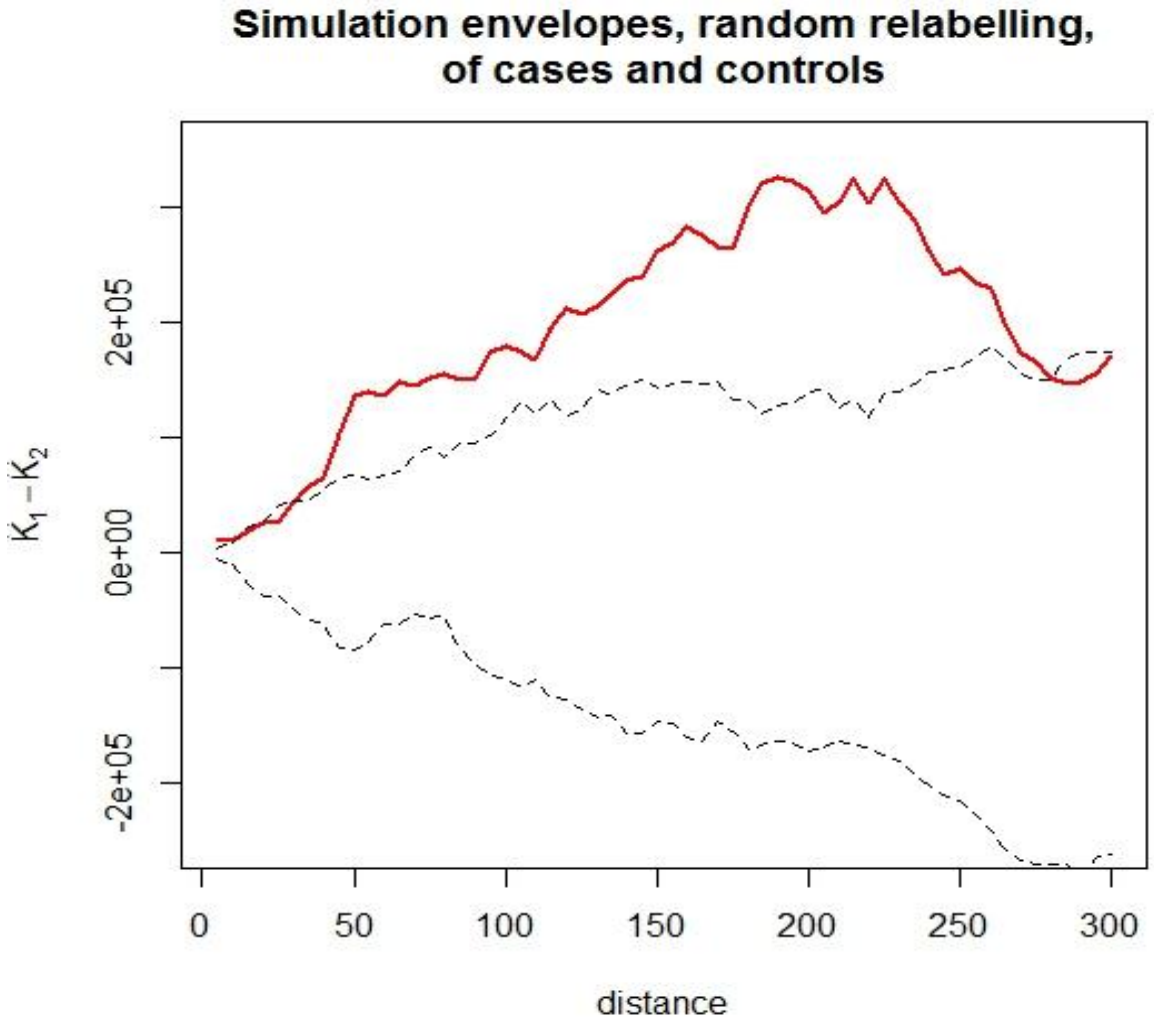
eastern of the study area (Figure 6)

Figure 6: P-value of surface of upper respiratory tract infections of the study area

The table below shows the age groupings, young age, middle age and old age. The output indicates weak associations using distance as proxy to the quarry sites A.J. Fanj, Love Enterprise and Premium Terrazzo. The dusty haulage road has weak correlation but stronger than the rest

Table 14: Output of the generalized additive modelling of the risk factors

	ESTIMATE	Std.Error	Z -value	Pr(>|z|)



Test of clustering after relabeling cases and controls severally showed clustering in red line as the upper limit. As you enter the community there are less cases and at the end also cases are reduced.

CHAPTER FIVE

5.0 DISCUSSIONS

5.1 Introduction

This chapter gives a descriptive result, interpretation and findings of the study.

5.2 Description of Results

The economic gains in the mining industry which includes quarrying, seeks to ensure that quarrying activities are carried out responsibly, hence the Ghana Mining Law 2015, section 8 takes into account the protection of the environment and local communities after mining operations which confirm section 72 (prevention of pollution of Environment) of the Minerals and Mining Act - 1986 (PNDCL 153). Air Pollution according to the investigation, revealed major negative effects of quarrying on the environment. Quarrying activities at Odugblase and Klo-Begro produced high amount of dust through blasting, crushing of rock particles, stockpile of dust and transportation through fugitive dusty haulage road. The dust produced travel into the

atmosphere, causing pollution to the environment. The cluster of upper respiratory tract infections from the investigation revealed air polluted related diseases, which reflects the extent of negative effect of air pollution as a result of quarrying on the environment.

World Health Organization (WHO) produces evidence regarding the linkage of air pollution to specific diseases, such as cardiovascular and respiratory diseases and cancers, as well as burden of disease estimates from existing air pollution exposures, at country, regional, and global levels. (WHO, Air quality guidelines 2016) further stated that by reducing air pollution levels, countries can reduce the burden of diseases from stroke, heart disease, lung cancer, and both chronic and acute respiratory diseases, including asthma. This will lessen morbidity and mortality rates in quarrying communities where dust yield is high as a result of dusty haulage roads and quarrying activities.

The implication could lead to high expenditures on hospital and medication. Health data has also supported the deadly effects of quarrying activities on the people in the three communities. There had been a sharp rise in dust related diseases from 2005 when limestone quarrying started in the area. Cough, catarrh, sneezing, sore throat and bringing out phlegm were the major dust related ailments suffered by the people in a research by (Kissi,2012) on a study in these communities that records from health facilities in the quarrying catchment area increased from 2005 when quarrying activities started as compared to 2003.

Noise pollution was a type of environmental pollution which may increase the risk of hearing loss, sleep disturbances, stress and heart disease. A new analysis conducted on environmental assessment on noise pollution as a cardiovascular health hazard, (American Public Health Association,2013) revealed small decreases in noise could add up to major economic savings. Noise constitutes a real danger to people's health: At home, at work, and at play, noise

can produce serious physical and psychological stress. Research on loud noise during peak hours creates tiredness, irritation and impairs brain activities so as to reduce thinking and working abilities. (Passchier-Vermeer W. N, Health Council of the Netherlands, 1993)

Noise pollution is another negative health effect of quarrying at Klo-Begro and Odugblase on the environment as mentioned by the respondents. The unpleasant sound produced by quarrying activities creates an unfriendly environment for most residents. Households complained that, quarrying activities or operations such as crushing, blasting and excavation produced very high level noise that disturb the whole environment throughout the day and night. The deafening noise produced by quarrying activities result in sleeplessness for most residents; affecting the sick, pupils and school activities, the aged and workers who require enough sleep to refresh their minds for their various activities. Equipment and vehicles used to convey goods from the quarry sites are also said to contribute to noise pollution in the community. Noise can cause annoyance, can also affect wildlife by driving them from their habitat, churches meetings, community meetings, are also disturbed by noise from blasting from the quarries per responses of the respondents.

Vibration from blasting by quarrying activities was identified with earth-moving, processing equipment, and can give rise to vibration, audible noise, fly rock and dust levels and can cause structural damage to properties through vibration transmitted in the ground and pressure waves through the air can cause collapse of some houses and continuous maintenance of the cracks by the frequent vibrations (Langer, 2001).

Vibration was mentioned as another crucial negative health effect of quarrying at Odugblase and Klo-Begro on the environment. Quarrying major component is blasting activities which

produces high level vibrations which creates unimaginable panic and fear to residents especially unannounced blasting. Respondents said vibrations produced from blasting activities resulted in cracks in their buildings and in some cases the facility collapsed, which is a health hazard to livelihood. According to (Occupational Safety Health Act no 105- 89, 4) in every workplace where any vibration is transmitted to the human body through solid structures, becomes harmful to health or otherwise dangerous, all practicable control, preventive and protective measures shall be taken by the employer to secure the safety and health of any such person who may be exposed to the vibration.

The investigation also saw their water bodies got polluted which is a threat to them, their livestock and other animals that drank it. Floods might be responsible for water related diseases in the communities. People in the study area in the LMK/YK municipalities live at the risk of the diverse infections in performing their daily activities, which include farming, teaching and learning, trading and performing of domestic chores.

5.3 Association of dusty road and upper respiratory diseases

The study revealed a significant correlation between dusty road and a cluster of upper respiratory tract infections and supported by the relative risk surface map of respiratory tract infection generated from the kernel ratio of intensity of cases and controls. The contours generated from the relabeling hypothesis after thousand simulations showed highest risk areas in red continuous lines enclosing areas where the risk surface is so high with less than 0.05 p-values, the green line marks areas with 0.05 p-values and the white contour marks areas with very low relative risk with 0.95 p-values.

The kernel density has high intensity and clustering of cases around Odugblase the study area as shown by the statistic plot. The probability of living in Odugblase and being a case is very high as shown by the probability plot with probability of being a case almost the value of one (1), that is a near certain event. The haulage road through Odugblase community and Klo-Begro are not tarred and dusty. However, this road is very busy because quarry materials are hauled through it by heavy trucks thereby generating a lot of dust. Based on the study hypothesis, the quarry site and road which emit a lot of dust, were possibly impacting on the health of the communities. Using distances to the road and quarry sites as proxies to exposure to putative sources of both cases and controls in the generalized regression additive modelling, there were some associations between the respiratory tract infection and the distances, as well as age and occupation but not significant. The weak association could possibly be due to the fact that the distances which were used as proxy could not account for the actual pollution emanating from the quarry sites and the road. The dusty haul road and quarrying activities are required information for the study. The test concluded that there was no significant association between age of the respondent and upper respiratory tract infection.

5.4 Quarrying activities and environmental effects

People living close to quarries are also affected by the activities that go on in that area. (Azad and Ashish 2006), findings from Pali in India, the safety of human beings is not put into consideration as there is no personal protective equipment being provided to workers, helmets, safety belts, masks, safety shoes are foreign things. It is confirmed by respondents their families who are residing close to these units are more vulnerable to silica exposure. The children, the women and elderly breath this toxin each day and night. Dusty haulage roads and air pollution

from the quarry sites contributed immensely to the poor performance of plants and crop growth and yield per the findings (Kissi,2012) due to high concentrations of dust deposit.

The investigation revealed serious concerns raised by the two quarrying communities as negative effects on buildings, water systems, farmlands and crops. Farmlands are covered by flood waters which were pumped from the quarry pits. Most buildings observed developed cracks with some near collapse. These cracks were basically due to strong vibrations of blasting. The vegetation in the area is also affected because dust accumulation destroys cuticles for proper functioning of the plants and hinder their growth. The dust accumulates on the leaves of the plants and block the stomata which are very important for the growth of the plant as is used in the process of gaseous exchange.

Quarrying is very important activity in the building industry for the construction of buildings and roads. The quarrying industries provide employment to a large population and to other related industries such as block building and construction of drainage materials. The quarry companies do not rely on the quarrying activities only but most of them are involved in construction.

Dust produced by haulage vehicles

The heavy vehicles that carry up to 12 tones in weight and used for transportation damage the roads leaving a lot of dust.

5.5 Mitigation measures

The respondents suggested dust reduction from the quarries as: watering the quarry sites before blasting, pre information to blasting so that they can take precautionary measures to prevent the effect of dust pollution, watering of the haulage road daily and often in the short term and the road should be tarred in the medium term. Relocation of the quarries to another area or the

community should be relocated so that they don't develop accelerated or chronic respiratory diseases in the long term. Fencing of the quarry sites in order to reduce accidents such as people falling into the quarry pits and their livestock is another requirement by the (Occupational Safety and Health Act no 105- 89, 4) and compensation for damage and accidents that are caused by the quarrying activity in the area.

CHAPTER SIX

FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

The investigation gathered information from the health facilities on the health of the people, questionnaire administration, observations and

analysis from the investigation suggest that hazardous conditions due to dust pollution from the quarries, blasting fumes, dusty road, might be responsible for upper respiratory diseases conditions in the communities. The analysis showed clustering of upper respiratory diseases cases along the dusty haulage road and further from the road there was water related disease conditions. Health data from the three health facilities support the effects of dust related diseases on the increase which suggest quarrying activities on the communities might be the causal agent. There was low reporting of upper respiratory diseases pre to the quarrying activities but a sharp

rise in dust related diseases from 2005 when quarrying activities started in the area. Cough, catarrh and sneezing are the major dust related diseases suffered in the community (Kissi,2012). Laws and guidelines from EPA about quarrying activities seem not adhered to. The social responsibilities are also on the low side. The people are interested in relocation of the community as a result of the adverse health effect as their houses stand the chance of collapse. Flora and fauna has suffered as well as biodiversity loss. The forest reserve in the quarry environ existed since 1957 and forms part of the 34 designated Globally Significant Biodiversity areas and covers the entire reserve with the presence of different wildlife species which is destroyed. Regulatory bodies such a EPA, NGO, s in health, local communities and pressure groups should be well equipped to monitor compliance with laid down laws and guidelines. Concentration on monitoring activities on the operations of quarrying or enforcement of relevant regulations and laws, improvement of health and safety for the communities, protection and preservation of the environment (air, water and land resources), and communities. Quarry companies should be mandated to adopt modern technology of dust strapping such that a negligible quantity of dust escapes from the various operations to the communities, which has affected the residents in a negative way and impacted their survival on their farming activities which bring low crop yield.

Despite the negative impacts revealed by the investigations, the communities have gained some benefits from quarrying as some people in the area have been employed as quarry workers to reduce unemployment and food vendors who sell to get some income. The quarry workers also buy food stuffs like plantain and cocoyam from the farmers.

6.2 RECOMMENDATIONS

Health screening exercises should be undertaken at least once in a year to determine new trends in diseases occurrence A health post should be sited in one of the communities as people may not

be reporting upper respiratory diseases because they have to travel long distances to seek for health. The government should revoke licenses of quarry owners who do not adhere to the set laws and social responsibilities. The drainage system in and around the quarries must be improved to reduce flooding of farmlands and breeding sites for mosquitoes and other water related diseases. The Government of Ghana and all its bodies like EPA should ensure that the laws governing quarrying and mining institutions are adhered to through surveillance. Stakeholders and especially the mining community should be part in the decision making when it comes to the location of quarrying industries and environmental impact assessment.

Haul trucks from quarry should not be allowed to use the unpaved road which passes through the three communities. These trucks generate a lot of dust which disturb the inhabitants and a contributory to high cases of upper respiratory diseases.

Future research

• Further research on more advanced methods of reducing the effects of the quarrying activity on the environment and underground water. Actual dust concentrations within the communities should be measured with air sampler at several locations. This information should be used to generate air pollution field, which will be used in regression model to assess the association between the quarry activities and the respiratory tract infection

• The correlation between wind direction and dust impact on the community.

• Research should be done to identify vibration effects on the health of the people living in the surrounding area.

REFERENCES

Akabzaa,z M. T. (2000). Boom and Dislocation - The environmental and social impacts of mining in the Wassa West District of Ghana. Third World Network. (TWN-Africa)

Aliyu AA, Shehu AU. Occupational Hazards and Safety, Measures among Stone Quarry Workers in Northern Nigeria. Niger Med Pract 2006;2:42-7.

American Public Health Association. Policy No. 7522(PP). Available at: http://www.apha.org/advocacy/policy/policysearch/default.htm?id=800. Accessed December 7, 2013

Ayodele A, E. and Lameed G.A. (2010). Effects of quarrying activity on biodiversity: case study of Ogebere site. Ogun state Nigeria. http://www.academicjournals.org/ijbc Azad

Azad S.A and Dr. Ashish Mittal (2006). The Stone quarrying industry around Delhi impact on Worker and the Environment. Boock

Azand and, S.A. & Ashish, M. (2006). The stone quarrying industry around Delhi- impact on workers and the environment.

Banez, J., Ajon, S. M., (2010). Report on Quarrying and its environmental effects. U.N. Journal, Vol 10.

Barret, M.E.& Eck, B.J. (2012). Best management practices for quarry operations, complying with the Edwards Aquifer Rules. Title 30, Texas Administration Code, chapter 213, or 30 TAC 213.

Bell FG, Stacey TR, Genske DD (2000) Mining subsidence and its effect on the environment: some differing:135–152

Bivand RS, Pebesma E, Gómez-Rubio V (2013). Applied Spatial Data Analysis with R, volume 10 of Use R! 2nd edition. Springer-Verlag, New York. ISBN 1-4614-7617-8. URL http://www.asdar-book.org.

Brunsdon and Comber take readers from 'zero to hero' in spatial analysis and mapping through functions they have developed and compiled ... ***2015*** - 360 sidor..

Divya, C.M., Divya, S., Ratheesh, K. & Volga, R. (2012). Environmental issues in stone crushers.

Environmental Protection Agency Act,1994 of Ghana

Gauch H G (2001). Multivanate Analysis in Community Ecology Cambridge University Press,

Ghana Statistical census report 2000 and 2010

Howard, Bob, and Cameron, Ian, 1998, Dust control: Best Practice Environmental Management in Mining, Environment Australia, 73 p.

Hsin-Yi, C. (2012). The impact of quarrying. Retrieved December 14, 2012, from www.sustainablefloors.co.uk Last, J. M. (1998). Public health and human ecology (2nd ed.). (pp. 153-200). Prentice-Hall International Canada: McGraw-Hill Medical Publishing

J. Banez, S. Mae Ajaon, J. R. Bilolo and J. M. Dailyn, "Quarrying and Its Environmental Effects," 2010. http:www.scribd.com

Kissi P. (2012) Assessment of the effects of quarrying activities on some selected communities in the Lower Manya Krobo District page 85

Langer William H. (2001), Potential Environmental Impacts of Quarrying Stone in Karst-— A Literature Review, U.S. Department of the Interior U.S. Geological Survey

Langer, W.H., Drew, L.J. & Sachs, J.S. (2004). Aggregates and the environment. American Geological Institute (US Geological Survey) 4220 King Street, Alexandria, VA 112302; ISBN 0-922152-71-3

Last (1998) Report on Carcinogens. Background Document for. **Silica**, **Crystalline**. (Respirable Size). December 2 - 3, **1998**. Meeting of the NTP Board of Scientific Counselors Report on Carcinogens Subcommittee

Musyoka, 1997 Impact of mining to the environment and land use a case study of

National Institute of Occupational Safety and Health Hazard (NIOSH) Review (2002). Health effects of occupational exposure to respirable crystalline silica.DHHS 2002 – 129: 23.

NIOSH Hazard Review. Health Effects of Occupational Exposure to Respirable Crystalline Silica. DHHS 2002-129. pp. 23

Noise Pollution and Health,28 February 2016, https://multerland.wordpress.com/2016/03/10/e-co-energi-and-stoy/ 28 February 2016.

Okafor F C (2006). Rural Development and the Environmental Degradation versus Protection: In P. O. Sada and T.Odemerho (ed.). Environmental Issues and Management in Nigerian Development

Oyaigheviven VO (1998). A conceptual frame work for an Environmental Management Policy in P.O. Sada and F.O. Odemerho. Environmental Issues and Management in Nigerian Development

Passchier-Vermeer W. Noise and Health. Publication No A93/02E. The Hague: Health Council of the Netherlands, 1993 Noise and Health. Publication No A93/02E. The Hague: Health Council of the Netherlands, 1993

Sharma S. Malaria in stone quarry area of Faridabad complex (Haryana). Indian Journal of Malariology. 1993;30:113-117

Siachoono stone quarrying in Kangudo division

Sustainable Development Goal 6: Ensure availability and sustainable management of water and sanitation for all

Sustainable Development Goals 3: Ensure healthy lives and promote well-being for all at all ages

The Ghana Mining Law 2015,http: http://www.iclg.co.uk/practice-areas/mining-law/mining-law-2015/ghana

Ugbogu, O.C., Ohakwe, J. &Foltescu, V. (2009). Occurrence of respiratory and skin problems among manual stone-quarrying workers. African Journal of Respiratory Medicine, March, 2009 pp 23-26

W. C. Montgomery, "Environmental Geology," 3rd Edi- tion, Wm C. Brown Publishers, Dubuque, 1992

Ward, J.V. 1989. The four-dimensional nature of lotic ecosystems. Journal of the North American Benthological Society 8(1):2-8.

WHO, Ambient (outdoor) air quality and health, Fact sheet, Updated September 2016

APPENDIX

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