NOISE PRODUCED FROM MECHANISED QUARRYING AND OCCUPATIONAL HAZARDS AT STIRLING QUARRY

BY

KULABAKO VIVIAN

16/U/6356/PS

216010070

A DISSERTATION SUBMITTED TO THE SCHOOL OF FORESTRY, ENVIRONMENTAL AND GEOGRAPHICAL SCIENCES IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF BACHELOR OF ENVIRONMENTAL SCIENCE OF MAKERERE UNIVERSITY

AUGUST 2019

DECLARATION

I hereby declare that this is my original research report and has never been submitted to any institution by any other person for any award.

Signature: ..... **Date:** 13th September 2019

VIVIAN KULABAKO

APPROVAL

This is to certify that this research report developed by VIVIAN KULABAKO has been developed under my guidance as the University supervisor and is now ready for submission to the Department of Environmental Management Makerere University.

Signature: ..... **Date:** 13/9/2019

MR. KENNETH BALIKOOWA

DEDICATION

I dedicate my work to mostly my cherished and supporting family. My sincere appreciation goes to all my friends and supervisor that have engaged in its accomplishment spiritually, financially and academically.

ACKNOWLEDGEMENT

First, I would love to thank the Lord Almighty for enabling me reach this far with my studies and by his Grace and protection I have accomplished my research work.

My profound gratitude goes to my family for their insisting prayers and support. I also take this opportunity to appreciate all the people that have been of great help in the course of my research through knowledge, guidance and encouragement.

Special thanks go to my supervisor Mr. Kenneth Balikoowafor the untiring assistance, time, support, advice and acceptance throughout the whole process of research. May the Lord reward you abundantly.

To the Department of Environmental Management administration that has provided me with continuous guidance and heading me to access more knowledge on a daily basis.

Contents

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

Db - Decibels

WHO- World Health Organization

HPD- Hearing Protection Device

NIHL- Noise Induces Hearing Loss

NEMA- National Environment Management Authority

OHSI- Occupational Health and Safety Impact

ILO- International Labor Organization

CPCB- Central Pollution Control Board

NIOSH- National Institute of Occupational Safety and Health

WBV- Whole Body Vibration

SNHL- Sensor Neural Hearing Loss

ABSTRACT

The research analyses the different occupational health impacts to the corresponding noise levels generated from given activities carried out at Stirling quarrying site in Mbalala district. Thirteen respondents were approached for relevant information through use of an interview guide for both workers and key informants at the site. Sound from selected activities and a few surrounding households was recorded and seismic damages on the walls of the houses observed. The research shows that mechanized activities at the quarry vary in the levels of noise released and recorded at different receptor locations. Different impacts that are faced at the site due to noise pollution have been recorded which shows that they are both short and long term to workers in the age bracket of 20 to 45 years , surrounding human beings and infrastructures.

Annoyance, headache, hearing impairments are significantly the same amongst workers however, other effects like flue due to the dusty environment, skin burns and irritations due to the scotching sun, drowning of workers due to the open pit filled up with water during rainy seasons, eye irritations, accidents, injuries, lack of sleep are faced by both workers and neighboring inhabitants.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND TO THE STUDY

Noise from quarries has become more severe and widely spread compared to ancient times due to technological advancements that have introduced heavy machinery. Despite attempts at regulation, noise pollution has become an unfortunate fact of life worldwide which is imposed on society against their will and at times places and volumes over which they have no control. (Goines and Hagler, 2007). Various guidelines against maximum noise levels have been put in place in order to regulate its release from different commercial activities in which mining sites are inclusive. Maximum permissible noise levels of mining and quarrying sites are 109dB and 114dB for some facilities with duration of 4hours Daytimes and Night times. Noise levels produced from quarries is from some of the different quarrying activities such as drilling, crushing, transportation, blasting. The United States Census that was conducted in 2000 found that 30% of Americans complained of noise and 11% found it to be bothersome. Among those who complained, 40% found noise sufficiently bothersome to make them want to change their places of residence (U.S. Census Bureau, 2006). The potential health consequences of noise pollution are medically and socially significant as well as being numerous, pervasive and persistent (Goines and Hagler, 2007). Effectively and essentially, it is crucial to carry out research studies in produced sound levels in quarries and respective impacts in order to mitigate them. In the quarrying industry, employees make use of explosives, chemical compounds or mixture that undergo rapid burning or decomposition with the generation of large amounts of gas and heat that give rise production of sudden pressure effects. The chief use of explosives in peace time is for blasting and quarrying (Hussein, 2006). Occupational health is an important public health concern for the working population. Various aspects of the working environment could expose an individual to potential hazardous elements. Noise is considered as one of these potential hazards and it is currently seen as a global health concern. Noise, which is defined loosely as annoying sounds, is part of the everyday human activity. Excessive noise beyond tolerated levels from all these sources is hazardous and could cause hearing impairment. This is a widespread occupational hazard, which could result in noise-induced hearing loss (NIHL). Other

associated health effects include elevated blood pressure, sleeping difficulty, annoyance and stress, and temporary threshold shift (TTS) (Aslam, M.J et al, 2008).

1.2 STATEMENT OF THE PROBLEM

Noise pollution from stone quarries can cause major annoyance, occupational hazards and may lead to various health and physical problems such as hearing impairments and perhaps cause psychological and physiological effect to workers. These effects can affect both quarry workers and those residing near stone quarries especially when the quarry sites are near residential areas (Ashley, 2004).

The consequences can significantly interfere with communication, disturb sleep, lack of concentration, irritability and reduced working efficiency. It is said that continued exposure to high noise levels causes headache, increase in blood pressure, and nervous breakdown as well as Infrastructural damages due to different levels of vibrations. Though substantial work has been carried out on other environmental impacts of stone quarrying, noise pollution appears to be one of the relatively neglected area of investigation in stone quarrying field.

1.3 GOAL AND OBJECTIVES OF THE STUDY

1.3.1 Goal of the study

The general objective is to raise awareness on the environmental impact of stone quarries to workers and neighboring communities.

1.3.2 Objectives of the study

i. Determine the noise generated by various activities in the stone quarry.
ii. To compare the level of noise generated by various activities in the stone quarry against national permissible levels.
iii. Determine the significance of noise pollution.
iv. To identify health precautions taken by workers against noise impacts.

1.3.3 Research questions

1. What specific activities release noise at the quarrying site?

2. How many Decibel units are produced by each mechanized activities at the quarry per day and night?

3. Do the released Decibels adhere to the standards and regulations of permissible noise levels?

4. How long are the workers exposed to noise and the exposure limits of the human ear to Noise levels?
5. What occupational hazard cases of noise pollution are experienced at the quarry?
6. Are workers provided with protective gears against Noise pollution?
7. What are some measures that may be implemented for workers to adopt in order to mitigate the different occupational hazards?

1.4 JUSTIFICATIONOF THE STUDY

The research relevancy or importance is to help find out the different levels of noise pollution produced from various quarrying activities and the ability to suggest and perhaps implement some of the mitigation measures necessary upon them. This will in turn improve workers' health and production efficiency and as well as inhabitants around the quarry socially, economically and environmentally within Mbalala. On the other hand, the research shall help the company become aware of the consequences and different occupational hazards faced by its workers and know how to mitigate them. This shall also increase production efficiency and profit levels of the company as well as meeting the set regulation requirements from NEMA.

CHAPTER TWO

LITERATURE REVIEW

2.1 NOISE GENERATED IN STONE QUARRIES

Manmade noise can be chiefly attributed to machines and modern equipment of various types of technological devices and other manual tools. Irrespective of the source, noise is a pollutant and besides its contribution to stress levels and other body malfunctions are yet to be fully understood. Some empirical research conducted on pregnant female mice reveals that aircraft taking off which brings 120 to 160 Decibels (dB) caused miscarriages in them (Baldwin, 2007).

The noise level in stone quarry can be depend on few factors such as operation, truck traffic, topography, ground cover around the site and climate condition. Stone quarry site have highest level of noise due to crushing stone activities where the extracted rock were transferred to primary crusher and screening facilities, resulting in the desired product sizes. The noise producing from stone crusher is some continuously and some intermittent. Intermittent noise can be come from crusher during the time of breaking the stone and also from loading and unloading operation. Meanwhile, continuously noise produce come from vibratory screens which operates at higher frequency and producing abnormally high noise level without enclosure. Truck traffic such as lorry, tractors and excavators also give rise to noise level.

2.2 NATIONAL PERMISSIBLE LEVELS

Regulations are put into place for purpose of ensuring the maintenance of a healthy environment for all people in Uganda, the tranquility of their surroundings and their psychological well-being by regulating noise levels and generally to evaluate the standards of living of the people. (The National Environment (Noise Standards and Control) Regulations, 2003). Under sections 28 and 107 of the NEA Cap 153.

Permissible Noise levels (6) through establishment of maximum noise levels from all sectors are set to ensure excessive noise levels in excess of permissible levels. "Subject to these Regulations, no person shall an activity specified in regulation 6; emit noise in excess of the permissible noise levels. Unless permitted by a license issued under these Regulations. Part IV talks about License for Noise in Excess of permissible noise level which is required by stone quarries in Mbalala due to high chances to exceed the noise limits. (The National Environment

(Noise Standards and Control) Regulations, 2003). Under sections 28 and 107 of the NEA Cap 153.

According to Behroozi Lar et al. (2012), sound pressure level of tractors is ranged between 91 dBA to 93 dBA which exceeded National Institute for Occupational Safety and Health (NIOSH) allowable 85 dBA criteria. It caused driver and other workers exposed more to noise pollution. Besides that, topography and ground cover around the site play an important role in noise emission. The location of stone quarry at higher places and surround by little land cover makes the noise emission higher compared to other sites. Roller sand screen site also located at place where no such barriers causing it producing higher noise level after stone quarry. Furthermore, climate condition such as temperature inversion and wind gradient also may increase noise levels by 5 to 10 dB and increase as much as 20 dB in extreme condition. It happens when sound-wave propagation path is focusing at a single point (EPA, 2000). The exposure of noise higher than permissible limits could raise the problem from annoyance to hearing loss. Continuous exposed above permissible limit may lead to long-term effects on the human auditory system. The effects are including bursting of eardrum, permanent hearing loss, stress, fatigue, irritation, inefficiency and unproductive (Naik et al., 2007).

Pandey et al (2006) studied the environmental problems due to generation of noise fromhaul truck in mining industry. In their report, they mentioned the noise exposure limit482.8 Noise Survey in Mines for industrial workers as per CPCB (Central Pollution Control Board, New Delhi. The Central Pollution Control Board, India has recommended certain guidelines for the maximum permissible exposure to different intensities of sound with regard to occupational health and safety of the industrial workers. For a full shift of 8-hours work is permissible if the noise level is 90dB or less. For higher noise levels,there should be a 50% reduction in maximum permissible working time for every 3dB increase in noise level over a range of 90-114 dB.

2.3 SIGNIFICANCE OF NOISE POLLUTION

Occupational noise-induced hearing loss or noise-induced hearing loss (NIHL) is a worldwide problem in the industry and it contributes to 16% of hearing loss among adults globally, ranging from 7% to 21% in various sub-regions and higher in developing countries (Ismail, 2013).

The levels of noise arise from mining industry seem to be higher when compared to other industries. For this reason, noise exposure and noise-induced hearing loss (NIHL) are prevalent in mining. Assessment of noise emission levels that arise from various mining operations is required to prevent and minimize the NIHL. Because the studies for preventing occupational hearing loss among miners are inadequate, a quarry and stone crushing-screening plant was selected to generate site-specific data. The noise levels of the environments in which workers work were measured and also a hearing test centre applied hearing tests to the workers. According to the hearing test results, it was determined that the part of workers have hearing loss. The main factors affecting the NIHL were assumed as experience, noise level, miners' age and occupation, and by taking into account the sub factors of the main factors, multi way contingency tables were prepared. Then hierarchical loglinear analysis method was implemented to categorized data; thus, the probabilities might affect NIHL was investigated. At the end of this study, it was found that the most risky occupation group was the drivers, and additionally, these workers were mostly exposed to 70–79 dB(A) noise level. When the important interactions are evaluated, it is determined those 4–11 years experienced crusher workers have high probability of NIHL because of high exposure to 90–99 dB(A) noise level. Moreover, the most important interactions which may affect the NIHL were identified and the precautions to reduce hearing loss were presented (Onder, 2012).Nyantubu et al (2007) conducted a study at a selected quarry site in South Africa where 156 workers with occupational exposure to vibration, and 140 workers with no exposure to vibration were randomly selected for study. The results showed that the prevalence of HAVS in vibration-exposed workers was 15%, with a mean latent period of 5 to 6 years compared to the non-exposed with 5% prevalence. The two groups however gave a history of exposure to rock drills. Noise-induced hearing loss is also a common health problem associated with quarrying and according to Futatsuka et al. (2005), noise is mostly produced by either impact or vibration. This happens at the stone crushing unit, when boulders are crushed and transported along conveyors, at the boulder loading point when boulders are fed into receiving pit, and at the sieves when the gravel is sorted. Noise can have the following effects on the health of workers and owners: Distortion of sounds (hearing something, but not understanding), temporary or permanent hearing loss, A continual ringing in the ears for which there is no cure ("tinnitus" in medical terms) 13 Quickened pulse rate, increased blood, pressure

and a narrowing of the blood vessels, abnormal secretions of hormones, muscle tensing, nervousness, sleeplessness and fatigue

2.4 EFFECTS OF NOISE ON HUMAN HEALTH

Exposure to loud noise continuously without protection causes various health problems to workers and the local population, especially Noise-Induced Hearing Loss (NIHL) (Bauer & Babich, 2007). NIHL happens when there's are increase in the threshold of hearing (threshold shift) which is hearing threshold is increased to 10 dB and above in 2000, 3000, and 4000 Hz in one of ear or both (hearing impairment). There are two types of NIHL that is temporary hearing loss and permanent hearing loss (Gyamfi et al., 2016). Apart from NIHL, there are problems occur as a result of exposure to loud noise such as an increase in the number of accidents at work, sickness, loss of productivity, communication disorders, sleep disorders, lack of concentration, irritability, less efficient, headache, increased blood pressure, nerve damage and eventually lead to deafness (Gyamfi et al., 2016; Naik et al., 2007)

Sleep disturbance: Interference with sleep patterns is frequently reported by those living near airports operating night flights. A recent study of residents in high noise areas close to Heathrow, Gatwick, East Midlands and Coventry airports found between 1 in 5 and 1 in 10 people often reporting difficulty getting to sleep or being woken early. The European Court of Human Rights has ruled that the UK Government's procedure for decision-making about night flights was flawed, and that this flaw amounted to a "violation of the respect for private and family life and the home" under the European Convention on Human Rights. This judgment did not state that night flights themselves were a violation of human rights. The Government is appealing the decision in the meantime, night flights continue as before, but if the judgment is upheld, the Government would need to review the regulation and operation of night flights (Anatasi et al., 2003).

Annoyance: Noise can lead to people feeling stressed and angry. It may interfere with conversations and leisure activities in the home, disrupt activities requiring concentration, and discourage people from using outdoor spaces. Further factors may affect whether noise is viewed as "annoying": Occurrence of exposure – noise may be more annoying if it occurs often, even if each noise event is quieter. Lack of control – inability to alter or escape from the noise source

may make it more annoying. The subjective response to aircraft noise makes it difficult to quantify the relationship between noise and annoyance. However, noise levels below 50 dB (A) are unlikely to cause community annoyance while levels of 55 dB (A) may severely annoy some people (Upham et al., 2003).

Cardio vascular effects: The WHO points to a "weak link" between frequent exposure to loud noise and effects on the cardiovascular system, but has called for further research before it can offer any guidelines (WHO, 2001)(Asamoa, 2011).

Noise is an unwanted sound-produced by a source causing vibrations in the medium around it (Agunwamba, 2001). According to LI &Tian, (2012), it is excessive noise that can even cause hearing loss after prolonged exposure. Kirchner et al.(2012) in an experiment discovered that 10 dB average at 2000Hz, 3000Hzand 4000 Hz can hypothetically induce hearing loss of human beings. WHO (2015) reiterates that approximately 1.1 million people universally are at the risk of losing their hearing abilities due to persistent exposures to precarious sound levels especially those working in a noisy environments. Neghab et al(2009) in a study identified Noise Induced Hearing Loss (NIHL) as rampant occupational hazard among the industrial workforce. The study involved 140 coordinated sound unexposed individuals from a similar industry. As per the discoveries, hearing of 38.5% and7.8% among the exposed and the unexposed got debilitated respectively giving resounding difference between the groups (Neghabet al, 2009).Ismail et.al.(2013) demonstrated NIH conditions in six stone mining locations in Malaysia involving 97 respondents between the ages of 18 and 50 years with at least 6-monthsin a quarry and without family history of ear diseases. The outcome showed commonness of NIHL at 95%. Out of this84% was mild and 62% had both ears affected. These findings were comparable to Ali et al. (2012) whose study on laborers from a cement plant in 13 Nigeria, a West African country showed that most of the studied workers (67.1%) were conclusively determined to suffer from mild Sensor neural Hearing Loss (SNHL). The findings were in concurrence with Ali et al. (2012) when 67.1% of laborers in a cement manufacturing plant in Nigeria endured gentle Sensor neural Hearing misfortune. Luxton et al. (2011) established relationship between interrupted sleeps among the United States soldiers in Iraq emission and symptoms of depression. Those who had no satisfactory sleep showed signs of post-traumatic stress and behaviors including increased abuse of drugs. NIHL is not a concern at

low levels and it's only a potentially hazardous above noise levels of 80 dB and where exposure is prolonged, children being more vulnerable (Savale, 2014). The potential risk to workers is dealt with by the Health and Safety Executives and at times by Local Authorities (Sliwinska-Kowalska& Davis, 2012). People are said to get disturbed by noise if it distracts their concentrations e.g. from hearing spoken conversation, listening to the radio or sleeping. The sensation of discontentment instigated by noise is annoyance (Sung et al 2017).

2.5 HEALTH PRECAUTIONS TAKEN BY WORKERS AGAINST NOISE IMPACTS

Studies involving the monitoring of worker noise controls, analyzing Hearing Protection Device (HPD) effectiveness -and testing of improved Sound Level monitoring techniques specifically for mining systems are being conducted (Bauer and Baibich, 2006).

In light of the findings, appropriate strategies that focus on mitigating occupational health and safety hazards associated with quarrying activities will help ease the burden that they have on the health sector as a whole. This is because they pose great threat not only to public health but also economic growth at local, national and global levels. The results led to a conclusion that respondents had occupational health and safety problems associated with quarrying activities. The study recommends the authorities should ensure that the quarry management and quarry workers adhere to regulations on occupational health and safety. This provides for the rights of every person to fair labor practices, reasonable working conditions, and a clean, healthy environment. The government should also ensure that all places carrying out mining activities are well researched on and communicate to the public on the laws and regulations to be adhered to, thus, enhance safety of human beings and environment (Wanjiku, 2015)

However, the present work is an attempt to assess the relative levels of noise produced from different quarrying activities engaged in at the Mbalala stone quarrying site and their corresponding occupational hazards to workers at the site. The most shared problem associated with noise pollution among many people particularly during the nights is their inability to sleep well uninterrupted sleep is a requirement for good physiological and mental functioning in fit persons which brings about negative perception amongst people.

People are said to get disturbed by noise if it distracts their concentrations e.g. from hearing spoken conversation, listening to the radio or sleeping. The sensation of discontentment instigated by noise is annoyance (Sung et al 2017)

A few of the respondents experience shock due to sudden noise from the use of explosives and ground vibration that result from rock blasting. According to reports, the detonation of explosives in quarrying operation causes ground vibration, which produces effects such as stress, anxiety, and increased pulse rate, loss of sleep, fatigue and excessive contraction of pupil among residents living near quarry site (Salvato, 1992, Alloway and Ayres, 1995).

According to WHO-ILO (2001), the prevention of occupational diseases calls for a multi-disciplinary approach. While health hazards should be controlled at source by engineering measures such as enclosure and effective ventilation, there are other complementary control measures including administrative control, use of suitable personal protective equipment (PPE), education, training and supervision of workers, environmental monitoring and health surveillance. Medical examination is a common means of conducting health surveillance whereby the health status of persons is monitored to determine departures from normal health, WHO-ILO (2000), so as to identify potential problem areas and the effectiveness of existing preventive strategies. Many occupational diseases are chronic in nature, having minimal early signs and may be difficult to treat or even incurable e.g. noise induced hearing loss (NIHL) and pneumoconiosis. Regular medical examination of workers who are exposed to particular health hazards at work can detect abnormalities or diseases at the early stage so that timely treatment can be given to increase the prospect of cure and reduce the cost of care.

CHAPTER THREE

STUDY AREA AND METHODOLOGY

3.1 DESCRIPTION OF THE STUDY AREA

Stirling Quarry is a commercial company located approximately 30km from Kampala City off Jinja road at Mbalala and is made of typical pink granite gneiss rock which is characterized by angular shaped aggregates after crushing. Mbalala is a relatively hilly area with spatially located settlements. The hills harbor different types of rocks and trees which favor the climatic nature of Mbalala which makes the area suitable for the company to carry out rock mining. On the other hand, many people in this region participate and work in the many quarries located at the hills which reduce the levels of unemployment in the area thus being a Socio-economic factor. Stirling Company owns a quarrying section which specifically mines rocks that are crushed after various processes to produce smaller sized stones.

The Company owns offices logistics based and equipment in particular in Uganda with a formidable fleet of earthmoving machines 5 crushing plants and 3 asphalt plants. During the mining activities, Noise is released which mostly affects especially the workers and the surrounding inhabitants as well hence bringing about the different occupational hazards from noise pollution. Therefore, mitigation measures have to be put across and in action in order to curb the consequences resulting from various noise levels in the quarry.

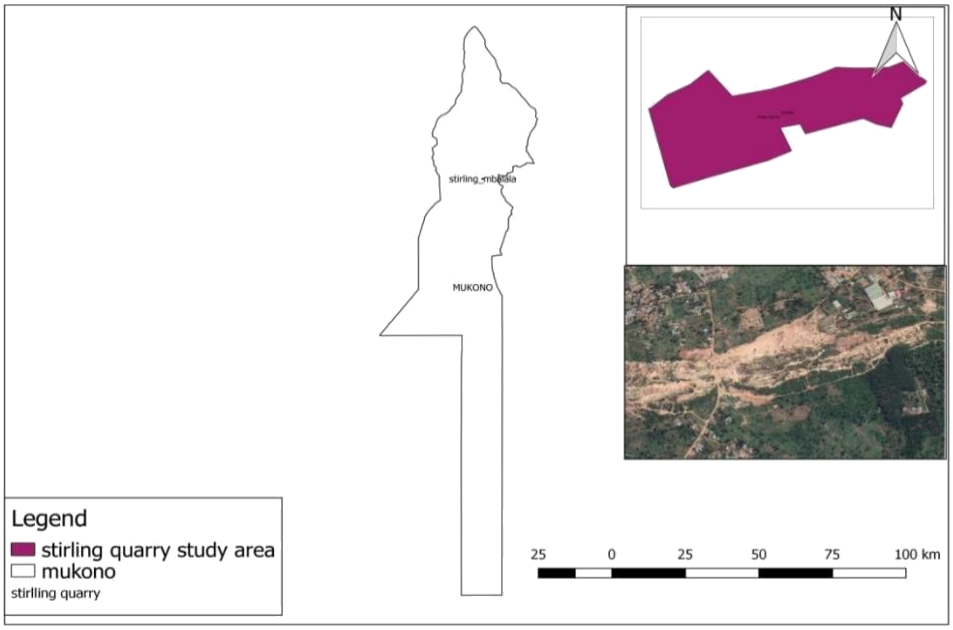

Figure 1: Stirling stone quarry (Mukono district)

3.2 RESEARCH DESIGN

The study was carried out between September and October 2018. It aimed at investigating and identifying the different occupational hazards of noise pollution at Stirling stone quarry in Mbalala which was an explanatory design. This was targeting the various major mechanized activities at the quarry in order to get an insight on how each of them affects the workers and other people that were highly impacted both health wise and physically.

3.3 METHODOLOGY

The study obtained noise measurements from purposely and randomly selected respondents at major quarrying activities which include Blasting, Drilling, Transportation, Crushing and early warnings where Sirens were utilized. This was because the quarry specializes in mechanized techniques since it is a large commercial enterprise which was of greater help.

Around the site is located a few number of inhabitants due to the unbearable effects from the site with its associated daily activities.

A total of 13 respondents quarry workers were interviewed and direct observation for physical or seismic visible impacts due to blasting respectively were used to answer some of the research questions.

From each selected 2 expertise were conveniently selected to provide relevant information for the interview guide of the research study to find out the significance of noise, attitudes and perception of workers on noise pollution at the quarry and neighboring inhabitants

Data about noise level on each activity was recorded at intervals during operational hours for 30minutes (divided in 10 minutes of recording) with the assistance of an android application Noise meter by JINASYS was approved by the National Institute of Occupational safety and Health (NIOSH) was used to record the corresponding noise levels of each selected mechanized activity.

The attained decibel measurements were analyzed using Minitab software and then compared to the National Environment (Noise Standards and Control) Regulations, 2003 and WHO guidelines for community noise.

The data was analyzed using descriptive and inferential statistics where descriptive analysis contained simple percentages to answer the research questions.

Minitab software was used to tabulate and analyze the logs recorded by the noise meter to identify significant activities and differences. One way Anova and One sample T test were used to test statistical differences in various variables between Noise levels in dB.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 NOISE GENERATED BY VARIOUS ACTIVITIES IN THE STONE QUARRY

Several activities done in the stone quarry were found to generate noise. The activities studied were crushing, blasting, early warning siren, hauling and drilling and the level of noise released differed among them. Table 1 shows the results of noise levels from different activities.

Table 1: Noise generated by specified mining activities

Quarry activity	Mean (dB)	Std. Deviation	Minimum (dB)	Maximum (dB)
Siren	84.0214	1.7023	80.200	87.500
Blasting	82.0041	3.5218	65.400	91.000
Drilling	80.7903	2.5393	23.500	86.200
Crushing	79.2187	0.7506	57.000	80.800
Hauling (on truck)	69.7646	6.9089	21.600	88.100
Hauling (away from truck)	48.8948	14.7198	20.400	69.300

Five different activities within the stone quarry were studied. Among them blasting produced the highest amount of noise with a maximum of 91dB followed closely by the siren. While the warning siren was the most noise generating activity based on average even though blasting registered higher maxima. The results suggest that pollution from mining can be reduced by targeting the most noise generating activities for action. For instance, activities like warning siren and blasting can be scheduled to take place during times when people are less sensitive to high noise levels. Fortunately, blasting and siren operations in the mine are intermittent, they

happen only for a short period of time and it's the less noise generating activities like hauling of material and crushing that are continuous as long as the mine is operational.

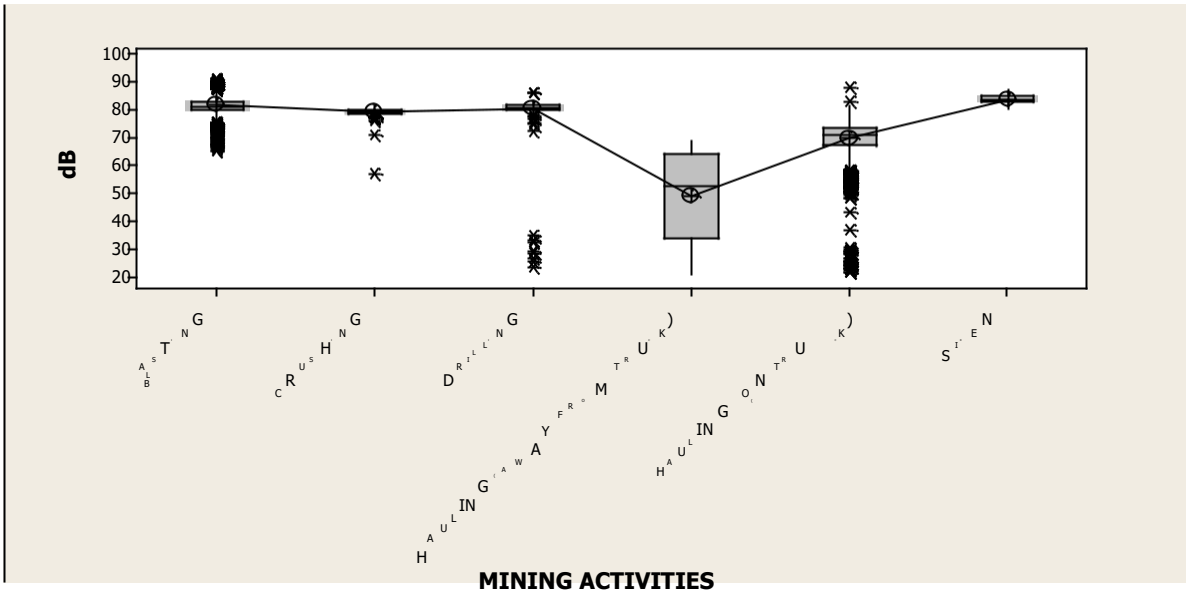

Figure 2: Levels of noise generated by various mine activities

There is a great significant difference in the dB levels produced among different mining activities $P<0.01$. From the tukey test there was a statistically significant difference between: Blasting (M=82.00, SD=3.52) and Hauling(Away from trucks) (M=48.90, SD=14.72); Crushing (M=79.22, SD=0.75) and Hauling(Away from trucks) (M=48.90, SD=14.72); Drilling (M=80.79, SD=2.54) and Hauling(Away from trucks) (M=48.90, SD=14.72); Hauling(on trucks)(M=69.77, SD=6.91) and Hauling(Away from trucks) (M=48.90, SD=14.72); and Siren (M=84.02, SD=1.70) and Hauling(Away from trucks) (M=48.90, SD=14.72).

Products from the quarry are transported using heavy vehicles like haul trucks and tippers which generate noise both within the quarry and to the neighboring households outside the quarry. Hauling noise levels were as low as 20.400 dB due to the very quiet ambient noise levels recorded after the heavy truck has passed and releases the least maximum decibels due to the distortion of sound waves by trees between the road and household where recordings were taken. H. Vardhan et al (2005) investigated the principal sources of sound from heavy earth-moving machinery, namely a bulldozer and a front-end loader. They have found that the major sound sources were the exhaust and air inlet for the engines and the engine cooling fan on the bulldozer.

At the quarry blasting is used to break up the big pieces of rock into smaller pieces which are later hauled away to be crushed into the different size classes for production of different quarry products. Blasting is done using field electronic detonators, there are no fixed delay times associated with these detonators which have an electronic memory that allows them to be programmed either prior to loading or any time prior to firing by a direct communication between the blasting machine and the detonator Eltschlager (2008). This method of blasting is popular for being quick and less costly as opposed to other methods like ripping and shoe-hoeing. The level of sound from blasting was not high due to distortion from trees and a rough landscape. The general surrounding could have helped in mitigating the effect of blasting sound (Bannerman, et al 2018).

G. Singh (2009) discussed on environmental issues with best management practices of responsible mining and gave report on the impact of noise in mining areas. As per his study, the availability of large diameter, high capacity pneumatic drills, blasting of hundreds of tones of explosive etc. were identified as noise prone activities. In-pit crushing system with mobile crusher and large capacity materials handling plants were being installed to facilitate speedy handling of large quantities. All these activities were the major sources of noise and vibrations in and around the mining complexes.

4.2 THE GENERATED SOUND LEVELS COMPARED WITH THE NATIONAL STANDARDS

4.2.1 Permissible levels for mines and quarries

When the noise levels generated by the individual quarrying activities were compared with permissible noise levels for mines according to the national standards of 114dB, the one sample t-test shows that none of the activities generated noise in excess of the permissible levels. This implies that the operations of the quarry are well within the legal requirements.

Table 2: One sample T-test results of noise generated with the national standard for stone quarries

Quarry activity	Mean(dB)	T-value	P value
Siren	84.0214	-1060.77	1.000
Blasting	82.0041	-546.92	1.000
Drilling	80.7903	-784.91	1.000
Crushing	79.2187	-2743.71	1.000
Hauling (at the truck)	69.7646	-375.96	1.000

Hauling generated the least noise decibels amongst all quarrying activities. However, this does not mean that it has no significant impacts upon human health especially after a long term exposure to drivers and loaders.

4.2.2 Permissible levels for the general environment

Measurements done outside the quarry revealed that the amount of noise pollution experienced by the general environment from the quarry exceeded the permissible standards. Hauling, siren and blasting all emitted sound levels above 55 dB as shown in (Table 3).

Table 3:One sample T-test results of noise released by stone quarry activities compared with the permissible levels for the general environment

Quarry activity	Mean (dB)	Maximum (dB)	T-value	P value
Siren	84.0214	87.500	1026.90	0.000
Blasting	82.0041	91.000	461.59	0.000
Hauling (away from truck)	48.8948	69.300	-4.06	1.000

Blasting releases greater noise levels to the general environment as compared to other activities which calls for more strict safety policies which protect the surrounding households and quarry employees against significant effects of blasting. However, hauling has least significant impacts due to the low noise decibels released to the households and short term exposure that they experience.

4.3 IMPACTS OF NOISE POLLUTION FROM THE STONE QUARRY

The generated amount of noise was compared to thresholds for noise by World Health Organization (WHO) guidelines for community noise 1999 (Table 4) in order to assess the significance of the noise produced and the results are shown in the table below.

Table 4: World Health Organization guidelines for community noise (1999)

Critical health effect(s)	**Decibels**
Hearing impairment.	(85-100)
Interference with rest and recovery, sleep disturbance	(70-45)
Annoyance	(50-55)
Speech intelligibility, disturbance of information	(30-35)
Disruption of tranquility	As low as possible

Respondents were asked about the impacts of noise they encounter on their health and most of them reported the effects of noise in Table 5 below. Headache was the dominant impact faced by most works and people in the surrounding households of the quarry. Its prevalence was due to the continuous ongoing quarrying activities that are carried out on a daily basis which has resulted into severe health cases. However, most of the impacts had a higher prevalence amongst the quarry workers than in local people.

Table 5: Effects of exposure generated by noise from the activities

Quarry activity	Health effect(s)
Blasting	Annoyance, headache, nausea, hearing loss, blood pressure hypertension
Drilling	Stress, headache, tinnitus, auditory fatigue, hearing loss
Transportation	Sleep disturbance, stress, headache, auditory fatigue
Crushing	Stress, headache, anxiety
Siren	Annoyance, sleep disturbance, stress, headache, nausea, hearing loss, hypertension

While blasting generates high levels of noise, the duration of noise is short compared to transportation which is a continuous activity as long as the quarry is in operation as materials are moved from one place to another. However, noise from blasting has a higher intensity which causes severe health impacts to both workers and the neighboring community. Transportation causes more health effects to drivers and loaders since they operate directly at the truck for a longer duration compared to the gate keeper and the neighboring households from the quarry that are exposed to noise from trucks at intervals for quite a shorter period of time. Crushing has a lower significance since the noise generated is low. However, the mild effects are brought about by the continuous release of noise throughout the working hours. Both workers and the locals are exposed to noise from the siren for a long period of time which makes it highly significant compared to other activities that generate noise for a shorter time period. Drilling causes mild health effects due to the reduction of the noise intensity by the shock absorbers used during the drilling operation and its shorter duration.

M.A. Ramlu (2005) discussed the occupational noise exposure and hearing damage in mining industries. According to him use of various noisy equipment used in industrial plants particularly in heavy industries like mining, civil construction, iron and steel, and wide range of other engineering industries, the workers can run the risk of hearing damage. Hearing loss can impair the quality of life through a reduction in the ability to communicate with each other. Overall it

affects the general health of the human beings in Hearing accordance with the World Health Organization's (WHO) definition of health (H. Suter (1991).

R. Rylander (2006) studied noise, stress and annoyance and discussed the effect of noise on human health. According to him, the energy related noise levels are poor predictions for the reactions in man as noise is always interpreted in the central nervous system, generating secondary and tertiary reactions that are not controlled by the brain cortex. The simulation of these reaction pathways in acute situations lead to involuntary reflexes and feelings of fright and despair. In chronic exposure situations a give-up stage may develop with reduced corporal and mental functions. In the acoustical panorama peak level noises usually cause the most pronounced effects as they stimulate reactions of fear and flight (Bannerman S.D et al (2018). Prolonged exposure to these activities by individuals usually leads to noise related ailment such as ear infection and other related ailments such as asthma, pneumonia and Upper Respiratory Infection (URT). Continuous increase in noise activities generated by the various quarrying companies and hauling operations by way of heavy-duty trucks seem to suggest the reason for the increase in complains of ear-related diseases during these periods. Yamanaka et al (1982) listed many ailments directly or indirectly related to noise. However, the epidemiological studies have not yet clearly confirmed links between noise levels and physical ailments. No matter what the level or the exposure period is, the noise has significant effects on human health, Anonymous (2012).

Other significant effects at the quarry were noted and these included accidents, drowning due to open pits especially when it rains, death, flue, injuries, underground water pollution, electric shocks, diseases like malaria due to stagnant water.

4.4 HEALTH PRECAUTIONS TAKEN BY WORKERS AGAINST NOISE IMPACTS

The interviews revealed that workers were provided with personal protective equipment (PPE) like safety boots, safety helmets, ear muffs and others to reduce exposure to mining hazards. Employers make sure that workers know how to use PPE and they are actually using these at work. Training programs are designed to make sure that those using PPE are aware of why it is needed and when it should be used, and must also understand its limitations and it is important that replacement equipment is always available to the workforce. The use of signs at entrances

and in quarries helps remind employees and visitors which PPE is required in different areas of the quarry and also promotes continued use of equipment.

Monthly check up of workers for early treatment of workers before severe health impacts,

Early warning and reduction of time the siren lasts, Provision of first aid, Use of sound absorbers, Use of highly modified quarrying machines that generate minimal sound levels, Limited working hours to reduce long term exposure effects were all employed to abate adverse impacts that would result from noise pollution at the quarry.

It has been suggested elsewhere that in order to mitigate this environmental hazard, existing and future quarry companies within the study area should consider a 1000 meter buffer zone around quarry sites to fend off future residents from occupying these places (Bannerman, et al 2018). The interviewees opined that structures that are already within this buffer zone should be evaluated and compensated in order to save residents from the adverse effects of blast noise. They also stressed the importance of communities in close proximity to quarry taking on tree planting around their houses to provide some amount of noise absorption. It was not clear how the quarry would subsidize this effort. Additionally, well planned blasting schedules are used and the nearby residents are notified before blasting activities take place.

CHAPTER FIVE

CONCLUSIONS AND RECCOMENDATIONS

5.1 CONCLUSIONS

Blasting produces higher sound levels amongst other mechanized activities for there is a significant difference between released noise levels which highly affect both workers and neighboring people. However, sound from hauling away from truck produces the least number of decibels thus nearly correspond to the ambient sound level of the general environment.

The study found that at most the machines used in the quarry exceed the tolerable threshold of sound thereby having the potential of damaging the hearing status of workers together with other corresponding effects. Variation in noise levels was influenced by the topography, geological discontinuities, rock properties, distance and presence of wind.

Different kinds of effects are caused by each level of sound along with the level of exposure however; the age of workers also contributes on the severity of the effects. Blasting generating the higher decibels also brings about the most severe occupational hazards like hypertension. On the other hand, health problems especially cough and eye problems caused by irritation from the quarry dust all stand out as challenges facing the rural dwellers.

5.2 RECOMMENDATIONS

Regular environmental impact assessment should be carried out in the area by the Ministry of Environment to forestall irreplaceable damages to the environment through embarking on regular monitoring to access noise levels and ensure that companies do not emit noise greater than the tolerable limits.

The quarry company should provide commensurate compensation for damaged houses and health costs injured by the rural dwellers and also compelled to fulfill their civic obligations of providing health care services, protection equipment and safety precautions. This can be done through timely sensitization of both the company stuff and rural dwellers in order to prevent long and short term effects that may come up due to noise pollution.

Efforts to ensure access and use of earplugs by quarry workers and rural dwellers could be beneficial in reducing the absolute prevalence of hearing impairment especially the elderly and long serving workers who are at a higher risk of developing hearing loss.

Most preferably, people neighboring the vicinity of the stone quarry should be advised to relocate to safer places of residence or provided with compensation for their property. This shall reduce on the risk of health complications and damage of properties.

REFERENCES

USEPA (2008). Region 4: Laboratory and Field operations – PM 2.5: Objectives and History. As available at en.wikipedia.org/wiki/particulate

Asamoah-Baidoo, A., 2011. Noise-induced hearing loss among workers at the Kotoka International Airport (Doctoral dissertation).

Ismail, A.F., Daud, A., Ismail, Z. and Abdullah, B., 2013. Noise-induced hearing loss among quarry workers in a north-eastern state of Malaysia: a study on knowledge, attitude and practice. Oman Medical Journal, 28(5), p.331.

Nanda, S.K., 2012. Noise impact assessment and prediction in mines using soft computing techniques (Doctoral dissertation)

Onder, M., Onder, S. and Mutlu, A., 2012. Determination of noise induced hearing loss in mining: an application of hierarchical loglinear modelling. Environmental monitoring and assessment, 184(4), pp.2443-2451.

Noise Standards and control Regulations (2003) Quarrying processes and quarrying products at: http://www.northstonematerials.com/quarrying_process_and_quarry_products.

Gyamfi, C.K.R., Amankwaa, I., OwusuSekyere, F. and Boateng, D., 2016. Noise exposure and hearing capabilities of quarry workers in Ghana: a cross-sectional study. Journal of environmental and pu blic health, 2016.

Aslam, M.J., Aslam, M.A. and Batool, A., 2008. Effect of noise pollution on hearing of public transport drivers in Lahore city. Pakistan Journal of Medical Sciences, 24(1), p.142.

Goines, Lisa and Hagler, Louis (2007). Noise Pollution: A Modern Plague. *Southern Medical Journal*, 100 (3): 287-294.*Research*.2:1195.

World Health Organization in 1995. http://www.who.int/docstore/peh/noise/guidelines2.html.AccessedMay16,2017.

Suter AH. Noise and its Effects Administrative Conference of the United States (1991).

U.S. Census Bureau, Housing and Economic Statistics Division. Available at:http://www.census.gov/hhes/www/housing/ahs/ahs99/tab28.html.Accessed May18, 2017.

NEMA (2004), Environmental Legislation of Uganda. NEMA Kampala

Ashley; M. N (2004) Duties, silicosis and Tuberculosis in small scale pottery workers, Indian journal of community medicine; 102:138-142

Hussein, S. (2006) Rehabilitation of products, Quarries and other surface of mined hands, Geological Survey Miscellaneous, 76, Ontaria: Min of Natural Resources.

WANJIKU, M.W., 2015. Occupational health and safety hazards associated with quarrying activities; A case of Mutonga Quarry, Meru County, Kenya (Doctoral dissertation).

Neghab, M., Maddahi, M., &Abdolreza, R. (2009). Hearing impairment and hypertension associated with long term occupational exposure to noise.Iranian Red Crescent Medical Journal, 2009(2), 160-165.

Ismail, A. F., Daud, A., Ismail, Z., & Abdullah, B. (2013). Noise-induced hearing loss among quarry workers in a north-eastern state of Malaysia: A study on knowledge, attitude and practice. Oman Medical Journal, 28(5), 331-336. doi:10.5001/omj.2013.96 [doi]

Ali, A., Garandawa, H. I., Nwawolo, C. C., &Somefun, O. O. (2012). Noise-Induced Hearing Loss at Cement Company, Nigeria. Online Journal of Medicine and Medical Science Research, 1 (3), 49–54.

Luxton, D. D., Greenburg, D., Ryan, J., Niven, A., Wheeler, G., &Mysliwiec, V. (2011). Prevalence and impact of short sleep duration in redeployed OIF soldiers sleep, 34(9), 1189-1195.

Savale, P. (2014). Effect of noise pollution on human being: Its prevention and control.European Journal of Environment Research and Development, 8(4)

Sliwinska-Kowalska, M., & Davis, A. (2012). Noise-induced hearing loss.Noise and Health, 14 (61), 274.

Sung, J. H., Lee, J., Jeong, K. S., Lee, S., Lee, C., Jo, M., & Sim, C. S. (2017).Influence of transportation noise and noise sensitivity on annoyance: A cross-sectional study in South Korea.

International Journal of Environmental Research and Public Health, 14(3), 322.

Nyantubu B, Barber C, Ross M, Curran A, Fishwick D, Dias B, Kgalamono S, and Phillips J.(2007). Hand arm vibration syndrome in South African Gold Miners. Occupational Medicine, 57(1),25-29.

Futatsuka M, Shono M, Sakakibara H, and Quan P, (2005). Hand Arm Vibration Syndrome among Quarry Workers in Vietnam. Journal of Occupational Health, Vol. 47,165-170.

WHO-ILO (2000).'Occupational Health for workers in the informal sector' WHO-ILO Joint Effort on Occupational Health and Safety in Africa, 16-20 October 2002.

WHO-ILO (2001).'The World Health Organization (WHO)/ International Labour Organization (ILO).Joint Effort on Occupational Health and Safety in Africa

International Organisation for Standardisation (2011). Mechanical vibration and shock Hand-arm vibration—Method for the measurement and evaluation of the vibration transmissibility of gloves at the palm of the hand. ISO 20345. Geneva: ISO.

World Health Organization. (2015). Hearing loss due to recreational exposure to loud sounds: A review.

Omubo-Pepple, V., Israel-Cookey, C., &Alaminokuma, G. (2009). Effects of noise-induced hearing loss within Port Harcourt metropolis, Nigeria. Journal of the Nigerian Association of Mathematical Physics, 14(1), 439–448.

B. Truax, Ed.,Handbook for Acoustic Ecology, 2nd ed. World Soundscape Project,Simon Fraser University, and ARC Publications, 1999, http://www.sfu.ca/sonicstudio/handbook/Audiogram.html.

R. T. Sataloff and J. Sataloff,Occupational Hearing Loss. CRC Press, Taylor&FrancisGroup, London, 2006.

R.K.Pandey, N.R.Thote, and T.N.Singh,2006 “Noise exposure to haulage truck operators -some investigation,” inInternational Symposium on Environmental Issues of Mineral In-dustry, Nagpur, pp. 31–39

N. Burger, A. von Wielligh, P. de Wet, R. OttermanĘ, and J. Steyn, August 2004.
“Design and development of a low noise rock drill,”The Journal of The South African Institute of Mining and Metallurgy, pp. 403–410,

S.M.Eston, A.C.Santos, and W.S.Iramina, W.T.Hennies, L. da Silva, and A.P.Chaves, Eds., Balkema, Rotterdam, 1996, “Some consideration on noise in the mining industry,” in Mine Planning and Equipment Selection pp. 221–228.

Y. Osada, 1988. “An overview of health effects of noise,”Journal of Sound and Vibration, vol.127, no. 3, pp. 407–410,

Bauer, E.R. &Babich, D.R. (2007). Noise Assessment of Stone/Aggregate Mines: Six Case Studies. Journal of Mining Engineering,59(8), 55-13.

Bernama. (2008). PeningkatanMasalahHilangPendengaranAkibatKebisinganTempatKerja Membimbangkan. (http://www.bernama.com/bernama/v3/bm/news_lite.php?id=347656) .

EPA (Environmental Protection Agency). (2000). NSW Industrial Noise Policy. Sydney: Environment Protection Authority

.

Behroozi Lar, M., Payandeh, M., Bagheri, J. &Khodarahm Pour, Z. (2012). Comparison of Noise Level of Tractors With Cab and Without in Different Gears on Driver Ear and Bystander. African Journal of Agricultural Research, 7(7), 1150-1155.

Naik, D.P., Ushamalini.&Somashekar, R.K. (2007). Noise Pollution in Stone Quarrying Industry –A case study in Bangalore District, Karnataka, India. Journal of Industrial Pollution Control, 23(1), 43-48.

Alloway, B. J. and Ayres, D. C. (1995). Chemical Principles of Environmental Pollution. Blackie Academic and Professional, London. Pg. 250-290.

Agunwamba, J. C. (2001). Waste engineering and management tools. Immaculate Publication Limited, Enugu.

Tian, B., & LI, L. (2012). Current Situation of Environment Pollution in Mining Area Construction and Preventive Measures [J]. Coal Technology, 7, 90.

Kirchner, D. B., Evenson, E., Dobie, R. A., Rabinowitz, P., Crawford, J., Kopke, R., & Hudson, T. W. (2012). Occupational noise-induced hearing loss: ACOEM task force on occupational hearing loss.Journal of Occupational and Environmental Medicine 54 (1), 106-108.

H. Vardhan, N.C.Karmakar, and Y.V.Rao, "Experimental study of sources of noise fromheavy earth-moving machinery,"Noise Control Engineering Journal, vol. 53, no. 2, pp.37–42, 2005.

M.A.Ramlu, "Occupational noise exposure and hearing damage,"Mining Engineer's Jour-nal, vol. 6, no. 7, pp. 9–20, 2005.

G. Singh, "Environmental issues with best management practices of responsible mining," inThe 20th National Convention of Mining Engineers, hosted by The Institution of Engineers(India), Neyveli Local Centre, Tamil Nadu, 30 January 2009, pp. 28–43.

H. Suter,Noise and Its Effect, http://www.nonoise.org/library/suter/suter.html, 1991

R. Rylander, "Noise, stress and annoyance,"Noise and Vibration World Wide, vol. 37,no. 6, pp. 1–13, June 2006.

Yamanaka, K., Nakagawa, 1., Kobayashi, F., Kanada, S., Tanahashi, M., Muramatsu, T., and Yamada, S., 1982. Criteria for Acceptable Levels of the Shinkansen Super Express Train Noise and Vibration in Residential Areas, J. of Snd..andVib., Vol. 84, No. 4, pp. 586-591

Anonymous 2012. World Health Organization, Burden of Disease from Environmental Noise. Available at:http://docs.wind-watch.org/WHOburden-of-disease-from-environmental-noise-2011.pdf 2011.

APPENDICES

APPENDIX ONE: INTERVIEW GUIDE

Dear participant

THANK YOU FOR YOUR WILLINGNESS TO HEAR ABOUT THIS STUDY. MY NAME IS VIVIAN KULABAKO A STUDENT AT MAKERERE UNIVERSITY. I AM CONDUCTING A STUDY IN WHICH YOU ARE A POTENTIAL PARTICIPANT. THIS STUDY IS A REQUIREMENT FOR THE AWARD OF A BACHELOR'S DEGREE THAT I AM ABOUT TO COMPLETE.

If you agree to participate in this study, you will be asked to sign this form and a copy of which will be given to you.

1. How long have you engaged in the activity of stone quarrying?

2. How old are you?

3. Is stone quarrying or mining the only economic activity involved in?

4. What proportion of people do involve in Stone quarrying activities?

5. Is stone mining enough to sustain you and your family?

6. What is the rate of people who visit health facilities in the area that suffer from hearing impairments and other diseases relating to noise pollution?

7. What are some of the other impacts related with stone quarrying.

8. Does the company provide protective gears and allowances incase of any impact?

9. What are the common health and physical problems associated with different Noise levels at the quarry?

Interview guide for key informants

1. What are the socio-economic activities carried out during stone quarrying?

2. What are the major quarrying activities that produce the highest levels of noise? Note their corresponding decibels.

3. In your own opinion, does one need skills to work at the quarry?
4.How many hours do quarry workers take before their dispature from the site?

4. What do you do when a worker is injured due to noise during work?

5. Is it necessary to have Personal Protective Equipment (PPE) at the quarry?

6. Is there need to carry out regular health checkups for quarry workers?

7. Which groups of people are most affected by the different kind of noise?

8. What other negative challenges have been faced by workers and due to Noise pollution?

9. What are some of the measures that have been implemented to mitigate noise pollution and its associated problems?

Participants name…….

Date ……

Signature/Thumb print …….

Interviewer's name……

Date …….

Signature ……...

APPENDIX TWO: OBSERVATION CHECKLIST GUIDE

Different quarrying activities carried out at the stone quarry.

If workers are availed with the necessary PPE during operations.

Are the PPE equipments replaced after a given time period.

The time operations start and how long they last.

Which groups of specialized people are most affected by the noise levels produced.

The sex of the workers employed at the quarry.

Different seismic impacts within the surrounding allocations.

How they’ve managed to abate the effects.