ASSESSMENT OF OCCUPATIONAL HAZARD AWARENESS AND SAFETY MEASURES AMONG QUARRY WORKERS IN BOMET COUNTY, KENYA

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Assessment of Occupational Hazard Awareness and Safety Measures among Quarry Workers in Bomet County, Kenya

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DECLARATION

This thesis is my original work and has not been submitted for a degree in any other University.

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This thesis has been submitted for examination with our approval as University Supervisors.

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DEDICATION

I dedicate this work to my dear husband Japheth, my lovely sons Myles and Migel for their encouraging words, perseverance and their continuous support during this period of study. I also dedicate it to my late Mother, Father, brothers and sisters for laying the foundation of my education .You are all heroes!!

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ABBREVIATIONS AND ACRONYMS

ANOVA	Analysis of Variance
CO	Carbon monoxide
CO_2	Carbon dioxide
DOSHS	Directorate of Occupational Safety and Health Services
EASW	European Agency for Safety at Work
EMCA	Environmental Management and Coordination Act
GoK	Government of Kenya
HAVS	Hand-Arm Vibration Syndrome
HSA	Health and Safety Administration
HSE	Health and Safety Executive
ILO	International Labour Organization
KNBS	Kenya National Bureau of Statistics
NEMA	National Environment Management Authority
OEL	Occupational Exposure Limit
OSH	Occupational Safety and Health
OSHA	Occupational Safety and Health Act
PM	Particulate Matter
PM_{10}	Particulate Matter 10
$PM_{2.5}$	Particulate Matter 2.5
PPE	Personal Protective Equipment
SGR	Standard Gauge Railway
SPSS	Statistical Package for Social Science
TSP	Total Suspended Particles
USA	United states of America
WHO	World Health Organization
WIBA	Work Injury Benefit Act

DEFINITION OF TERMS

Aggregate	It refers to sand, gravel and crushed stone.
Awareness	Having an idea or hold concept about in your mind about something.
Blasting	Using explosives to break rock.
Carbon dioxide	A colourless, oduorless and tasteless gas with a specific gravity of 1.53 with respect to air.
Carbon monoxide	A colourless, oduorless and tasteless gas with a specific gravity of 0.97 with respect to air.
Drilling	Boring of holes into the rock mass in preparation for blasting.
Explosive	Any chemical compound that when subjected to heat produce a practical effect by explosion.
Hazard	A situation that poses a level of threat to life or health.
Health	State of being free from illness or injury.
Implementation	Is the act of putting a plan, an idea or program into action.
Inhalable dust particles	Materials that are hazardous when deposited in the respiratory tract including the nose and the mouth.
Knowledge	Deep understanding and familiarity about something
OSH measures	Are programs, activities and guidelines that aim at promotion and maintenance of a safe and healthy workplace.
Quarry	A type of open-pit mine from which rock material are extracted.
Quarry Pit	A surface excavation allocated to an operator within a quarry site for extracting building stone, construction aggregate, sand and gravel.
Quarry Site	A cluster of quarry pits within a locality.
Quarry Worker	A person employed by a quarry operator to carry out quarrying activities.

Respirable dust particles	Materials that are hazardous when deposited in the gas exchange region
Risk	A measure of the probability and severity of adverse effects.
Safety	A condition of being protected from occupational accidents and or health adherence
Safety measure	A plan or action taken to increase or ensure protection from danger

ABSTRACT

Quarrying is a major economic activity in Kenya that supports the local construction industry, creates employment opportunities and is a major contributor to the national economy .However,despite these positive contributions, the industry is typically associated with hazardous working conditions, which affect the health and safety of workers.The International Labour Organization (ILO), estimates that quarrying accounts for 8% of the global work related fatalities.The study adopted Analytical cross sectional design and from a population of 542 a sample of 230 quarry workers were randomly selected from four quarry sites.A structured questionnaire was self-administered to collect data on awareness of occupational hazards and safety measures from the respondents as a result of their daily work activities. An observation checklist was also used to record how quarry activities were being performed by workers. The interview was conducted with quarry managers and the institutions involved in Occupational safety and Health. The study further assessed the ambient air quality measurements with respect to inhalable particles (PM_{10}), respirable particles ($PM_{2.5}$), Carbon monoxide (CO) and carbon dioxide (CO_2). The measurements was done using 3M EVM-7 Series Multi parameter Environmental Monitor, at a height of 1.5metres from the ground in order to properly determine the exposure level to which the workers are exposed to and 25 metres away from the pollutants at a rate of 1.67 Liter per minute for 30 minutes. Data collected from the questionnaires was cleaned, coded, tabulated and subjected to statistical analysis. SPSS Version 21.0 was used to analyze the quantitative data. It was established that 81.7% of the workers were aware of occupational hazards in the quarry where the main source of information about hazards was colleagues (55.5%). The most known health hazard among respondents was manual handling of heavy loads (63.5%) while the effect of hazard encountered by 73% of respondents was back/shoulder/waist/arm pain. Only 27.8% of the workers were aware of safety measures in place. It was also established that lack of management commitment (97%) was the top contributing factors affecting implementation of OSH measures in quarries. The study found that the PM_{10} and $PM_{2.5}$ concentration ranged between 10.75 to 20.10 mg/m^3 and 5.12 to 7.7mg/m3 respectively. The average concentrations for CO and CO_2 ranged between 0.41 to 1.8 ppm and 802 to 2060 ppm respectively.The study concludes that the level of awareness of occupational hazards was high among the respondents. However, the respondents were insufficiently equipped with knowledge on safety measures to comprehensively mitigate occupational hazards. It also concludes that the dust concentrations failed to meet the recommended occupational exposure limit of $10mg/m^3$ and $5mg/m^3$ respectively as stipulated under Factories and other places of work (Hazardous substances) Rules of 2007 standards and therefore exposed the workers to the risk of respiratory, skin and eye health problems. The study recommends that quarry management should carry out safety inductions to all workers before they commence their contracts so as to promote a safety culture, provide the necessary PPE for workers and adopt other methods of dust suppression such as use of bag filters and scrubbers. It also recommends that the enforcement bodies (NEMA and DOSHS) should impose higher restrictions and enforcement guidelines for establishing quarries with proper provision for OSH services before granting licenses to quarry operators/owners.

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Quarry is one of the many extractive industries playing an important role in the economies of many countries, including Kenya by creating employment, sustaining livelihoods and providing national income. Quarrying activity provides much of the materials used in traditional hard flooring such as granite, limestone, marble, sandstone, slate and even clay to make ceramic tiles (Aloh et al., 2017). Quarrying products are increasingly demanded for industrial, domestic, agricultural, and other purposes so as to satisfy the needs of the rapidly growing population. According to the economic survey of 2019 by the Kenya National Bureau of Statistics (KNBS), there are over thirty thousand quarries scattered all over the country, employing over a million Kenyans either as permanent or casual labourers. These numbers of quarries are likely to increase due to the upcoming infrastructural projects in the country, especially the construction of roads, affordable housing, and Standard Gauge Railway (GOK, 2007).

Quarrying is a non-renewable activity that involves the disturbance and excavation of surface and underlying strata including aquifers for the purpose of exploiting minerals, stone, and sand.Extraction of stone, ballast, gravel, clay, and sand is done in various parts of the country, Bomet County included. This activity is on the increase within Bomet County due to increased demand of products as a result of rapid urbanization of Bomet town and the surrounding areas. In addition, poverty, unemployment, reduced farm sizes and increased population have all collectively exacerbated the activity which is labour intensive requiring low skilled workers earning low wages (Okoko & Kamwele, 2015).These jobs are seen as a quick way to earn money, yet they are not adequately paying and a lot of underage employees are recruited for cheap labour, despite the health risks the workers are exposed to (Kibet, 2014).

Quarry industry has a number of common safety hazards and health issues associated with its activities. The use of large earth-moving vehicles and machines, the handling of explosives and heavy loads, ever-present airborne dust, and simply working on dangerous sites are all aspects of quarrying that increase the risk of both accidents and occupational diseases. These hazards include but not limited to cuts and injuries, falls from heights, vibration, effects and complications of noise, inhalation of dusts and fumes and bites from snakes (Abbasi, 2018). Air-borne particulates pose a potential health risk to quarry workers in the form of respiratory, dermal, ocular irritation and damage. A particular concern in some quarries is the inhalation of dust containing silica which can lead to silicosis, an irreversible lung disease resulting in inflammation of the lungs and breathing difficulties which progresses even when exposure stops (Utembe et al., 2018).

Quarrying is one such mining activity which comes with both positive and negative effects on its immediate surroundings. These include environmental, health, social and economic effects. The negative effect includes destruction of the environment and property damage. This is because the process of quarrying involves the elimination of overburden, drilling, blasting, and crushing of rock materials and haulage (Ata-Era, 2015). This degrades the landscape by leaving unfilled pits due to lack of rehabilitation plan. The disused and abandoned pits fill with water and become ponds or create artificial lakes. These lakes also act as breeding grounds for mosquitoes which spread malaria. The abandoned quarries are dangerous spots where several children have drowned in them and people killed and thrown into them. Abandoned pits act as hiding places for organized crime and drug peddlers while others act as dumping sites making areas with quarrying activities very scary to live in (Okoko & Kamwele, 2015).

Occupational hazard is a risk an individual is exposed to at the workplace and during work periods. They may be exposed to biological agents, chemical, physical factors and ergonomic conditions which predispose the individual to occupational diseases with a variety of health effects(Amabye, 2016).This appears to affect a considerable number of people in a variety of jobs and indirectly impact on the economy especially in developing countries where individuals take for granted health and safety concerns associated with work due to lack of awareness and fundamental understanding of interactions between work and health (Diwe et al., 2016). Quarry workers are no exception because the rate of work related injuries and illness in the quarry industry is one of the highest of all occupational groups worldwide due to the physical nature of work involved, coupled with poor workplace health and safety standards (Wanjiku et al., 2015).

Kenya has made significant progress towards attainment of Occupational Safety and Health particularly through the enactment of the Occupational Safety and Health Act (OSHA) No. 15 of 2007 and the promulgation of the new Constitution of Kenya, 2010 .However, despite the presence of institutional and legal frameworks addressing work related safety and health issues, workers in many sectors, including quarries, remain highly vulnerable to occupational health hazards and risks (Wachira, 2016). It is therefore important to determine the workers' awareness of the occupational hazards and safety measures with the intention of highlighting their health education and training needs in order to empower them to take self action in the pursuit of good health and wellbeing.

1.2 Statement of the problem

Quarrying is a major economic activity in Kenya that supports the local construction industry, creates employment opportunities and is a major contributor to the national economy (Okoko & Kamwele,2015).However,despite these positive contributions, the industry is typically associated with hazardous working conditions,which affect the health and safety of workers (Stemn, 2018).The International Labour Organization (ILO), estimates that quarrying accounts for 8% of the global work related fatalities (ILO, 2017) while in the United States, analysis of 16 year fatality data indicated that the industry had the highest fatality rate of 30.3 per 100,000 workers with 52% of these fatalities occurring at surface, sand or gravel quarries (Eiter , Kosmoski &Conno r, 2016).Due to devolution of services to the Counties, there has been phenomenal infrastructural growth in the town, thus increasing demand for quarry products.This has led to many workers seeking employment in this sector that includes under aged children, young women of childbearing age and even expectant women, irrespective of the associated health hazards. Also since almost all quarry companies in Bomet County are privately owned, they are driven by profit making and reduced costs of operation by aiming at maximum productivity from their workforce, most of the workers are not provided with protective gear and as a result they are exposed to great danger. Lack of clear regulatory framework for the management of quarries in the country and inadequate and uncoordinated enforcement of existing laws has led to haphazard and unsafe quarry operations. It is in view of the aforesaid issues in the quarrying industry that this study embarked upon to assess occupational hazard awareness and safety measures among quarry workers in Bomet County.

1.3 Justification

The quarrying industry is regarded as a risk industry worldwide because of the hazardous nature of its activities (Mabika, 2018). Workers in this industry need improved protection of their health as the country faces a rapid expansion of the construction industry. It has been noted that there are various quarry accidents and complaints associated with quarrying activities in the country, some of which have even claimed workers lives (Kenya News Agency, 2020). For instance, five people died instantly and severall others hospitalised in Kyogong quarry, Bomet County after quarry walls collapsed in the year 2013(Makiche, 2013).Data obtained from the Directorate of Occupational Safety and Health Services (DOSHS) office in Bomet County shows that none of the quarries are registered as workplace under Occupational Safety and Health Act (OSHA), 2007, while only twelve have been licensed by National Environmental Management Agency (NEMA) to carry out quarrying activities. Also there has been no independent evaluation of their safety status periodically as required by law. It is therefore important that a study of this nature be carried out to determine the occupational hazards awareness and safety measures among quarry workers with a view to making necessary recommendations to achieve safe work Environment.Bomet County was selected since there were no studies that had been carried out in it as compared to other quarries country wide. The findings will help the management and employees in closing the gaps and hence develop good OSH practices in the industry. It will be useful to policy makers and researchers working on occupational health and safety for packaging strategies for improving health and safety in workplace.

1.4 Hypotheses

1.4.1 Null hypotheses

Quarry workers in Bomet County are not aware of occupational hazards and safety measures in place to minimize potential effects of hazards they are exposed to.

1.5 Main objective

To assess occupational hazard awareness and safety measures among quarry workers in Bomet County, Kenya

1.5.1 Specific objectives

1. To establish the level of occupational hazards awareness among quarry workers in Bomet County.
2. To identify the safety measures that have been put in place to minimize the potential risks of quarrying activities on workers.
3. To determine occupational air quality with respect to $PM_{2.5}$, PM_{10}, CO and CO_2 in Bomet quarries in relation to allowable limits.
4. To determine the factors affecting implementation of occupational health and safety measures in quarry operations.

1.6 Research questions i

1. What is the level of awareness of occupational hazards among quarry workers in Bomet County?
2. What are the safety measures that have been put in place to minimize the potential risks of quarrying activities on workers?
3. What is the concentration of $PM_{2.5}$, PM_{10}, CO and CO_2 of air in Bomet quarries in relation to allowable limits?
4. What are the factors affecting implementation of occupational health and safety measures in quarry operations?

1.7 Scope of the study

The study was conducted in Bomet County, at twelve quarries that were registered with NEMA, and focused on occupational hazards awareness and safety measures among quarry workers. The data was collected between October 2017 and March 2018.

1.8 Conceptual framework

Quarry jobs are hazardous and take place in settings which are both unhealthy and unsafe. Depending on the types of hazards, their intensity and length of exposure determines the probability and consequences of an injury or ill health occurring. Creating hazard awareness among employees will promote a safe system of work. This reduces hazards and risks to workers, which in turn leads to higher productivity, which can lead to higher profits. These may be intervened by institutional factors such as enforcing laws and regulations by the management and government officers.

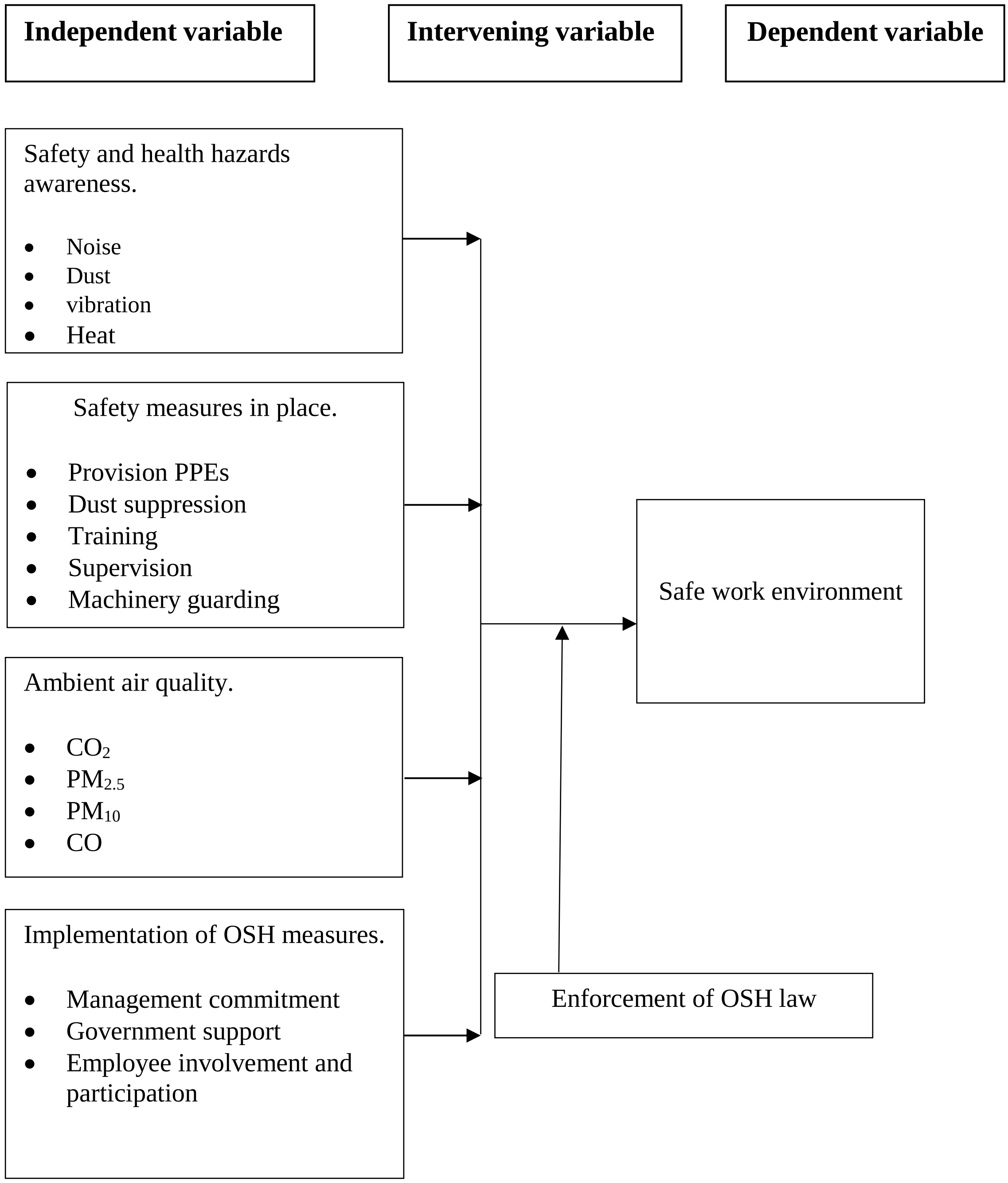

Figure 1.1: Conceptual framework

CHAPTER TWO

LITERATURE REVEIW

2.1 Theoretical Principles

The quarry industry remains a vital contributor to the global economy. The products of quarrying have significantly improved human livelihood and are the bedrock of other industries including construction and agriculture (Stemn, 2018).Though industries have been established to meet various human needs since the dawn of civilization, some if not all pose detrimental effects on the health of man. Efforts on awareness and international concern of the problem of occupational diseases and accidents remain modest globally as 160 million people are affected by avoidable occupational diseases annually (Ramesh *&* Bobby, 2014).According to the U.S. Mine Safety and Health Administration (MSHA, 2015), 37 quarry workers were fatally injured in accidents at non-metal quarry sites. Similarly, in Australia, Safe Work Australia, acknowledged that despite the reduction in fatality rate from 12.4 in 2003 to 4.4 in 2015, the number of deaths in the industry still remains high at a yearly average of 9 (Stemn, 2018).

Quarrying is a hazardous operation and consists of considerable environmental, health and safety risk to workers (Chu *et al,*, 2017).Much of work involve the use of complex heavy machinery, equipment and processes as well as numerous and diverse worker activities that take place in a dynamic work environment, involving long periods of standing, stooping, bending and carrying out repetitive movements in awkward body positions (Wanjiku et al, 2015). The risk of accidents due to fatigue, poorly designed tools, difficult terrain, exposure to adverse environmental conditions, use of explosives and machines without appropriate safety measures makes workers vulnerable to work related accidents and illness (Mabika, 2018).

Due to the hazardous nature of quarry occupations and the often-remote location of the sites, medical care is a critical ingredient that lacks in most developing countries Kenya included. Some of these sites lack proper sanitation, safe drinking water and hygiene facilities expose workers to the risk of health hazards and contracting many diseases. They area also vulnerable to greater risks due to insufficient knowledge, limited access to resources and information on hazard identification and risk management and being outside the scope of labour and health inspections (ILO, 2014).

2.1.1 ILO: The Safety and Health in quarrying Convention

The Safety and Health in Mines Convention, 1995 (No.176) is central to achieving the ILO's decent work agenda and a decent future of work and is the key to resolving the challenge of occupational safety and health in the mining industry. It regulates the various aspects of safety and health characteristic for work in mines, including inspection, special working devices, and special protective equipment of workers. It also prescribes requirements relating to mine rescue. The Convention came up with recommendations entitled R183 Safety and Health in mines Recommendation, 1995 (No 183). The recommendations include such quarries should formulate, carry out and periodically review a coherent policy on safety and health in mines, This Recommendation supplements the provisions of Convention No. 176 with regard to requirements relating to the supervision of safety and health in mines; the standards equipment and appliances used in mines; and to mine rescue and first aid. The Recommendation also provides for operating plans and procedures with regard to emergency situations at mines and the rights and duties of workers and their representatives.

2.1.2 ILO: Code of practice on safety and health in quarrying

The codes of practice are technical standards which provide guidance for specific sector or topic areas. This code complements The Safety and Health in Mines Convention, 1995 (No.176) and its supplementing Recommendation (No 183). It provides guidance on appropriate strategies to address the range of occupational safety and health risks encountered in quarrying in order to prevent as far as is reasonably possible accidents and diseases for all those engaged in this sector. The code of practice identified the main contributors to injuries and ill health to include among others working with machines, vehicles, tools, exposure to excessive noise and vibration, falls from heights, lifting heavy weights and other work giving rise to musculoskeletal disorders; exposure to dust and other organic substances, explosives, dust, radiation, Heat and cold stress, fatigue and falling objects (ILO, 2018). It is based on the principles of the Convention, including risk assessment, addresses issues such as the interaction between large-scale and small-scale artisanal miners and also comprises a section on automated machinery, a development that has great potential to change the work carried out by nearly all workers in opencast mines worldwide.

2.2 Common OSH hazards in quarrying activities

A hazard may be defined as a danger to workers that is inherent in a particular occupation, in quarrying, workers are exposed to a variety of hazards that are unique to the occupation. These includes but not limited to physical, biological, chemical, ergonomic, mechanical, safety and psychosocial hazards (Abbasi, 2018). When compared with other workplaces, quarrying has unique and inherent characteristics that result to different OSH hazards.

Some of the frequent hazards encountered in quarries include;

2.2.1 Mechanical Hazards

The tools, equipment's, machinery, and plant used in undertaking quarrying operations can cause a number of negative health effects to the workers. Many machines used in carrying out quarrying tasks involve moving parts, sharp edges and hot surfaces which have the potential to cut, stab, crush, struck or wound workers if used unsafely (ILO, 2018).

Vehicles are necessary for transporting goods and people. However, many people die and are injured due to being struck, crushed or run over by reversing vehicles, overturning, collision with other vehicles, or falling while entering or leaving the very high cabs of many vehicles used in quarrying operations. Accidents may also occur as a result of technical failures such as faulty brakes and steering or because of driver misjudgments.

2.2.2 Chemical hazards

These are hazards arising from liquids, solids, dusts, fumes, vapours and gases. Chemicals used in quarrying activities include explosives which are used to break the rock. These explosives are made of chemical materials which if not properly managed cause health problems besides being able to cause physiological harm.The storage and transport of chemicals within quarry area can cause harm to workers if not properly handled. Exposure to these chemicals can cause respiratory problems, dermatitis or skin irritation and chemical burns to the skin (ILO,2018).At the quarry site, workers might be exposed to chemicals by breathing them in, ingestion and absorption through the eyes or skin (Abbasi, 2018). Chemicals at work sites can cause headaches, eye irritation, dizziness, faintness, sleepiness and affect judgment and coordination. They can damage to the central nervous system and can harm the skin, liver, kidneys and cardiovascular system. Some solvents increase the likelihood of cancer. Welding fumes which may include a cocktail of metal fumes can cause serious health problems in the long term. The respiratory system is affected and, as chemicals are absorbed, they can slowly affect the brain and internal organs (ILO, 2016).

Diesel engine exhaust is a complex mixture of gases, vapours and particulate matter. The most hazardous gases are carbon monoxide, nitrogen oxide, nitrogen dioxide and sulphur dioxide. Diesel particulate matter and other particles of similar size are carcinogenic and appear to increase the risk of lung cancer in exposed workers at concentrations above about 0.1 mg/m^3(ILO ,2018).

2.2.3 Biological hazards

These include the hazards of organisms such as bacteria, viruses, fungi, and parasites that cause disease in the workers exposed to them. Quarrying is associated with poor working conditions with the limbs exposed to biological hazards. Among various dangers involved are a risk of snakebites and injury (ILO, 2018). Quarry workers are exposed to contact with wild and poisonous animals that includes insects, spiders, scorpions, snakes, and other poisonous plants (Abbasi, 2018).

2.3.4 Psychosocial Hazards

According to Ramesh and Bobby (2015), contend that psychosocial hazards are related to the way work is designed, organized, and managed as well as the economic and social context of work. These hazards are also associated with psychological and physical injury or illnesses. The quarrying operations are associated with long working hours. Many workers travel long distances and may be away from homes for many days or even weeks. Loneliness and isolation can therefore be experienced. These situations cause anxiety in many workers and their families and many people are adversely affected in their personal lives. Violence in the mines arises from different situations including mobbing and bullying. Places of work may be the most important sources of health stresses if workplace operations have not been studied thoroughly and the associated health hazards have not been eliminated or controlled. According to the Abbasi (2018), the feeling of job insecurity, poor work life balance, poor remuneration and long working hours as well as unrealistic job expectations cause severe stress which may increase workers‟ vulnerability to other forms of work place hazards.

2.3.5 Ergonomic hazards

Ergonomics hazard occur when the type of work, the body position, and the working conditions put strain on the body. The use of inadequate equipment and tools, unnatural body position, prolonged static posture, carrying of heavy loads and working, long hours are some of the factors that give rise to ergonomic hazards in quarring. Other factors include: Frequent lifting, Poor posture, Awkward repetitive movements and using too much force frequently (ILO, 2016).

2.3.6 Physical hazards

Physical hazards are factors within the environment that have the potential to harm the body.

The common physical hazards associated with ill health in quarries are;

2.3.6.1 Noise

It is all unwanted sound which causes annoyance and interferes with efficiency, induces stress and disturbs concentration .High noise levels can be generated from rock blasting, rock crushers, sound from engine excavators and dumping trucks and Lorries which pose a risk of noise induced hearing loss to workers (Abbasi, 2018). It can be controlled at the source by identifying the source of noise and replace or remove the noise machinery or part of the machine. The use of silencers and vibration isolation can also be done to reduce high noise levels (ILO, 2018).

2.3.6.2 Dust

The quarrying process involves breaking the rock or removing the soil. These activities generate a lot of dust and pebbles. These dust and pebbles can be can cause a variety of respiratory diseases amongst quarry workers. Pneumoconiosis, the general term given to a range of lung diseases caused by breathing dusts, typically causes chest tightness, shortness of breath and coughing.According to Abbasi, (2018), it is carried by moving air when there is sufficient energy in the airstream and is removed through gravitational settling (sedimentation), washout such as during rainfall or by wetting and through impaction on surfaces. Settled dust can be re-suspended where conditions allow, either by wind blow from bare surfaces or by disturbance such as vehicle movement (ILO, 2016).

2.3.6.3 Heat

Heat is also a problem when working in quarries. The principal sources of heat include the amount of physical activity workers are doing, the ambient air temperature and humidity, the proximity to hot engines principally diesel powered machines and sunlight .These conditions take a heavy toll on the body and they can affect attention and concentration thus leading to injuries (ILO, 2016). Excessive exposure to heat can cause a range of heat-related illnesses, from heat rash and heat cramps to heat exhaustion and heat stroke. Heat stroke can result in death and requires immediate medical attention. Exposure to heat can also increase the risk of injuries because of sweaty palms, fogged-up safety glasses, dizziness, and burns from hot surfaces or steam (Abbasi, 2018).

2.3.6.4 Fire

Fires and explosions pose a constant threat to the safety of quarry workers. Although fire hazards are not seen as such as a high risk compared with falling from a height and slipping, tripping and falling, fire hazards need to be considered at all stages of the quarrying process (Abbasi, 2018). Source of fires include mobile equipment maintenance, welding and cutting operations and the storage, handling and use of flammable and combustible liquids. Diesel powered equipment may increase the risk of fire or explosion since it emits a hot exhaust, with flame and sparks, and its high surface temperatures may ignite any accumulated dust or other combustible material (Utembe et al, 2015).

2.3.6.5 Ionizing radiation

Abbasi (2018) promulgate that radon gas can be released from rocks during the blasting process or it may also enter a mine through underground streams. It is a gas and therefore it is airborne. Though not perceived by a normal human eye, radon and its decay products emit ionizing radiation some of which have enough energy to produce cancer cells in the lungs. (Work Safe New Zealand, 2016).

2.3.6.6 Vibration

Workers at quarries are exposed to hand arm and whole-body vibration. The former is generated by tools such as pneumatic drills, angle grinders and chain saws while the latter is generated by quarry vehicles and some fixed plant machinery.The use of hand-held vibrating tools in quarries causes a health problem known as Hand–Arm Vibration Syndrome (HAVS) whose symptoms include tingling, numbness, loss of grip strength and pain (Utembe et al., 2018).

2.3 Hazard Hierarchy Control Measures

Hazards and risks to workers' safety and health require identification and assessment on an ongoing basis. Preventive and protective measures are implemented in a hierarchical order; Elimination of the hazard at the source which is achieved at the design stage through engineering controls. Control the hazard at source, through the use of engineering controls or organizational measures, substitution of hazardous substance with less hazardous without compromising the product, isolation of the hazardous area through barrier, minimize the hazard by the design of safe work systems, which include administrative control measures. Where residual hazards cannot be controlled by collective measures, the employer provides for appropriate personal protective equipment, including clothing, at no cost, and implement measures to ensure its use and maintenance (Barasa, 2014).

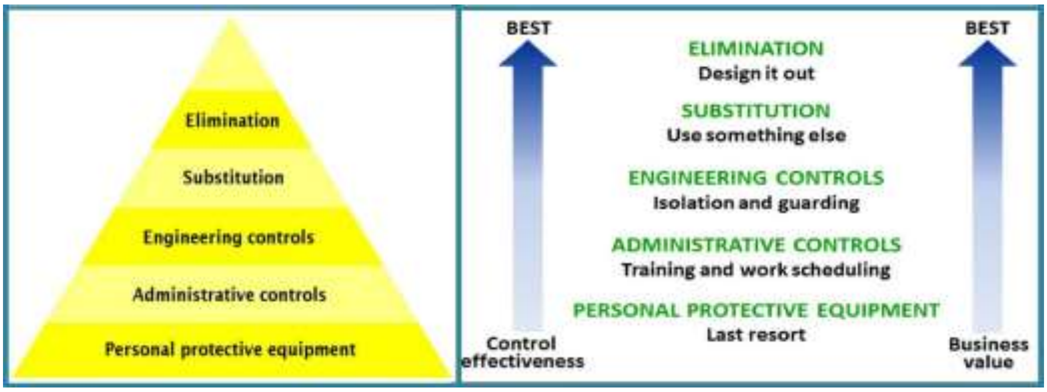

Figure 2.1: Hierarchy of hazard control. Source: Wikipedia**.**

Hazard prevention and control procedures or arrangements are established and adapted to the hazards and risks encountered by the organization. They are reviewed and modified on regular basis in order comply with national laws and regulations, and considers the current state of knowledge, including information or reports from organizations. These may include labour inspectorates, occupational safety and health services, and other services as appropriate (1LO, 2014).

2.4 Ambient air quality in quarries

An air pollutant is a substance in the air that can cause harm to humans and the environment and can be in the form of solid particles, liquid droplets, or gases. Air pollution, therefore, describes any harmful gases or particles in the ambient air brought about by product of combustion (Complete or incomplete) of petroleum products and industrial waste such as ground-level Ozone (O3),particulate matter (PM),Sulphur dioxide (SO2),Carbon Monoxide (CO), nitrogen oxides (NOx), volatile organic compounds (VOCs),Hydrogen Sulphide (H2S), sulphates and nitrates. The presence or absence of these pollutants will determine the quality of air at any particular place and time (Degan et al., 2015).

Air pollution is a common environmental problem in all quarries especially open cast operations. This alters the ambient air quality with its attendant geohazards such as visual impairment, noise, segmental vibration, heat, changes in barometric pressure and ionizing radiation (Onwe, 2015).

2.4.1 Particulate matter 2.5 ($PM_{2.5}$)

Particulates are the tiny solid or liquid particles that are suspended in air and which are usually individually invisible to the naked eyes. The particulates include soot, smoke, ash from fuel (mainly coal) combustion, dust released during quarrying and other solids from accidental and deliberate burning of vegetation (WHO, 2013).

Particles 2.5 microns and less are known as $PM_{2.5}$(Respirable dust). $PM_{2.5,}$ have small diameters, however large surface areas and may therefore be capable of carrying various toxic stuffs, passing through the filtration of nose hair, reaching the end of the respiratory tract with airflow and accumulate thereby diffusion, damaging other parts of the body through air exchange in the lungs (Chu et al,2017). The recommended exposure Limit is 5mg/m^3 as stipulated under Factories and other places of work (Hazardous substances) Rules of 2007.

2.4.2 Particulate matter 10 (PM_{10})

Particles 10 microns and less are known as PM_{10} (Inhalable dust). Most of this will be filtered out in the nose and throat. The short-term effects of (acute) exposure include, coughing, shortness of breath, tightness of the chest, irritation of the eyes, irregular heartbeat, and nonfatal heart attacks (Degan et al, 2015). The long-term effects (chronic) exposure include, reduced lung function, development of respiratory diseases in children, aggravation of existing lung diseases, premature death of people with lung disease, aggravation of existing heart diseases and premature death of people with heart disease (WHO, 2013).The recommended exposure Limit is 10mg/m^3 as stipulated under Factories and other places of work (Hazardous substances) Rules of 2007.

2.4.3 Source of $PM_{2.5}$ and PM_{10} in quarries

Dust is one of the most visible, invasive, and potentially irritating impacts associated with quarrying, and its visibility often raises concerns that are not directly proportional to its impact on human health and the environment (Kumar,Ranga & Shika, 2018).The main source of airborne particulate matter includes the following activities: site clearing, road construction, topsoil stripping and dumping, open pit drilling and blasting, stripping, loading and haulage.It can cause a variety of respiratory diseases amongst quarry workers(Onwe, 2015).

2.4.4 Carbon Monoxide (CO)

Carbon monoxide (CO) is a trace constituent of the troposphere, produced by both natural processes and human activities. Motor vehicle exhaust has been cited as the most important source for elevated carbon monoxide levels (NIOSH, 2020). CO is a colorless, odorless gas. It is also produced by burning wood, paper, or plastic products. Workers can be exposed to carbon monoxide in any workplace where equipment’s which uses petroleum products to power the machines are used. This results from partial combustion of carbon in the fuels (Eltschlager et al, 2015). It has the formula CO and molecular weight of 28.01 g/mole. It boils at -191.5 0C (at 210C) while its specific gravity (water = 1) is 0.79 at 0 0C. It has a vapor density of 0.97 and freezes at -205 0C (MSDS, 2010).The recommended exposure Limit is 50 ppm as stipulated under Factories and other places of work (Hazardous substances) Rules of 2007.It is also an asphyxiant that combines with the haemoglobin of the blood which decreases the amount of oxygen delivered to the tissues resulting to tissue hypoxia.

2.4.5 Carbon Dioxide

Carbon Dioxide (CO_2) is a colorless gas with a faint smell. It occurs in normal atmosphere in varying concentrations from 0.03 to 0.08% (NIOSH, 2020). It has the formula CO2 and molecular weight of 44. It melts at -56.60C (at 5.2 Atmosphere) and boils at 78.50C (at 760 mm Hg).It is denser than air and contains carbon and oxygen (MSDS, 2002). The recommended exposure Limit is 5000 ppm as stipulated under Factories and other places of work (Hazardous substances) Rules of 2007.Its health effects include shortness of breath and headache and may lead to unconsciousness in exposed person at a concentration of 5%

2.4.6 Source of CO and CO_2 in quarries

The source of carbon in both CO and CO2 is the fuel oil (CH2). All explosives create an amount of CO and CO2, depending on the oxygen balance of the formulation, some explosives produce more CO than others. The commonly used explosives contain an organic carbon. For simplicity, ammonium nitrate and fuel oil (ANFO) will be given as an example. The byproducts of the detonation of ANFO are primarily water (H2O), nitrogen (N2) and carbon dioxide (CO2), all nontoxic to people. In an ideal reaction1:

$$3NH4NO3 + CH2 => 7H20 + CO2 + 3N2$$

Noxious fumes are generated when the fuel oil portion is incorrect, water is introduced into the ANFO, or optimum detonation velocities are not attained due to inadequate priming. These secondary byproducts are CO and nitrogen oxides (NOx) (Eltschlager, Marcia & Baldassare, 2015).

2.5 Implementation of Occupational Safety and Health (OSH) Measures in quarries

According to ILO (2013), the main focus in occupational health is the maintenance and promotion of workers' health and working capacity; the improvement of working environment and work to become conducive to safety and health and development of work organizations and working cultures in a direction which supports health and safety at work and in doing so also promotes a positive social climate and smooth operation that may enhance productivity of the undertakings.

2.5.1 Management Commitment and Support

According to Mabika, (2018), management commitment and support is the management's involvement and engagement in action towards achieving a goal. Management commitment is manifested through various ways such as having and participating in safety training, facility inspections and incident investigations, empowerment of employees to make decisions, giving rewards and penalizing employees who do not follow safety measures such as the use of personal protective equipments (Ndegwa, 2015). Senso (2017) also sees management role as including developing loss control programmes, safety committees, employee selection procedures, employee and supervisor training feedback and incentives, positive workers' attitudes, improved engineering practices and enforcement of these practices and empowerment of workers. According to Amponsah-Tawiah & Mensah, (2016), Health and Safety policies work well if senior managers set examples and show that they are committed to their upkeep. The policy will not be enforced if managers set a bad example. To avoid this they should involve staff in the health and safety process, through consultation with unions or workplace committees, ensure that employees are aware of the policies

2.5.2 Employee Participation.

According to Ndegwa, (2015), Participation is the mental and emotional involvement of people in-group situations that encourages them to contribute to group goals and share responsibility for them. Participation is a fundamental workers' right, and it is also a duty. According to Smit et al, (2016), a genuine and consistent management commitment to safety prioritize involvement of employees, including empowerment, delegation of responsibility for safety and encouraging commitment to the organization. Employees are responsible for complying with all applicable OSHA standards, following all employer safety and health rules and regulations, and for reporting hazardous conditions to the supervisor. They also have a right to demand safety and health on the job without fear of punishment. According to Senso, (2017),forming employee's committees is one of the best ways to create and maintain interest and get employees involved in making a personal contribution to the overall safety programme.It encourages the modern style of participatory management, increases satisfaction, raises employee productivity and lowers the employee compensation rates. More than anything, people should be healthy and safe to perform their jobs securely.

2.5.3 Employee training

According to Rotich and Kwasira (2015), training is the use of systematic and planned instructions activities to promote learning. Safety training need to be carried out in the three settings: at induction, on the job and refresher courses using a variety of different training techniques such as lectures, discussions, films, role playing and slides, posters, safety awareness and campaigns and communications. Training and orientation of new employees emphasizing safety is especially important as the early months of employment are often critical because work injuries decrease with the length of service (Senso, 2017). Training should also be a continuous process as changes in technology may give rise to new hazards and thus need for refresher training. Training compliments education by providing employees opportunities to apply the knowledge provided by the education. Thus, the purpose of an education/ training procedure is to provide an environment for the acquisition of attitudes, knowledge or skills, so that newly acquired behaviors may be transferred to the job setting. A successful education/training program can impact workers' safety by giving them the tools and knowledge to use when faced with a novel emergency on or off the job (Gaceri, 2015). As part of normal induction training, employees should be made aware of their responsibility for health and safety, general health hazards, the use of safety clothing and equipment, the availability of medical services, safety rules, material handling, first aid fire prevention and procedures for reporting accidents (Ndegwa, 2015).

2.5.4 Government support

ILO (2006) requires governments to take necessary measures to provide guidance to workers and employer and maintain an adequate and appropriate system of inspection to make sure that different labor regulations, especially those related to workplace safety are complied with. According to Bird, (2014), Governments are responsible for drawing up occupational safety and health policies and making sure that they are implemented. The Government should supervise and advise on the implementation of a workers' health surveillance system, which should be linked with programmes to prevent accident and disease and to protect and promote workers' health at both enterprise and national levels .Considering the fact that companies lack financial resources to implement OSH, subsidy given by the government would be helpful (Amponsah-Tawiah & Mensah, 2016). As Gaceri, (2015) point out, Government laws and regulations have a strong influence on the extent to which firms implement OSH measures. Sometimes employers are not willing to provide comprehensive OSH programmes and external force is necessary to exert pressure on them

According to Kariuki (2011), lack of proper enforcement mechanisms, capacity challenges, emerging production techniques creating new risks, lack of comprehensive occupational health policy, poor infrastructure and funding, insufficient number of qualified occupational health and safety practioners, high unemployment rate and general lack of adequate information are among main drawbacks to the provision of effective enforcement and implementation of the law on occupational safety and health services in Kenya.

2.6 Legal framework with respect to Quarries

In the United States of America, Occupational Safety and Health Administration (OSHA), which is a national public health agency dedicated to the basic proposition that no worker shall have to choose between their life and their job. Under OSHA, standards are developed to protect workers from a wide range of serious hazards eg in Quarrying where OSH standard 21 deals with hazards specifically applicable in mining and quarrying (OSHA, 2018).

In the United Kingdom, occupational safety and health is managed by the Health and Safety Executive (HSE) through enforcement of the Health and Safety at Work Act, 1974 with amendments of 2008. The HSE enforces the law in many workplaces that includes safety in quarrying. HSE has developed regulations, codes of practice and many publications (guidelines) to assist in compliance of the main Act in various sectors of the economy that includes quarrying (www.hse.gov.uk).

In Kenya, the history of Occupational Safety and Health dates back to 1950 when it was found necessary to have a legal instrument to manage the safety, health, and welfare of employed persons in factories. The colonial government by then adopted the British Factories Act of 1937. In 1990, the Factories Act was amended to Factories And other Places of Work Act for purposes of enlarging the scope of coverage. In the year 2007, the Factories and Other Places of Work Act was repealed and replaced with the Occupational Safety and Health Act (GOK, 2007). OSH is managed by the Directorate of Occupational Safety and Health Services (DOSHS). It is a department in the Ministry of Labour that is responsible for promoting safety, health and welfare at work in all workplaces. The department enforces two Acts of parliament, namely the Occupational Safety and Health Act of 2007 (OSHA) and the Work Injury Benefits Act of 2007 (WIBA).DOSHS is mandated with the responsibility for ensuring employers provide prevention measures for accidents and diseases, undertakes systematic inspection and audits of workplaces with view of identifying the hazards and make recommendations for improvement, creating awareness to citizens and other people on matters of occupational health and safety, mainly through trainings.

The following Acts govern OSH in the quarrying Sector:

2.6.1 The Occupational Safety and Health Act (OSHA) of 2007

The Act apply to all work-places where any person is at work whether temporarily or permanently, including formal and the informal sector. The purpose of the Act is to secure the safety, health and welfare of persons at work and to protect persons other than those at work against risks to safety and health arising from, or in connection with, the activities of persons at work. The government has also developed a national policy for occupational safety and health. The policy addresses safety and health in all sectors, including the formal and informal sectors. The purpose of The Work Injury Benefits Act (WIBA) on the other hand is to provide for compensation to employees for work related injuries and diseases contracted in the course of their employment and for connected purposes.Though compensation applies to all workers, it is contributory and hence selfemployed workers who includes small scale farmers do not enjoy the services of this legislation (GOK, 2007).

2.6.2 The Constitution of Kenya, (2010)

Although the Constitution does not address OSH specifically, it includes a chapter on the Bill of Rights, which provides for the rights of every person to fair labour practices, reasonable working conditions, and a clean and healthy environment (GOK,2010).

2.6.3 Environmental Management and Coordination Act (EMCA, 1999)

The Act established the National Environment Management Authority (NEMA) which, among other functions, monitors and evaluates development activities to ensure there is no threat to environmental stability. Activities, such as quarrying become significant in this respect (GOK,1999).

2.6.4 The Mining Act of 2016

This is an Act of Parliament that stipulates the legal and institutional framework relating to the minerals and mining activities in the country. It derives it provision from the Kenyan constitution that provides for the sustainable extraction and use of environmental and natural resources. Activities in the quarrying industry can be traced in what the Mining Act of 2011 classifies as building material which includes among others: "all forms of rocks, stones, gravel and sand used for construction of building, roads, dams, aerodromes and landscaping or similar works.(GOK,2016).

2.6.5 Other subsidiary laws and regulations that govern OSH in Kenya

2.6.5.1 The Factories (First Aid) Rules, L.N. No. 160/1977

These require the quarry owners to put in place appropriate measures to ensure that those injured at work receive necessary medical attention. The Rules specify the contents of the first-aid box in accordance with the number of workers, and the training of first-aiders (GOK,1977).

2.6.5.2 The Factories and Other Places of Work (Safety and Health Committees) Rules, L.N. No. 31/2004

These rules apply to workplaces with 20 or more regular employees. They require the quarry owners to set up safety and health committees with equal representation of management and workers (GOK,2004).

2.6.5.3 The Factories and Other Places of Work (Noise Prevention and Control) Rules, L.N. No. 25/2005;

These rules require the quarry owners to carry out noise measurements, develop a noise prevention programme to reduce noise levels and provide hearing protection (GOK,2005).

2.6.5.4 The Factories and Other Places of Work (Medical Examination) Rules, L.N. No. 24/2005.

These rules require quarry employees to undergo medical examinations due to exposure to dust particles. Quarries are expected to seek the designated health practitioners to perform medical examinations as part of worker screening programs, for both predictive and preventive purposes (GOK, 2005).

2.6.5.5 The Factories and Other Places of Work (Fire Risk Reduction) Rules, L.N. No. 59/2007

These rules require the quarry owner to put appropriate measures in place to prevent the occurrence of fires within their premises. They address the safe handling, storage and transportation of flammable substances. They also require the occupier to provide means of evacuation, fire detection systems, firefighting equipment, and firefighting teams. The rules prescribe annual fire safety audits, the formulation of a fire safety policy, and training of workers on fire safety issues (GOK, 2007).

2.6.5.6 Factories and Other Places of Work (Hazardous Substances) Rules, L.N. No. 60/2007

These rules require the quarry owners to prevent employees from exposure to hazardous substances by putting various control measures in place. They prescribe occupational exposure limits (OEL) for hazardous chemical substances, safe handling, use and disposal of hazardous substances (GOK, 2007).

2.6.5.7 The Explosives (Blasting explosives) rules of 1962, L.N No.94/2010:

These rules authorize the use, storage, and handling of explosives in quarries where blasting is carried out (GOK, 2010).

2.7 Previous related studies

According to Sifuyan et al. (2012) research on Awareness and compliance with use of safety protective devices and patterns of injury among quarry workers in Sabon-Gari Local Government Area, Kaduna state North-Western Nigeria, On issues of work safety, 68.9% think their work is not safe. Majority of the respondents (97.3%) were aware of safety protective devices. A total of 89.2% use at least one safety protective device or the other at work. However, 71.6% of these use the devices always, showing a high level of compliance. Most of the respondents (81.1%) had experienced at least one workplace injury or the other in the past, most commonly was hand injury (80.0%), leg injury (30.0%), eye injury (11.7%), and facial injury (8.3%).

According to a study done by Wanjiku et al, (2015) on Occupational health and safety hazards associated with quarrying activities in Mutonga quarry, Meru county, Some of the hazards involved with the quarrying activities carried out by the respondents were indicated as: manual handling of heavy loads(42%), being hit by the tools(15%), exposure to dust(13%) and falling of rock block(7%). results indicated blasting (63.7%), drilling (74.8%), shaping stones (56.4%) and loading the trucks with rocks (53.2%) was associated with having health problems at the quarry.

According to a study done by Ndegwa (2015), on Perceptual Measures of Determinants of Implementation of Occupational Safety and Health Programmes in the Manufacturing Sector in Kenya, the results showed that the industries faced challenges in implementing OSH programmes that included lack of cooperation from employees, difficulties in interpreting OSH statutory requirements, lack of management commitment, compromise of inspection standards by government officers and so on. Coefficient correlation for management support was 0.42, employee training 0.64, legal framework 0.64 and employee participation 0.35. The regression model showed that management support explained 17.7% implementation of OSH programmes, employee training 42.2%, legal framework 42.2% and employee participation 12.25%. The overall multiple regressions showed that all the factors combined explained 61.8% of implementation of OSH programmes.

According to a study done by Kumar,Ranga and Shika (2018), on Impact of stone quarrying on ambient air quality in India, It was revealed in the study that quarrying dust causes air pollution .Work place dust concentration in different quarrying operations (in terms of respirable suspended particulate matter) was observed vary from140 μg/ m3to 2240μg/ m3. Maximum 2240 μg/ m3 dust concentration was found at drilling operation and minimum 140μg/ m3 was observed at the time of blasting operation. These values were much above than the permissible limits of for mining and quarrying area prescribed by WHO.It was observed that fine dust inhaled by workers leads to diseases related to lungs and liver. It was found that nearly 25% workers interrogated show dust related diseases, nearly 34% workers felt that the quarrying has caused air pollution affecting their health slowly and 41% mine workers felt that quarrying is the cause of increase in diseases.

2.8 Summary of literature review

Quarrying industry have contributed greatly to the economic growth and wellbeing of many countries across the world in terms of employment, direct and indirect revenues, and exports. However, despite these positive contributions, the industry is typically associated with hazardous working conditions, which affect the health and safety of workers. The industry has been regarded as one of the safety-critical domains with dangerous operations and an environment in which the workers are exposed to risks and hazards including but not limited to heavy lifting, or repetitive movements, twisting of the body, inhaling toxic chemicals and dust, unfavourable weather conditions and noise pollution that is injurious to human health.

In Kenya, by law, quarrying incident/accident reports are to be submitted to the DOSHS.Thus, there should have been the existence of a database that catalogs all reported incidents occurring within the industry, and such a database should be readily accessible to the public.However, accessibility to such data still remains a challenge and has been identified as the number one problem that hinders research in this area. It is therefore not surprising that accidents and injuries in Kenya quarry industry have been sparsely studied, although the industry was long identified as a major safety-critical domain. Hence, studies that consider the entire industry across different commodities and quarry type using rich data will be asignificant contribution for improving health and safety.

2.9 Research gaps.

Available literature on occupational safety and health in quarries has highlighted the challenges workers undergo. Some research studies revealed that many quarries are privately owned and therefore exploit their works to make profits at expense of improved working conditions, but the findings fail to provide solutions on how occupational safety should be enhanced in such set up. Some studies have attempted to identify critical risk factors and emerging issues in OSH area .Other studies have concentrated on the construction industry, fire safety and the few studies in quarrying industries have looked into the relationship between OSH hazards and effects on employees. In addition, only a few studies have been carried out on quarries in Kenya and these studies are inclined more towards the effects of quarrying on Environment. This proposed study is unique in that it will adopt an integrative approach that will capture not only the hazards in quarries and their effects but also the core factors in successful implementation of OSH measures, that is, management commitment, employee training, employee involvement and Government support.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Design

The study adopted Analytical cross-sectional research design, employing both qualitative and quantitative data collection methods. It is a non-experimental design which seeks to gather data from a group of subjects at only one point in time (Schmidt & Brown, 2019).This design is appropriate and convenient to the researchers since the study was limited by time and funds available and according to the argument advanced by (Wang & Cheng, 2020), the study design is relatively quick and inexpensive to conduct.

3.2 Study area

The research was carried out in Bomet County in the south rift valley region of Kenya. The study area lies between latitude $0^{0}29'$ and $1^{0}03'$ South and longitude $35^{0}05'$ and $35^{0}35'$ East, along B_3 road between Nairobi and Kisii via Narok, approximately 255km North West of Nairobi. It is bordered by four counties namely: Nakuru to East, Kericho to North and North East, Nyamira to North West and Narok to South East, South and South West.

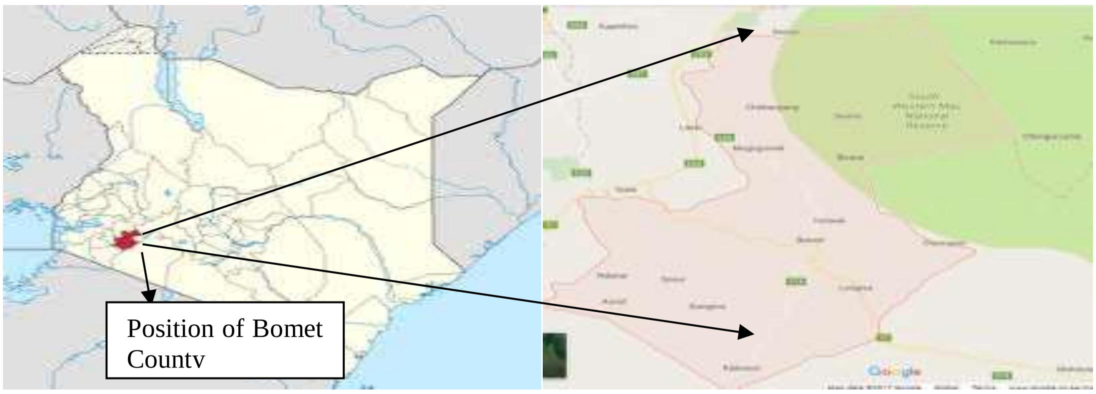

Figure 3.1: Map of Kenya showing Bomet County

3.3 Study population

Bomet County has 32 privately owned and operational quarries. Out of the 32 quarries, 12 were registered with National Environmental Management Authority (NEMA) by the time of data collection (2017). The target population was 542 workers comprising of plant operators, drivers, mechanics, machine operators, quarry pit workers and office clerks from the 12 quarries and distributed within the four types of quarries as shown in **Table 3.1.** According to Castillo (2009), a population is generally a large collection of individuals or objects that is the main focus of a scientific query. Population forms the basis from which the sample is drawn.The target population consisted of men and women workers above eighteen (18) years of age. All the quarries were coded since there actual names had been withheld for confidentiality.

Table 3.1: Distribution of quarry workers

Type of quarry	No of quarries	Total number of workers
Sand	2	116
Construction blocks	2	61
Murram	3	74
Stones	5	291
Total	**12**	**542**

3.4 Sample size determination

A sampling frame is a list of all the items where a representative sample is drawn for the purpose of research. Sampling must be so large that it allows a researcher to feel confident about the sample representativeness and it allows the researcher to make inferences of the sampling frame and the entire population (Silverman, 2005). In this study, sample size was determined by using Yamane Taro, (1967) formula:

$$n = \frac{N}{1 + N(e)^2}$$

Where;

n = the desired sample size

e =margin of error 0.05.

N = estimate of the population.

Substituting the above formula, the sample size was determined as follows

$$n = \frac{542}{1 + 542(0.05)^2} = 230$$

The study used a sample size of 230 respondents drawn from the quarry workers.

3.5 Sampling technique

Stratified random sampling was used in this study to draw respondents from the target population. According to Bryman and Bell (2007), stratified sampling "ensures that the resulting sample was distributed in the same way as the population in terms of the stratifying criterion. It gives flexibility to the researcher to make a decision on identification and allocation of the units for the strata. It also gives possibilities to use and make more than just one stratifying criterion. A two stage sampling strategy was adopted in this study. The first stage involved dividing quarries into four strata depending on material being quarried (sand, stones, construction blocks and murram). In the second stage, the workers were stratified according to work categories (quarry pit, crushing plant, mechanics, machine operators, drivers and quarry managers). This was important to have an even distribution of the units within the sampling frame and the sample. A selection of a simple random sample from each of the resulting strata was made. This minimized the sampling errors or biasness of the sample.

To get the exact sample for each stratum, the stratum population was divided by the total population and multiplied by the sample size.

Stratum sample size= [Stratum population/Total population] *Sample size

The total target population and sample size are as shown in **Tables 3.2, 3.3 and 3.4,** respectively.

Table 3.2: Number of workers per stratum per type of quarry

Category of workers	**Number of quarries and workers per category**				
Quarries	**Sand(2)**	**Blocks(2)**	**Murram(3)**	**Stones(5)**	**Total**
Quarry pit	105	59	65	27	256
Crushing unit	0	0	0	164	164
Machine operators	0	0	0	34	34
Drivers	9	0	6	30	45
Mechanics	0	0	0	27	27
Supervisors	2	2	3	9	16
Total	**116**	**61**	**74**	**291**	**542**

Table 3.3: Sample size distribution per strata

Category of workers	**Target population**	**Sample size**
Quarry pit	256	109
Crushing unit	164	70
Machine operators	34	14
Drivers	45	19
Mechanics	27	11
Supervisors	16	7
Total	542	230

Table 3.4: Specific sample per quarry per category of workers

Category of workers	Number of quarries and workers per category				
Quarries	**Sand (2)**	**Blocks (2)**	**Murram(3)**	**Stones (5)**	**Total**
Quarry pit	45	25	28	11	109
Crushing unit	0	0	0	70	70
Machine operators	0	0	0	14	14
Drivers	3	0	3	13	19
Mechanics	0	0	0	11	11
Supervisors	1	1	2	3	7
Total	**49**	**26**	**32**	**123**	**230**

3.6 Research instruments

Primary data was collected through a structured questionnaire **(Appendix I),** observation checklist **(Appendix II),** Interview guide **(Appendix III)** and measurements of Carbon monoxide (CO), Carbon dioxide (CO_2), Respirable dust ($PM_{2.5}$) and Inhalable dust (PM_{10}). The items in the questionnaire were designed to capture all the specific objectives of the study. The questionnaire sought to establish the occupational hazards associated with quarrying activities, safety measures put in place to control hazards and factors affecting implementation of OSH practices in quarries.

The observation checklist was used to record how work activities were being carried out, the general condition of the machines, the postures applied while working, the workplace layout, housekeeping, lighting and general ventilation.

The interview was conducted with quarry managers and the institutions involved in Occupational safety and Health. These institutions include: Directorate of Occupational Safety and Health and National Environment Management Authority. The interview was conducted after data collection from the quarry workers.

Dust levels measurements (PM_{10}, PM2.5), Carbon monoxide (CO) and Carbon dioxide (CO_2) was measured using 3M EVM-7 Series Multi parameter Environmental Monitor. Measurements were done at a height of 1.5metres from the ground in order to properly determine the exposure level to which the workers are exposed to and 0metres away from the façade of the CO, CO_2 and dust source for one hour. These measurements were done during operations (Monday to Saturday). Calibrations certificate of the equipment is attached **(appendix IV).**

Figure 3.2: Particulate path diagram **Figure 3.3: Gas Sensor Path illustration**

A pilot test was carried out in the neighboring Bureti Sub County to test the effectiveness of the questionnaire. The pilot involved 10% of the targeted sample size (23 quarry workers who were randomly selected). The instrument was found to be effective with minor adjustments. The essence of carrying out a pilot test was to improve on precision, clarity and eliminate ambiguous questions of in data collection instrument.

3.7 Study procedure

Permission to conduct this study was obtained from management of the respective quarries, through Bomet County NEMA office. Verbal consent for participation was sought from the participants.The objective of the study was explained to the management and the study participants.Questionnaires were assigned unique codes and the results of each individual questionnaire were kept in strict confidence. All information collected was filed and all files kept under lock and key in a cabinet.

3.8 Data analysis

The data collected was edited, collated to eliminate errors and coded for analysis using the Statistical Package for Social Sciences (SPSS version 21) tool. The coded data was analyzed both quantitatively and qualitatively.

For part E of the questionnaire (factors affecting implementation of OSH measures) was based on Likert's scale of five ordinal measures of agreement towards each statement from one (1) to (5) rated as follows:1= Strongly disagree,2= Disagree,3= Not sure,4= Agree,5= Strongly agree.

The rating scale is given below as,

1= strongly disagree ($1.00 \leq$ Mean index < 1.50)

2= disagree ($1.50 \leq$ Mean index < 2.50)

3= not sure ($2.50 \leq$ Mean index < 3.50)

4= agree ($3.50 \leq$ Mean index < 4.50)

5= strongly agree ($4.50 \leq$ Mean index < 5.00)

The mean index formula for all cases above is given as follows:

$$\textbf{Mean index} = \sum (\mu * n)/N$$

Where: **μ** is the weighting of each factor given by the respondents

n is the frequency of respondents

N is the total number of respondents

Descriptive analysis in form of frequencies, graphs, pie charts and percentages were conducted. This was followed by inferential statistics to measure the quantitative data. The inferential statistics done were Pearson's Product Moment Correlation Coefficient (PPMCC), simple linear regression , Analysis of variance (ANOVA).

Pearson's Product Moment Correlation Coefficient was used to determining the relationship between each of the independent variables (occupational hazards awareness, safety measures, and implementation of OSH measures) and the dependent variable (safe work environment).

Simple Linear Regression Analysis was used to establish the effected of the aforementioned independent variables on safe work environment.The R^2-value was used to measures the percentage of variation in the values of the dependent variable that can be explained by the variation in the independent variable.

ANOVA was used to test the significance of the regression. F-statistics was used to test the ratio of the variance explained by the regression and the variance not explained by the regression.

Multiple regression analysis was conducted to examine the combined effect of occupational hazards awareness, safety measures, and implementation of OSH measures on safe work environment.

The theoretical Regression equation $Y = \beta 0 + \beta_1 X_1 + \varepsilon$ was applied.

Where;

Y=Awareness of occupational hazards

β_0=constant

β_1 = (Increase)

X_1 = independent variables (occupational hazards awareness, safety measures, and implementation of OSH measures).

ε =error of estimate

CO, CO2 and dust levels collected were analyzed and compared with the Occupational Exposure Limit (OEL) adopted by ILO, WHO, NEMA and DOSHS standards. The data was backed-up in electronic storage devices and files containing the data were password encrypted.

3.9 Ethical Considerations

The present study adhered to ethical issues so as enhance credibility of research. Firstly, the researcher acknowledges the ideas borrowed from other researchers and authors through referencing as a way of avoiding plagiarism. Secondly, the researcher administered questionnaires strictly to individuals who consented to participate in the study. Individuals who were not willing to participate in the study were not forced either. Thirdly, the researcher ensured confidentiality of information that were provided during data collection since authorized personnel were allowed to access the data.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Response rate

The study targeted a sample size of 230 respondents out of which all filled and returned the questionnaires giving a response rate of 100%. This response was very good and conforms to Babbie (2007) stipulation that a response rate of 50% is adequate for analysis and reporting ;a response of 60% is good; a response of 70% is very good; a response of 80% and above is excellent.

4.2 Demographic Characteristics of the Respondents

4.2.1 Distribution of Respondents in quarries

The study found that sand quarries had 21.3%, construction blocks quarries had 11.3%, murram quarries had 13.9% and stone quarries had 53.5% of the respondents **(Figure 4.1)**. The study further established that stone quarries employed more workers than sand, murram and construction blocks quarries. This is because stone undergoes further processing to produce final products whereas sand, murram and construction blocks once quarried are used without further processing. This implies that lack of hazard awareness in stone quarries would mean a significant number of workers being exposed to occupational health hazards while working.

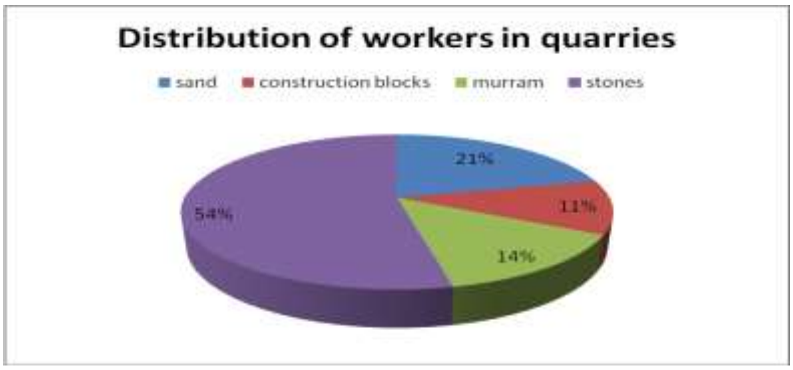

Figure 4.1: Distribution of Respondents in quarries

4.2.2 Participants gender

Most of the respondents were male [182 (79%)] while female were very few [48(21%)] in this study **(Figure 4.2)**. This was attributed to the high level of physical labour needed as nature of job entails physical activity like chiseling and breaking of rocks, lifting heavy loads and use heavy vibrating machines. Wanjiku et al (2015) in his study on Occupational health and safety hazards associated with quarrying activities reported that male workers in the quarry were high (87%) compared to their female counterparts (13%). However, this findings slightly differs with that of a study done by Apeteng et al (2016) ,where majority of the respondents(57%) were females while 43% were males.

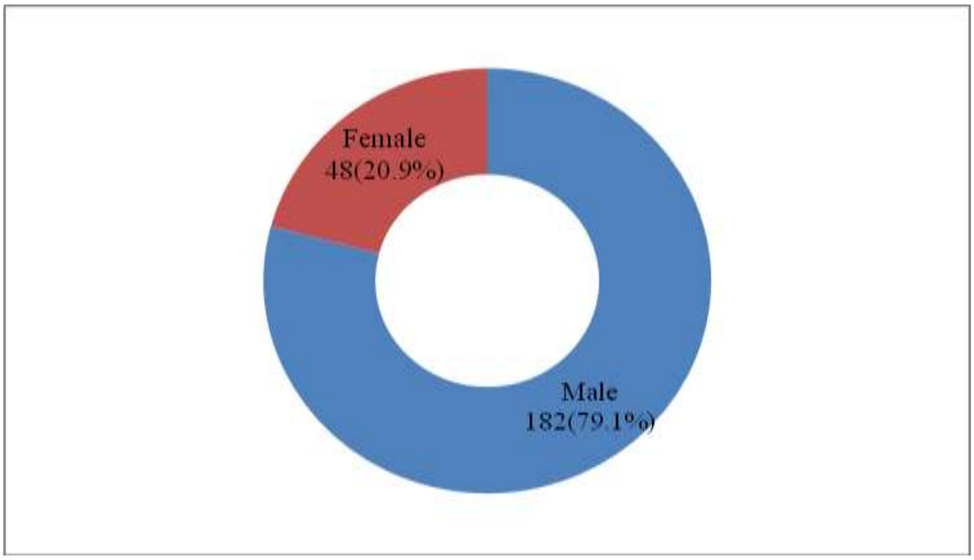

Figure 4.2: Gender of the respondents.

4.2.3 Age of the respondents

According to this study, 83(36%) respondents were aged between 18-29 years, 72(31%) were aged between 30-39 years, 39(17%) were aged between 40-49 years, 35(15%) were aged between 50-59 years and 1(1%) was over 60 years **(Figure 4.3)**. The age range for most respondents' falls between age group 18 -39 years .The reason for this could also be due to the strength and energy involved in such works.This age group are still very much full of strength and energy and so could engage in strenuous jobs.

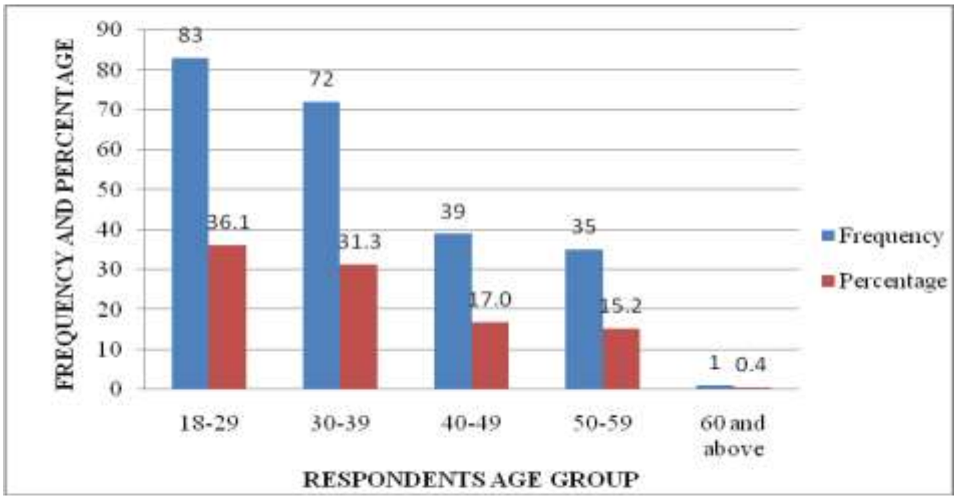

Figure 4.3: Age groups of respondent

4.2.4 Marital status of the respondents

The study showed that, 106(46%) participants were single, 121(53%) were married and 3(1%) were widowed **(Figure 4.4)**. Majority of the respondents are married individuals with their own families which implies that they have responsibilities over wives, husbands, children and other dependents as the case may be. This concurs with results of Wanjiku et al. (2015) who reported that 52.9% of respondents were married individuals .

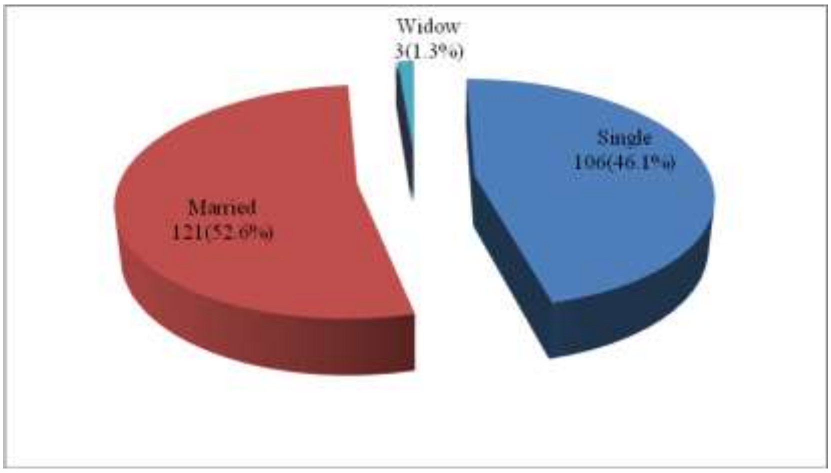

Figure 4.4: Marital status of the respondents

4.2.5 Level of education

The results showed that, 36(16%) participants had no formal education, 4(2%) had adult literacy, 95(41%) had primary education, 77(33%) had secondary, while 18(8%) had Tertiary has highest level of education **(Figure 4.5).** However, this is in contrast with findings of a study by Apeteng et al (2016) where 71.5% and 53% were illiterate respectively. It would be expected that a higher percentage of workers in quarry would have no formal education as shown in latter study since they are mainly from poor families. It could also be inferred that those with tertiary education became quarry workers probably because of inability to secure better jobs while those with primary and secondary education who lack the will to further their education due to finances mostly resort into learning quarry works. The fact that majority of respondents had one form of formal education can be utilized as an opportunity for an effective training programme to improve their knowledge on health and safety measures as it pertains to their work.

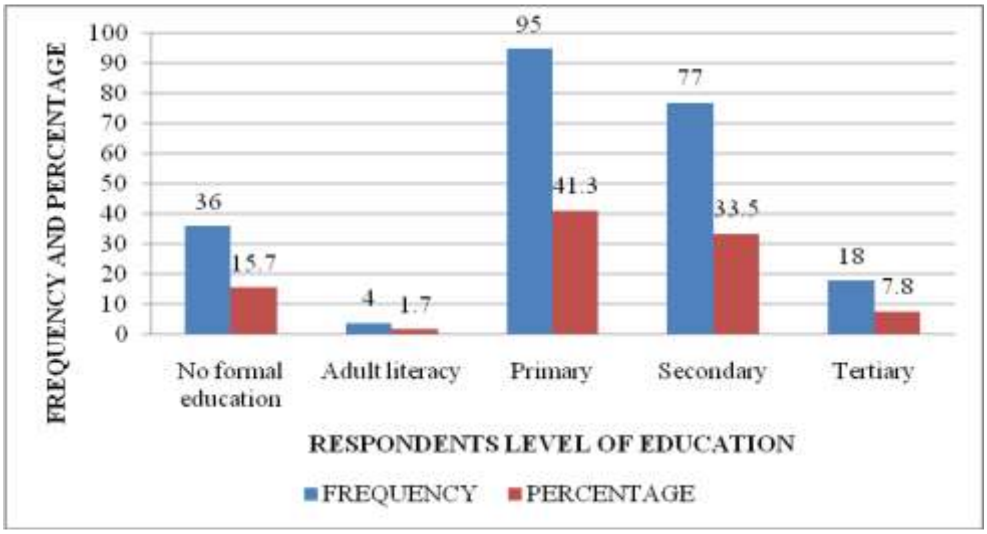

Figure 4.5: Education level of respondents

4.2.6 Work experience

The results showed that, 12(5%) of respondents had worked below 1 year, 78(34%) had worked between 1-4 years, 52(23%) had worked between 5-10 years, 33(14%) had worked between 11-14years, 19(8%) had worked between14-20years, while 36(16%) had worked for over 20 years. Majority (61.7%) of the participants had work experience of 10 years and below **(Figure 4.6)**.This may reflect a high turnover of manpower in quarrying industry. This may also be due to the fact that the predominant age group (18-29) years are highly mobile, moving from one location to another in search of greener pastures or due to hazards associated with quarry work, a worker does not work for long, however, this situation is not good for quarry industry because the longer the workers stay in the quarry industry, the better the awareness on occupational hazards, safety measures and use of safety equipments.

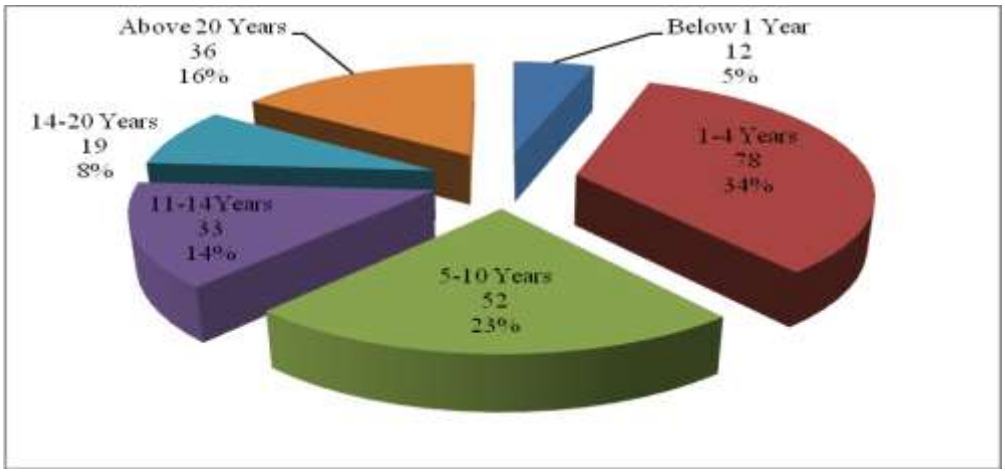

Figure 4.6: Number of years worked by respondents

4.3 Work characteristics

4.3.1 Respondents job designation

The study further sought to find out the sector of the quarry industry in which the respondents worked. From the findings shown in Figure 4.7, majority of the respondents were working in quarry pit (47.4%) followed by crushing unit (30.4%), machine operators at 6.1 %,drivers formed 8.3%, mechanics 4.8% while supervisors formed 3.0% **(Figure 4.7)**.

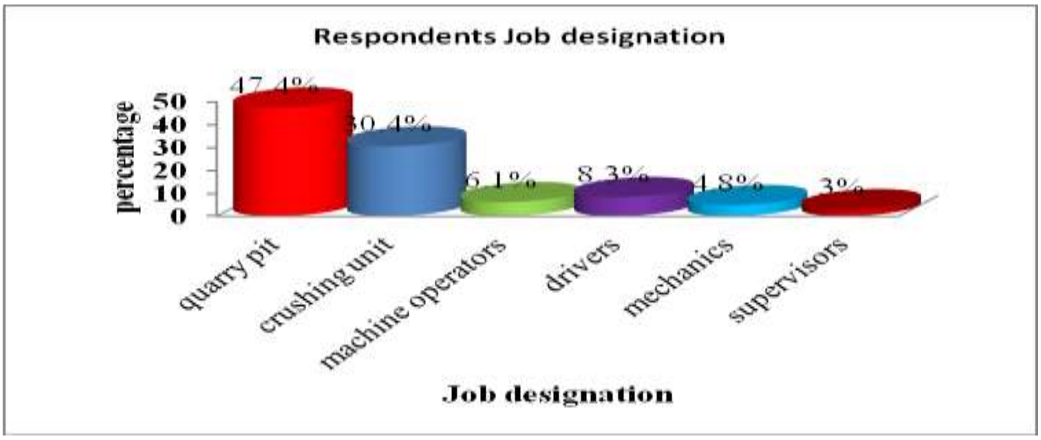

Figure 4.7: Job designation of the Respondents.

4.3.2 Terms of employment.

The finding of this study showed that the respondents were employed as casuals, temporary or permanent. In total 46(20%) participants were employed permanently in their respective sites, 18(8%) were working on contract basis while the remaining 166(72%) were working on casual basis **(Figure 4.8)**. Casual workers performed manual work such as scooping sand from pit, crushing plant, scooping murram from pit, cutting rock blocks into specific size and loading sand, murram and road blocks into Lorries while plant operators, mechanics, supervisors, were engaged permanently by quarry operators.

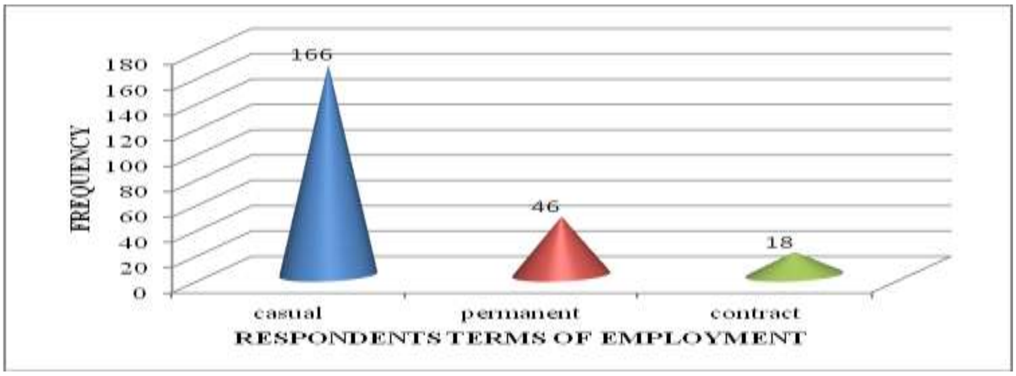

Figure 4.8: Terms of employment for respondents

4.3.3 Frequency of carrying out quarry activity and work schedule

The results revealed that 6(2.6 %,) of the respondents were working once a week, 38(16.5%) were working for 2-4 days, 176(76.5%) were working for 5-6 days while 10(4.3%) were working on daily basis **(Figure 4.9)**. The results revealed that 203(88.3 %,) of the respondents carried out quarry activities on a full day time schedule, 13(5.7%) on morning shift while 14(6.1%) on afternoon shift. Majority of respondents (76.5%) and (88.3%) were working for 5-6 days on a full day time schedule respectively. These activities are carried out in order to meet the high demand of raw materials by the building and construction industry. These findings concurs with a study done byWanjiku et al (2015),where results indicated the frequencies of carrying out the quarrying activities was (74.3%) between 5-6 days and (49.5%) of the respondents indicated they carried out the activities on a full day time schedule.

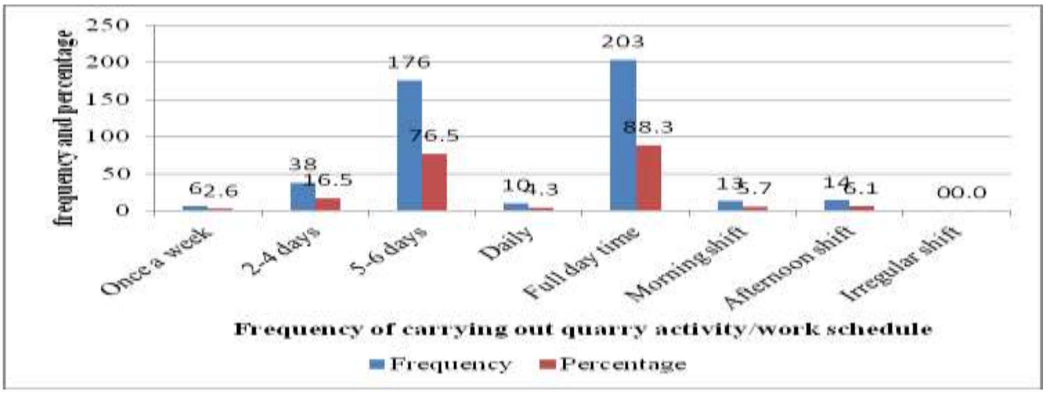

Figure 4.9: Frequency of carrying out quarry activity/Work schedule

4.3.4 Working hours per day

The results revealed that 43(18.7%,) of the respondents were working for 0-8 hours, 180(78.3%) were working for 9-12 hours, while 7(3%) were working for more than 12 hours **(Figure 4.10)**.This findings shows that a larger percentage of workers (78.3%) spent more than eight hours at work which is against the recommended average of eight hours of work per worker per day by International Labour Organization(ILO).This finding is consistent with that of Sifuyan et al(2012)who reported that (81%) of quarry workers in Kaduna state, North–Western Nigeria, were working for 5-12 hours a day . This large number of work hours may be related to the fact that much of the work in quarries is carried out by manual labour. It also means the long exposure time to occupational hazards at workplace and also workers may experience more fatigue at the end of the day, which can increase the risk of injury.

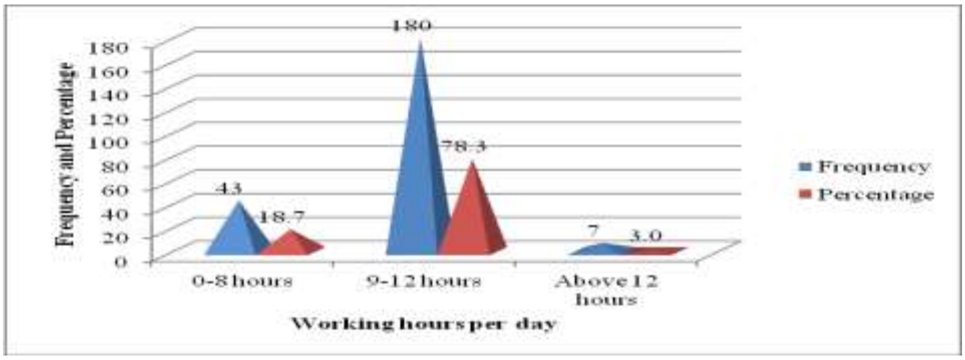

Figure 4.10: Working hours per day by respondents

4.3.5 Mode of learning quarry activity and site of work

The results revealed that 44(19.1 %,) of the respondents were trained in quarrying activities while 186(80.9%) reported to have no formal training in quarrying activities and advocated for observational/ on job training **(Figure 4.11)**. The results also revealed that 73(31.7 %,) of the respondents worked underground, 108(47%) worked above ground while 49(21.3%) worked both under and above ground.

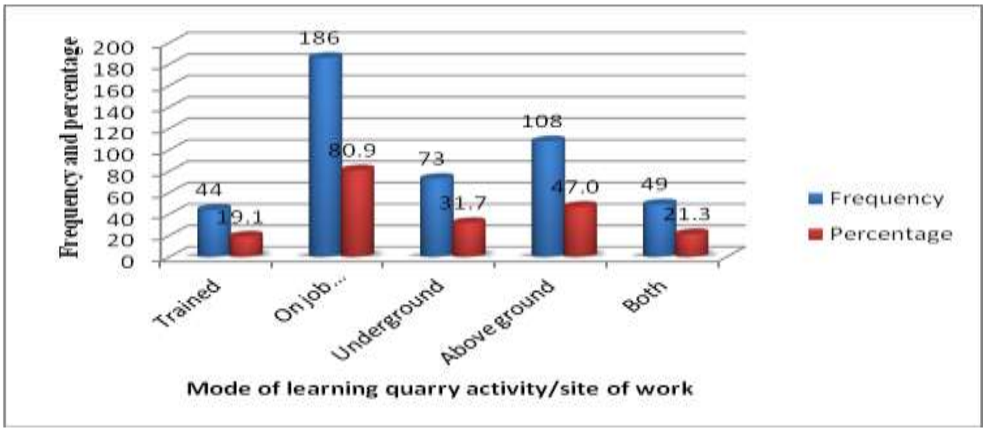

Figure 4.11: Respondents mode of learning quarry work and site of work

4.4 Awareness Of Occupational Hazards

4.4.1 Awareness of occupational hazards and source of information

The study results revealed that 188 (81.7%) of the respondents, were aware of hazards within their workstations **(Table 4.1)**. This could be explained to some degree by level of education and also the length of work experience observed in the majority of the respondents, where 218(94.7%) had been on work for at least one year and above. The longer the workers stay in the quarry industry, the better the awareness on occupational hazards, safety measures and use of safety equipments. Studies have demonstrated that the more a worker has experience, the more they are conscious in their work environment and less prone to accidents and injuries. The study findings corroborates that of Wanjiku et al (2015), among workers in Mutonga quarry in Kenya.

Table 4.1: Awareness of occupational hazards and sources of Information

Variable	Category	Frequency	Percentage
Aware about occupational hazards	Yes	188	81.7
	No	42	18.3
Sources of information	Newspapers/magazines/books	14	6.1
	Radio/Television	24	10.4
	School	12	5.2
	Health workers	56	24.4
	Colleques	104	45.2
	Family members	23	10.0
	Internet	18	7.8
	Employers	24	10.4
	Personal experience	75	32.6

The main sources of information of occupational hazards were mainly from colleagues' 104 (45.2%) and personal experience 75 (32.6%), **(Table 4.1).** This findings also concurs with that of Diwe et al (2016) where personal effort and on job training were attributed to as main sources of awareness of occupational safety and health.

4.4.2 Knowledge about Occupational hazards

The most known hazard by respondents was manual handling of loads 120(52.2%) followed by dust 118(51.3%) and falling rocks 92(40.0%),**(Table 4.3).**This is also similar to what was reported in a study in Kenya by Wanjiku et al (2015), where some of the hazards reported by the respondents were manual handling of heavy loads(42.4%), being hit by the tools(14.7%), exposure to dust (12.5%) and falling of rock block(6.6%). The findings also agree with those by Absar (2017), who reported 74.3% of sandstone mineworkers were able to cite the risk of injury from rock falls, accident from tools and equipments, fall from height and health related problems caused by exposure to dust (41%) while a few respondents cited musculoskeletal disorders caused by high loads and manual handling tasks (20.2%).

Table 4.2: Types of occupational hazards known by respondents

Variable	Category	Frequency	Percentage
Types of hazards	Falling from height	14	6.1
	Falling rocks/fly rocks	92	40.0
	Dust	118	51.3
	Extreme weather conditions	80	34.8
	Fire	9	3.9
	Vibration	44	9.1
	Noise	63	27.4
	Explosives	9	3.9
	Injuries from working tools	87	37.8
	Snake bites	14	6.1
	Manual handling of loads	120	52.2

4.4.3 Effects of occupational hazards

The effect of the hazards encountered by 138(60.0%) of the respondents while on duty was back/shoulder/waist/arm pain. This was attributed to a lot of manual works in quarries which includes scooping of sand from pit, loading of rock blocks, sand and murram into Lorries, cutting of rocks into specific sizes which requires a lot of bending and twisting of body while working in awkward positions. Also the use of hand tools which includes hammer, drill and wedge might have contributed to pain in arm .The study findings are consistent with those by Absar, (2017) where 13% of workers in the mining and quarrying sectors reported back problems, neck, shoulder, arm or hand problems.

Plate 4.1: Manual loading of Murram Plate 4.2: Manual loading of Sand

Respiratory complications was encountered by 126 (54.8%) of respondents could be attributed to the fact that air the workers inhale at work contains excessive amount of rock dust generated during drilling, blasting, crushing and screening of rocks **(Plate 4.3&4.4).** The study findings are consistent with those by Halwenge (2015) where most common ailments Exhibited by quarry workers was occasional dry and productive cough at 41% and 52%.

Plate 4.3: Dust generated during crushing

Plate 4.4: Dust generated during stockpiling

Stress/fatigue/exhaustion was experienced by 101(43.9%) of respondents. This was not surprising as majority of the respondents spent 5-6 days a week at work, working on full day shift and working for more than 8 hours a day. This could reduce productivity at work apart from tendency to increase likelihood of predisposing workers to occupational hazards.

Table 4.3: Effects of hazards known by respondents

Variable	Category	Frequency	Percentage
Effects of hazards	Eye irritation/itching	73	31.7
	Wounds/cuts/bruises	94	40.9
	Stress/fatigue/exhaustion	101	43.9
	Fractures	33	14.4
	Back/waist/shoulder/arm pain	138	60.0
	Respiratory complications	126	54.8
	Hearing problems	48	20.9
	Skin infections	32	13.9

4.5 Safety measures in quarries

4.5.1 Awareness of safety measures

The study sought to find out the safety measure put in place in quarries. According to the results in **Table 4.4**,64 (27.8%) were aware of these measures while 166(72.2%) were not aware of the safety measures .The respondents were also asked about who was responsible for workers safety at the work place,104(45%) fully agreed that both worker and employer were responsible for safety at work, 69(30%)said that it is the employers' duty to ensure safety and prevention of accidents at the workplace while 56(25%) indicated that everyone is responsible and the employer has more responsibility for safety at work place. The respondents were asked about the training in the quarry safety. In this regard, the study sought to find out on the level of training of the respondents on safety and technology in the quarry industry. From the findings, 206 (89.6%) of the quarry workers did not have any training on occupational safety and health at all. According to the ILO management guidelines of 2001 the employer being part of management is responsible for the safety and health of the workers.

Table 4.4: Awareness of Safety measures

Variable	Category	Frequency	Percent
Awareness of safety measures	Yes	64	27.8
	No	166	72.2
Training on quarry safety	Yes	24	10.4
	No	206	89.6
Responsibility of health and safety	Both Worker and employer	104	45.2
	Employer's duty	69	30
	Everyone and employer has more responsibility	56	24.3

4.5.2 Knowledge and use of PPEs among respondents

The study sought to find out the knowledge and use of PPEs among respondents. From the findings, 162(70.4%) indicated that they do not use personal protective equipment while at work while 68(29.6%) reported that they use, it was only 27(11.7%) who use them always. Nevertheless, the PPE mainly used were overalls (18.3%), hand gloves (5.7%), Helmets (3.9%) and old clothes (3.5%). The respondents indicated the reasons for not using protective clothing as not provided by the employer(70.4%).For those who were provided and not using indicated that they forget to use(12.2%) ,not comfortable(3.5%) and they can't afford/ too expensive to buy(2.6%).

The use of personal protective equipment as a way of preventing hazards and diseases in this study was poor as only 27(11.7%) of the workers used these equipments all the time. This finding was attributed to the fact that a higher proportion of workers 162(70.4%) were not provided with them while those who had 68(29.6%) had no training on the use and importance of this equipments. Another reason was as a result of the unskilled nature of the job and the operating system in the quarry which involves subcontracting of the quarries to operators whose major interest would be to maximize profit and so they would not bother to train or educate the workers of the dangers associated with working in the quarries.

Plate 4.5: Workers working without PPES   Plate 4.6: Workers provided with Overalls

The respondents' knowledge of the effect of the hazards encountered, appeared not to have positively influenced their opinion on the type of PPE they felt is the most important as the majority of the respondents felt that the overalls, hand gloves and helmets in that order, were the most important PPE; the face masks and the dust masks needed to protect against the commonly experienced respiratory symptoms by the respondents, were considered the least most important PPE.This findings agree with that of Wanjiku et al, (2015),where 74.8% of the respondents indicated that they did not use protective clothing while at work and those who used they only used gloves, overall and gumboots. The respondents indicated the reasons for not using protective clothing as being too expensive to buy and the protective clothing were not provided by the employer. This is the inverse of the finding by Sifuyan et al. (2012) which showed that (89.2%) of the respondents use safety protective devices. The safety protective devices most commonly used by these respondents were hand/finger gloves (83.3%) eye goggles (77.3%), and face masks (10.6%). None of them used overalls.

Table 4.5: Knowledge and use of PPEs among respondents

Variable	Category	Frequency	Percentage
Use of PPE	Yes	68	29.6
	No	162	70.4
Type of PPE known	Hand gloves	13	5.7
	Overalls	42	18.3
	Face/Dust masks	3	1.3
	Helmets	9	3.9
	Safety boots	7	3
	Gumboots	6	2.6
	Eye googles	2	0.9
	Earmuffs/plugs	1	0.4
	Reflective jackets	4	1.7
	Old/dirty cloth	8	3.5
	None	162	70.4
Source of PPE	Employer	47	20.5
	Bought myself	21	9.1
	No provider	162	70.4
Frequency for use	Always	27	11.7
	Rarely	162	70.4
	sometimes	41	17.8
Reasons for non use	Not provided	162	70.4
	Can't afford	6	2.6
	Forget to use	8	3.5
	Not comfortable	28	12.2

4.5.3 Availability periodical medical Checkup, firstiaid and emergency services

The study results revealed that 218(94.8%) of the respondents indicated that they were not provided with first aid services and they were no trained individuals to offer first aid in case of emergencies. Most of respondents 122(53.8%) agreed that there was availability of emergency services at the quarry, though the most appropriate way emergencies were handled was through taking the casualty to hospital.No periodic medical checkup is performed or scheduled for quarry employees.This was inverse to the results finding by Wanjiku et al, (2015),where majority (60.8%) of the respondents indicated that they were not trained on first aid methods and practices, though in the quarry there were trained individuals to offer first aid in case of emergencies.

Table 4.6: Availability of first aid and emergency services

Variable	Category	Frequency	Percentage
Availability of first aid services	Yes	12	5.2
	No	218	94.8
First aid providers in quarry	Trained individual	12	5.2
	No first aid providers	218	94.8
Availability of emergency services	Yes	122	53.8
	No	108	47.0
Ways emergencies are handled	Giving first aid to victim	12	5.2
	Taking victim to hospital	94	40.9
	Calling Bomet Red cross	16	7.0
	No emergency services provided	108	47.0
Periodic medical examination	Yes	0	0
	No	230	100

4.5.4 Technical safety measures

The study sought to find out the knowledge among respondents on Technical safety. This covers issues like the presence of fire safety measures, precautions during drilling, blasting and crushing, maintenance of machines and safe use and storage of explosives. From the findings in Table 4.9, 42(34.1%) of respondents indicated there are fire extinguishers in the quarry, 62(50.4%) of the respondents agreed that there is safe storage and usage of explosives including the use of explosive experts. On precautions done during drilling and blasting, 80(65%) of the respondents agreed that there is use of alarms, timing restrictions on operations, warning signs and restricted access by use of road blocks to drilling and blasting areas. The time restrictions imposed on the various activities is an appropriate measure in reducing the adverse effects (excess noise, vibration and dust) of the activity on workers and people residing in the catchment area. The time permitted for blasting ranges between 12.00 and 17.00 hrs, Monday to Saturday. Alarms, Warning Signals and restricted access by use road blocks was used by the companies to essentially create the awareness of workers and the residents in the catchment area on the time periods in which blasting and drilling usually take place. The interview scheduled with the personnel at the companies revealed that loud alarms are usually sounded prior to the initiation of any blasting activity. Also, warning signals are erected along roads, tracks and access routes to make residents privy to the various points where blasting are likely to take place. Lastly, vehicles plying along the quarry roads are all blocked when blasting activities are being carried out. This is essential to reduce or minimize the incidence of flying rocks causing damages to people and vehicles during the operations of the companies **(Plate 4.7).**

On precautions during crushing of rocks, 43(34.9%) agreed that there is safe location of workers during crushing. This indicates that not enough attention is paid to keep workers far away from such dangerous operations **(Plate 4.8)** because crushing of rocks involves the use of heavy equipment and may result in flying debris that may harm nearby workers.

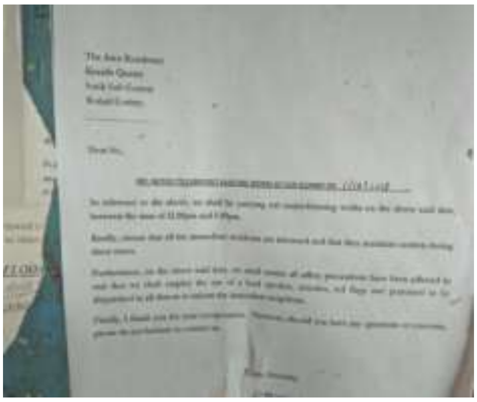

Plate 4.7: A notice to carry out blasting **Plate 4.8: Unsafe location of worker**

On equipment and machine safety, 50(40.6%) of the respondents agreed that safety features such brakes, lights, condition of tyres, proper maintenance, skilled machine operators and well guarded moving parts, warning signals, are always available .However, during the facility walk through, a major risk factor easily noticeable in most of the stone crushing quarries was the age factor of the machine and equipment in use. Most of the machines were obsolete with most of the safety guards removed or non-functional **(Plate 4.9).**

On maintenance of safe site,230(100%) of the respondents agreed that monitoring movement of dangerous machine was not done, there was no distinct routes for movement of workers away from machines and presence of fences around ditches. On site observation revealed that working in confine spaces was common in sand quarries without appropriate PPEs **(Plate 4.10)** while environmental sanitation was not taken seriously, as only one out of the twelve quarries had toilets and washing facility.

Plate 4.9: Unguarded machinery part   Plate 4.10: Working in confined space

On measures to suppress dust, all the respondents 230 (100%) agreed that dust generated at the processing points such as drilling, blasting, crushing and screening is sprayed with water and dusty haul roads is watered during dry and sunny days using water tanker. Other measures the company's must practice include sheeting of haul trucks to reduce fugitive dust, reduction of drop heights by attaching sleeves to conveyors , use of bag filters, cyclones and wet collectors (scrubbers) to remove fine and ultra- fine particles.

Table 4.7: Technical safety measures

Variable	Category	Frequency	Percentage
Presence of fire safety measures	Yes	42	34.1
(Fire extinguishers, hydrants, alarms, exits)	No	188	81.7
Safe storage and use of explosives	Yes	62	50.4
(Use of an explosive expert, MSDS, warnings signs where explosives are kept, ventillation)	No	61	49.6
Precautions during drilling and blasting	Yes	80	65.0
(restricted time warning signs, restiricted access, wet drill)	No	53	35.0
Precautions during crushing			
safe location of workers, measures taken to reduce noise, dust, vibration)	Yes	43	34.9
	No	80	65.1
Equipments and machine safety			
(brakes, lights, condition of tyres, proper maintanance, skilled machine operators,	Yes	50	40.6
guarding)	No	83	59.4
Maintaining safe site			
(monitoring movement of dangerous machine, distinct routes for movement of	Yes	0	0
workers away from machines, presence of fences around ditches)	No	230	100
Dust suppression measures	Yes	230	100
(Water spraying of rocks and haul roads	No	0	0

4.7 Ambient Air quality measurements

The study further assessed the occupational air quality measurements with respect to PM_{10}, $PM_{2.5}$, CO and CO_2 in all the quarries under study. The aim of the assessment was to establish exposure levels in the working environment due to various operations in the quarries and the results are as shown in **Table 4.8 and Table 4.9.**

PM_{10} and $PM_{2.5}$: The average concentrations were high above the recommended occupational exposure limit of 10mg/$m^3$and 5mg/m^3 as stipulated under Factories and other places of work (Hazardous substances) Rules of 2007. This was as a result of excavation, drilling, blasting and the crushing of rock products into their respective aggregate sizes. The PM_{10} levels were higher at drilling points than crushing and loading points in all quarries. A similar study by

Halwenge, (2015) showed similar results of higher concentrations of dust at drilling than at crushing,92.5mg/$m^3$and 75.0mg/m^3respectively.

Table 4.8: Air quality results for Stone crushing quarries

Quarry code	Location	Inhalable dust (PM_{10}) (mg/m^3)	Respirable dust ($PM_{2.5}$) (mg/m^3)	Carbon monoxide (CO) (ppm)	Carbon dioxide (CO_2) (ppm)
Q05	Drilling area	10.75±0.00	5.12±0.06	1.29±0.01	1368±0.82
	Crushing site	11.71±0.00	4.98±0.02	1.21±0.00	1222±1.25
	Loading area	12.68±0.00	6.02±0.14	1.98±0.00	991±0.80
Q06	Drilling area	13.47±0.21	8.29±0.00	0.44±0.00	1731±0.82
	Crushing site	12.40±0.13	7.7±1.02	0.15±0.02	1510±0.47
	Loading area	13.21±0.02	5.880.10	0.22±0.00	802±0.00
Q07	Drilling area	20.10±0.01	12.34±0.05	0.35±0.00	2060±1.25
	Crushing site	17.80±0.06	11.82±0.10	0.45±0.00	1710±0.47
	Loading area	12.98±0.01	13.50±0.14	0.27±0.01	791±0.81
Q08	Drilling area	12.60±0.00	7.40±0.01	1.40±0.00	1538±0.94
	Crushing site	9.71±0.00	5.27±0.34	0.78±0.01	1338±0.80
	Loading area	13.81±0.03	8.78±0.02	0.41±0.00	668±1.27
Q09	Drilling area	15.17±0.01	10.45±0.04	1.8±0.01	855±1.30
	Crushing site	11.16±0.01	14.14±0.07	0.78±0.00	796±1.70
	Loading area	11.82±0.00	12.16±0.45	2.29±0.00	802±0.84
	OEL	**10**	**5**	**50**	**5000**

CO and **CO_2:** The average concentrations were within the recommended occupational exposure limit of 50ppm and 5000ppm as stipulated under Factories and other places of work (Hazardous substances) Rules of 2007.The low concentrations of CO are due to the fact that CO is naturally oxidized by Oxygen in the atmosphere to CO2.This was attributed to the use of old diesel powered trucks and use of explosives containing organic carbon, mainly ammonium nitrate and fuel oil for blasting in stone crushing quarries. A similar study on suspended particulate matter at Stone crushing quarry in Rajastan showed similar results of lower concentrations (Kumar, Ranga & Shika, 2018).

From the above results, the dust particle in effect does not only affect the quality of local air, but results in serious respiratory disorders like lung cancer, tuberculosis and silicosis. In terms of dust emissions, the workers at the stone quarrying sites were the most vulnerable since there were high concentrations of dust in the air and they had no protective clothing like nose mask to reduce the inhalation of these dust particles.

Table 4.9: Air quality results for Construction blocks, murram and sand quarries

Quarry code	Location	Inhalable dust (PM_{10}) (mg/m^3)	Respirable dust ($PM_{2.5}$) (mg/m^3)	Carbon monoxide (CO) (ppm)	Carbon dioxide (CO_2) (ppm)
Q01	Quarry pit	6.52±0.25	2.68±0.09	Not Detected	485±4.00
Q02	Quarry pit	9.38±0.15	3.21±0.22	Not Detected	463±1.00
Q03	Quarry pit	7.31±0.03	2.98±0.27	Not Detected	228±3.27
Q04	Quarry pit	9.68±0.00	3.81±0.18	Not Detected	585±0.82
Q10	Quarry pit	4.17±0.05	1.88±0.02	Not Detected	337±1.63
Q11	Quarry pit	3.12±0.07	1.95±0.02	Not Detected	209±1.60
Q12	Quarry pit	2.64±0.03	1.18±0.03	Not Detected	198±1.41
OEL		**10**	**5**	**50**	**5000**

From the findings, PM_{10}, $PM_{2.5}$ and CO was detected at all the measured locations, whereas carbon monoxide was dot detected. However, the obtained results shows that the level of pollutants measured were within the recommended exposure limits stipulated under factories and other places of work (Hazardous substances),Rules of 2007.

4.8 Factors affecting implementation of OSH measures in quarries

The research sought to establish the factors that affect implementation of health and safety measures in quarries in Bomet County. In this area the researcher paid much attention on management commitment, training of employees on health and safety, employee participation and the absence of government support. Respondents agreed that all the factors listed were important in influencing the implementation of the OSH measures as the average index ranged between 4.0 to 5.0.as summarized in table 4.10 below.

Table 4.10: Factors affecting implementation of OSH measures in quarries

	Frequency of analysis/No. of Respondents						
Variable	**1**	**2**	**3**	**4**	**5**	**Mean index**	**Percentage**
Lack of management commitment	0	5	1	8	216	4.89	97
Lack of employee training	0	7	4	34	185	4.73	95
Lack of Government support	1	1	5	120	103	4.40	97
Lack of employee participation	0	30	6	50	143	4.32	84

4.8.1 Lack of management commitment

The study aimed at finding out whether lack of management commitment affects the implementation of health and safety measures in quarries**.** 97%, (mean index 4.89) of the respondents strongly agreed that lack of management commitment affects the implementation of health and safety measures. This may be as a result of the perception that safety is only cost related. This was noted during site visits where it was found that none of the quarry companies had any safety policies and materials, there were no warning signs and some workers seemed unaware of the risks they face as they worked and accident investigations and documentation were essentially non-existent as evident by the non-availability of accident/injury records in all the sites visited.This clearly indicates that the level of management commitment towards health and safety was low. This is inverse of a study done by Ndegwa (2015) on the influence on management support in the implementation of OSH programmes in manufacturing sector in Kenya where 79.3% of the respondents agreed that management was totally commitment to health and safety programmes implementation.

4.8.2 Lack of employees' training

Training influence the implementation of health and safety measures in the following ways: reducing unsafe acts especially for new employees, enhancing awareness by staff creates confidence in handling and preventing accidents. This study revealed that 95% (mean index 4.73) of the respondents agreed that lack of employees' training affects the implementation of the OSH measures. This concurs with the results obtained under the second objective of this study that was seeking to establish the essential safety measures in place within quarries. 89.6% of the quarry workers did not have any professional education or occupational safety and health training at all. This concurs with the results of Gaceri (2015) on factors affecting implementation of health and safety measures in supermarkets in Kenya where all the respondents stated that lack of training affects to a large extend the implementation of health and safety measures.

4.8.3 Lack of Government support

Government laws and regulations have a strong influence on the extent to which organizations implement OSH measures.97% (mean index 4.40) of the respondents felt that the government was not doing enough on enforcement of available OSH laws and regulations and thus the reason for laxity in the Implementation of OSH measures. Kenya as a nation has some good policies, but lack adequate implementation plans which are a major setback to the enforcement of such plans and subsequent compliance with such regulations. This was noted during interviews where most of the quarry supervisors and workers did not know the enforcer of OSH laws in Kenya. They were not aware of the laws because there are no forums for OSH law education that could help the employees to know at least their basic rights. This shows that there have been no other programs by the Government to further increase awareness of the OSH laws. This is also similar to what was reported by Ndegwa (2015), where 59.1% of the respondents indicated that government support affect implementation of OSH programmes to large extend.

4.8.4 Lack of employee participation

The study aimed at finding out whether lack of employee participation affects the implementation of health and safety measures in quarries. 84%(mean index 4.73) of the respondents felt that lack of employees' participation affects the implementation of the OSH measures. This was noted during the site visits where there were no health and safety representatives in all quarries visited. This concurs with the results of Senso (2017), where 82.7% of the respondents stated that lack of employee participation affects to a large extend the implementation of health and safety practices.

4.9 Inferential Statistics

Under inferential statistics, correlation and regression analysis were conducted. The aim of the correlation analysis was to determine the nature of the relationship between independent variables (occupational hazards awareness, safety measures, and implementation of OSH measures) and the dependent variable (safe work environment). On the other hand, the objective of conducting the regression analysis was to assess the extent of the effect of the aforesaid independent variables on safe work environment.

4.9.1 Correlation Analysis

In determining the relationship between each of the independent variables (occupational hazards awareness, safety measures, and implementation of OSH measures) and the dependent variable (safe work environment), Pearson's Product Moment Correlation Coefficient (PPMCC) was employed. The results of the aforesaid correlation analysis are presented in Table 4.11.

Table 4.11: Results of PPMCC

		Safe Work Environment
Occupational Hazards Awareness	Pearson Correlation	.212**
	Sig. (2-tailed)	.001
	n	230
Safety Measures	Pearson Correlation	.937**
	Sig. (2-tailed)	.000
	n	230
Implementation of OSH Measures	Pearson Correlation	.819**
	Sig. (2-tailed)	.000
	n	230

**. Correlation is significant at the 0.01 level (2-tailed).

According to the results of correlation analysis shown in Table 4.11, it is apparent that the existed a positive, weak but statistically significant relationship between awareness of occupational hazards and safe work environment ($r = 0.212$; $p = 0.001$). The results mean that as the quarry workers became more aware of hazards associated with their occupation, the more likely that their work environment was to be safe, though minimally. The results underlined the importance of enlightening the quarry workers on occupational hazards with the objective of enhancing the safety of their workplace.

The correlation results also indicated that the relationship between safety measures and safe work environment was positive, strong, and statistically significant (r – 0.937; p = 0.000) at p-value = 0.05.The findings were interpreted to mean that the extent of embracing safety measures was likely to result in similar increase in safety of the work environment. This could have been most probably due to the closeness of safety measures and safe work environment granted that it is almost apparent that when the safety measures are changed, the safety of the working environment is bound to change in a similar manner and degree.

The relationship between implementation of OSH measures and safe work environment was found to be positive, strong, and statistically significant (r = -0.819 p = 0.000) at p-value = 0.05. The results meant that, by enhancing the implementation of the aforesaid measures the more likely the work environment was to be safe, and the reverse was equally true. In other words, in order to ensure that the quarries are safe for workers and other people who visit the sites, it is very necessary to implement the laid down measures on occupational safety and health. Therefore, not only is having safety measures important but the implementation of the same is of equal if not greater essence to quarry workers and other relevant persons at the site.

4.9.2 Simple Linear Regression Analysis

The study further sought to establish the effected of the aforementioned independent variables on safe work environment. To this effect, simple linear regression analysis was carried out. The results to this effect are presented in Tables 4.12 to 4.20.

Table 4.12: Model Summary for Occupational Hazards Awareness against Safe Work Environment

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.212[a]	.045	.041	.23077

a. Predictors: (Constant), Occupational Hazards Awareness

According to the results shown of coefficient of determination shown in Table 4.12 (r^2 = 0.045), only 4.5% of variation in safe work environment could be explained by occupational hazards awareness. This meant being aware of the aforesaid hazards influenced very minimal changes in the extent of safety of quarry workers.

Table 4.13: ANOVA for Occupational Hazards Awareness against Safe Work Environment

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.573	1	.573	10.761	.001[a]
	Residual	12.143	228	.053		
	Total	**12.716**	**229**			

a. Predictors: (Constant), Occupational Hazards Awareness

b. Dependent Variable: Safe Work Environment

The results of F-statistics shown in Table 4.13 ($F_{1, 228} = 10.761$; p = 0.001) indicated that there existed a linear relationship between occupational hazards awareness and safe work environment. Therefore, it was viable to examine the effect of the stated awareness on safe work environment as shown in Table 4.14.

Table 4.14: Regression Coefficients for Occupational Hazards Awareness against Safe Work Environment

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
1 (Constant)	.870	.074		11.749	.000
Occupational Hazards Awareness	.130	.040	.212	3.280	.001

a. Dependent Variable: Safe Work Environment

According to the results of linear regression analysis shown in Table 4.14, it is apparent that the effect of occupational hazards awareness on safe work environment was found to be statistically significant (t = 3.280; p = 0.001) at p-value = 0.05. For a unit change in safe work environment to be realized, it was required that the aforementioned awareness to be changed by 0.130 unit while holding other factors constant (β_0 = 0.870).

Table 4.15: Model Summary for Safety Measures against Safe Work Environment

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.937[a]	.878	.878	.08236

a. Predictors: (Constant), Safety Measures

The results shown in Table 4.15 (r^2 = 0.878), depict that safety measures put in place in quarries found at Bomet County could explain 87.8% variability in safe work environment. These findings underline the important role played by safety measures at ensuring that quarry workers carry out their tasks in safe environment.

Table 4.16: ANOVA for Safety Measures against Safe Work Environment

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11.169	1	11.169	1646.575	.000[a]
	Residual	1.547	228	.007		
	Total	**12.716**	**229**			

a. Predictors: (Constant), Safety Measures

b. Dependent Variable: Safe Work Environment

The results of F-statistics shown in Table 4.16 ($F_{1, 228}$ = 11.169; p = 0.000) revealed that the relationship between safety measures and safe work environment was linear. Therefore, the two study constructs could be linked and explained using a simple linear regression model taking the form $Y= \beta_0+ \beta_1X_1 + \varepsilon$ where Y, β_0, β_1, X_1, and ε represent independent variable (safe work environment), constant (y-intercept), regression coefficient (gradient), dependent variable (safety measures), and error term respectively.

Table 4.17: Regression Coefficients for Safety Measures against Safe Work Environment

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
1 (Constant)	.187	.023		8.026	.000
Safety Measures	.786	.019	.937	40.578	.000

a. Dependent Variable: Safe Work Environment

The results shown in Table 4.17 indicated that, for every unit increase in safe work environment (or safety of the workplace), there had to be 0.786 unit increase in safety measures when other factors were held constant. It is evident from the t-statistics (t = 40.578; p = 0.000) that the effect of safety measures on safe work environment was statistically significant at p-value = 0.05. These results emphasize the importance of having safety measures in place if at all the quarries can be considered safe for workers and other people who may be visiting the sites.

Table 4.18: Model Summary for Implementation of OSH Measures against Safe Work Environment

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.819[a]	.671	.670	.13546

a. Predictors: (Constant), Implementation of OSH Measures

The results shown in Table 4.18 (r^2 = 0.671) indicated that implementation of OSH measures could explain 67.1% of variation in safe work environment. Therefore, any improvement or decline in the safety of quarries in Bomet Counties could be attributed to the extent to which the occupational safety and health measures were implemented.

Table 4.19: ANOVA for Implementation of OSH Measures against Safe Work Environment

Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	8.532	1	8.532	464.959	.000[a]
Residual	4.184	228	.018		
Total	**12.716**	**229**			

a. Predictors: (Constant), Implementation of OSH Measures

b. Dependent Variable: Safe Work Environment

The F-value ($F_{1,\ 228}$ = 8.532; p = 0.000) shown in Table 4.19, indicated that the relationship linking implementation of OSH measures to safe work environment was linear when examined at p-value = 0.05. Therefore, it was feasible to employ simple linear regression model ($Y= \beta_0+ \beta_3X_3 + \varepsilon$) to examine the effect of the said implementation on safety of quarries. The pertinent results are as shown in Table 4.20.

Table 4.20: Regression Coefficients for Implementation of OSH against Safe Work Environment

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	2.247	.054		41.906	.000
Implementation of OSH Measures	-.263	.012	-.819	-21.563	.000

a. Dependent Variable: Safe Work Environment

In accordance with the results shown in Table 4.20, a unit change in safe work environment was subject to -0.263-unit change in implementation of OSH measures in quarries when other factors were held constant. The results of t-statistics (t = -21.563; p = 0.000) depicted that the effect of the aforesaid implementation on safe work environment was statistically significant at –value = 0.05. This implied that implementation of OSH measures played a substantial role at influencing the safety of quarries and quarry workers in Bomet County.

4.9.3 Multiple Regression Analysis

Multiple regression analysis was conducted to examine the combined effect of occupational hazards awareness, safety measures, and implementation of OSH measures on safe work environment. The pertinent results are illustrated in Table 4.21, Table 4.22, and Table 4.23 respectively.

Table 4.21: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.939[a]	.882	.880	.08164

a. Predictors: (Constant), Occupational Hazards Awareness, Safety Measures, Implementation of OSH Measures

The general relationship between occupational hazards awareness, safety measures, and implementation of OSH measures, on one hand, and safe work environment, on the other, was positive and strong (R = 0.939). As shown in Table 4.21, the aforesaid relationship was established to be statistically significant ($p = 0.000$) at p-value = 0.05. This meant that, by enhancing the foregoing aspects represented by the three study constructs, there was a high likelihood that the safety of the quarries could be improved substantially. It was thus recommended that the management of quarries should enlighten particularly workers on various issues regarding occupational health and safety while at the workplace. Appropriate safety measures should not only be put in place; rather, they should be fully implemented in order to ensure safe working environment. The results of coefficient of determination ($R^2 = 0.882$) indicated that occupational hazards awareness, safety measures, and implementation of OSH measures could explain 88.2% variability in safe work environment. Essentially, therefore, the aforesaid issues were inferred to be paramount in influencing changes in the work (quarry) environment from safety perspective.

Table 4.22: ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11.209	3	3.736	560.643	.000[a]
	Residual	1.506	226	.007		
	Total	**12.716**	**229**			

a. Predictors: (Constant), Occupational Hazards Awareness, Safety Measures, Implementation of OSH Measures

b. Dependent Variable: Safe Work Environment

According to the results shown in Table 4.22, the F-value depicted by F (3.736) = 560.643; p = 0.000 indicated that, at p-value = 0.05, there existed a linear relationship between occupational hazards awareness, safety measures and implementation of OSH measures, and safe work environment. As such, it was feasible to determine the influence of occupational hazards awareness, safety measures, and implementation of OSH measures on safe work environment in quarries found in Bomet County using the adopted multiple regression model ($Y= \beta_0+ \beta_1X_1+ \beta_2X_2+ \beta_3X_3 + \varepsilon$). The results of the aforementioned influence are captured in the regression coefficients presented in Table 4.23.

Table 4.23: Regression Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
1 (Constant)	.193	.135		1.424	.156		
Occupational Hazards Awareness	-.034	.016	-.055	-2.106	.036	.774	1.292
Safety Measures	.812	.043	.969	18.909	.000	.200	5.007
Implementation of OSH Measures	.006	.017	.018	.330	.741	.178	5.632

a. Dependent Variable: Safe Work Environment

Diagnostic test to assess the extent of multicollinearity between independent variables (occupational hazards, safety measures, and implementation of OSH measures) was conducted. Multicollinearity refers to a situation where more than one predictor (independent) variables in a statistically model are linearly related (Alin, 2010). In multiple regression, predictor constructs which are highly correlated provide minimal independent explanatory ability of the model. According to the results depicted by the Variance Inflated Factor (VIF), all the predictor variables returned VIF < 10. According to reliable sources, A VIF ≥ 10 illustrates a potentially harmful Collinearity (Franke, 2010). Therefore, it was concluded that the multicollinearity between the aforesaid variables was within acceptable threshold which is VIF = 10. It is apparent from the results shown in Table 4.23 that $Y= 0.193 - 0.034X_1+ 0.812X_2+ 0.006X_3$. This implies that for a unit change in safe work environment, there had to be -0.034 unit change, 0.812 unit change, and 0.006 unit change in occupational hazards awareness, safety measures and implementation of OSH measures respectively while holding other factors constant ($\beta_0 = 0.193$). It is evident from the foregoing results that, safety measures ($\beta_2 = 0.812$) were the most crucial factors which impacted on the safety of work environment or quarries in Bomet County. According to the results of t-statistics, the effect of occupational hazards ($t = -2.106$; $p = 0.036$) and safety measures ($t = 18.909$; $p = 0.000$) on safe work environment was found to be statistically significant at p-value = 0.05.

CHAPTER FIVE

CONCLUSION AND RECCOMENDATIONS

5.1 Conclusion

From the study, it can be concluded that

I. The level of awareness of occupational hazards was high among the respondents and the source of awareness was colleques.
II. The respondents were insufficiently equipped with knowledge on safety measures to comprehensively mitigate occupational hazards.
III. Lack of management commitment, lack of employee training, lack of employee involvement and lack of government support are the top contributing factors affecting implementation of OSH measures in quarries
IV. The dust concentrations failed to meet the recommended occupational exposure limit of 10mg/m^{3}and 5mg/m^{3}respectively as stipulated under Factories and other places of work (Hazardous substances) Rules of 2007 standards and therefore exposed the workers to the risk of health problems.

5.2 Recommendations

Based on the findings of the study, the following recommendations are made with the hope that if implemented there will be improvement in the health of quarry workers in Bomet County and the Country at large.

I. The quarry management should carry out safety inductions to all workers before they commence their contracts so as to promote safety culture, develop OSH programmes to guide employees to work safely , provide the necessary PPEs (helmet, dust masks and safety boots) for workers and adopt other methods of dust suppression e.g use of bag filters and scrubbers.
II. The enforcement bodies (NEMA and DOSHS) should impose higher restrictions and enforcement guidelines for establishing quarries with

proper provision for OSH services before granting licenses to quarry operators/owners.

5.3 Area of further study

I. Ergonomic risk factors and health effects on workers since the study found that the workers exhibited back/waist/shoulder pains.

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APPENDICES

Appendix I: Quarry workers Questionnaire

Survey ID number: ……………………………..

Date of interview: ………………… Time started: ……………. Time finished: …………

Please mark only the box you feel best fits the statements below. There are no wrong answers

Section A: Socio demographic characteristics of respondents

1. Gender: Male [ ] Female [ ]

2. Age: Below 18 [ ] 18-29 [ ] 30- 39 [ ] 40-49 [ ] 50-59 [ ] 60 and above [ ]

3. Marital status: Single [ ] Married [ ] Divorced [ ] separated [ ] Widow [ ]

4. Highest level of Education: No formal Education [ ] Primary [ ] Secondary [ ]

Tertiary [ ] Adult Literacy [ ] others [ ]

5. Years spent in quarry: Below 1 Year [ ] 1-5 Years [ ] 5-10 Years [ ] 10-15 Years [ ]

15- 20 Years [ ] Above 20 Years [ ]

Section B: Quarrying Activities

6. What is the type of work that you do in the quarry?

a) Maintenance work [ ] b) Cutting rock block into specific size [ ]

c) Plant operator [ ] d) Lifting cut rocks from quarry pit [ ]

e) Driller [ ] f) Loading sand to lorry [ ]

g) Driver [ ] h) Crusher operator [ ]

i) Others (specify)…………………………………………………………

7. Which of the following best describes your work terms in the quarry?

Casual [ ] Permanent [ ] Contract [ ]

8. How often do you work in the quarry?

Once a week [ ] 2-4 days [ ] 5-6 days [ ] Daily [ ]

9. Which of the following best describes your usual work schedule in the quarry?

Full-day-time [ ] Morning shift [ ] Afternoon shift [ ] Night shift [ ] Irregular shift [ ]

10. How many hours do you work in a day: 0-8hours [ ] 9-12hours [ ] above 12 hours [ ]

11. How did you learn how to do this activity? Trained [ ] Observation [ ]

12. Where do you work? Underground [ ] above ground [ ] both [ ]

Section C: Awareness of occupational hazards

13. Are you aware of any activities in your daily work that pose a risk of danger or harm to your health? Yes [ ] No [ ]

14. If the answer to question no.15 above is YES, Where did you first learn about it?

a) Newspapers/magazines [ ] b) Radio [ ]
c) Television [ ] d) School [ ]
e) Training on safety at work [ ] f) Health workers [ ]
g) Colleagues [ ] h) Family members [ ]
i) Internet [ ] j) Books [ ]
k) Employer [ ] l) others (specify …………………

15. If the answer to question no.15 above is YES, which ones do you know of

a) Falling from height [ ] b) Dust [ ]
c) Falling objects [ ] d) Heat [ ]

e) Fire [ ]
f) Vibration [ ]
g) Noise [ ]
h) Transport (Hit by vehicle) [ ]
i) Explosives [ ]
j) Injuries from machine [ ]
k) Snake bites [ ]
l) Slip and trips
m) Manual handling of heavy loads [ ]

18. Are you aware of effects of the occupational hazards mentioned above? Yes [ ] No [ ] 19. If the answer to question no.18 above is YES, which ones do you know of

a) Amputation [ ]
b) Eye itching/irritation [ ]
c) Wounds/cuts/bruises [ ]
d) Stress/Fatigue/Exhaustion [ ]
e) Fractures [ ]
f) Back/waist pain [ ]
g) Burns [ ]
h) Difficulty in breathing [ ]
i) Chest pain [ ]
j) Difficulty in hearing [ ]
k) Skin infection [ ]
l) Electrocution [ ]
m) Others (specify)

……………………………………………………………………….

Section D: Safety measures in quarries

20. Are you aware of any safety measures in your work area? Yes [ ] No [ ]

21. Have you ever undertaken any safety training on a quarry site? Yes [ ] No [ ]

22. Who is responsible for health and safety in the quarry?

Both worker and employer [ ] Employers duty [ ] everyone but employer has more responsibility [ ]

23. Do you know of any Personal Protective Equipment? Yes [ ] No [ ]

24. If the answer to question no.23 above is YES, which ones do you know of

a) Helmets [ ]
b) Face masks [ ]
c) Hand gloves [ ]
d) Eye goggles [ ]
e) Coats/overalls [ ]
f) Earplugs/muffs [ ]
g) Dust masks [ ]
h) Reflective jackets [ ]
i) Boots [ ]
j) Safety harness/ belts [ ]

k) Others (specify)……………………………………………………………………

25. Do you have any Personal Protective Equipment? Yes [ ] No [ ]

If the answer to question no.25 above is YES, How did you get them?

Bought myself [ ] borrowed from a friend [ ] provided by employer [ ]

26. How often do you the PPEs? Always [ ] Rarely [ ] Sometimes [ ]

If the answer to question no.25 above is No, Why don't you use them?

Forgot to use [ ] Not a necessity [ ] Not comfortable [ ]

27. In case of an accident/injury, are you given any first aid? Yes [ ] No [ ]

If yes, who provide the first aid? The management [ ] Trained individuals (quarry workers)

29. Are emergency services available in the quarry? Yes [ ] No [ ]

If yes, how are they handled? Giving first aid to victim [ ] Tacking victim to hospital [ ] Calling Bomet Red Cross services [ ]

30. Have you undergone any medical checkup during the course of your employment Yes [ ] No [ ]

Respond to the following statements about the technical safety measures that are available in your workplace and your awareness by ticking where appropriate.

No.	Statement	Yes	No
1.	There are essential fire safety measures in place (fire extinguishers, fire hydrants, alarms and exit signs and doors)		

2.	There is an explosive expert on site		
3.	Explosive stores are well ventilated		
4.	There are proper warning signs where explosives are stored		
5.	There is restricted access to drilling and blasting areas		
6.	There is restricted time during blasting		
7.	There is use of warning signs and alarms before blasting		
8.	There is safe location of workers during crushing of rocks		
9.	There are measures to control dust emission during crushing		
10.	Machines and equipment are operated by competent operators		
11.	All moveable parts are well guarded		
12.	There is proper maintance of machines(replace old tyres, brakes)		
13.	There is monitoring of movement of equipments		
14.	There is distinct routes for movement of machines away from workers		
15.	There is presence of fences around ditches and dangerous sites		
16.	There are procedures in place for emergency evacuation		
17.	There are leaflets/posters about safety in quarries		
18.	There is water spraying of rocks before drilling and crushing		

Section E: Factors affecting implementation of OSH measures in quarries

The following items describe the factors which affect the implementation of health and safety measures in quarries. Please tick (√) the answer that most reflects your opinion to indicate the extent to which each factor can affect the implementation of health and safety measures.

Key

1= Strongly disagree 2= Disagree 3= Not sure 4= Agree 5= strongly agree

No	Factors	1	2	3	4	5
1.	Lack of management commitment/support					
2.	Lack of employee training					
3.	Lack of employee participation					
4.	Lack of Government support					

Thank you for your response

Appendix II: Observational checklist

Occupational hazards	Yes	No	Additional comments
Falling from height			
Fumes			
Dust			
Excessive noise			
Falling objects			
Vibration			
Radiations			
Heat			
Manual handling of loads			
Safety measures			
PPE present			
PPE in use			
Posting of warning signs on dangerous places			
Availability of First Aid Kits			
Machinery guarding			
Use of safety harness			
Presence of guard rails			

Appendix III: Interview guide

a) Quarry owners/operators/management

1. What was the land used before quarrying?

2. What do you use for blasting?

3. What are some of the effects of quarrying on workers?

4. What are some of the health and safety measures you have put in place to minimize the effects of quarrying activities?

5. Are you aware of any laws and regulation governing quarrying activities? If Yes,

6. Who are the enforcers of these laws?

7. What plans do you have after the completion of the quarrying activities in the area?

8. What are some of the challenges do you experience in your quarry.

9. What is the way forward in maintaining health and safety in the quarry industry?

b) Law enforcement officers

1. What is role of your department/institution with respect to quarrying operations?

2. Are you aware of the existence of quarrying companies in the County?

3. What are the main quarrying companies operating in the County?

4. Have these quarrying companies registered with your department?

5. If no, why? What are you doing about it?

6. What measures are being put in place by your department to mitigate the negative effects of quarrying in the County?

7. Do you collaborate with the other enforcement bodies in any way in taking decisions on the quarrying activities? If yes, how do you collaborate with them?

9. What are the factors affecting implementation of health and safety measures in quarries?

Appendix IV: List of quarries in Bomet County

Quarry Site		Material quarried	Size (acres)	License/not licensed (EIA)
1.	Kyogong (2 sites)	Sand	200	Licensed
2.	Bomet Township	Construction blocks	2	Licensed
3.	Motigo	Sand	1	Not licensed
4.	Kapngetuny	Sand	0.5	Not licensed
5	Kaparuso	Sand	1	Not licensed
6	Chemengwa	Sand	0.5	Not licensed
7	Kembu	Sand	2.5	Not licensed
8	Kapkimolwo	Stones	15	Licensed
9	Kipisorwet	Sand	2	Not licensed
10	Longisa	Stones	1.5	Licensed
11	Masare	Stones	20	Not licensed
12	Olbutyo	Stones	5	Not licensed
13	Sigor 1	Murram	3	Not licensed
14	Ndanai	Murram	1.5	Licensed
15	Kipsonoi(Shengli)	Murram	0.5	Licensed
16	Maranketi in Sigor	Stones	1	Not licensed
17	Sigor 2	Stones	0.5	Not licensed
18	Rotik- Ndanai	Murram	3	Licensed
19	Tabarit- Gelegele	Murram	2	Not licensed
20	Ngariet	Murram	2.5	Not licensed
21	Kipngosos	Murram	1	Not licensed
22	Arong	Murram	3	Not licensed
23	Seanin(3 sites)	Murram	15	Not Licensed
24	Kapkwen	Construction blocks	2	Not licensed
25	Terek	Murram	1.5	Not licensed
26	Kambit	Murram	0.5	Not licensed
27	Chepkonga 1	Stones	1	Licensed
28	Chepkonga 2	Stones	1	Licensed
29	Kapsimotwa	Construction blocks	5	Licensed
30	Josmeno supplies	Murram	2	Not licensed
31	Kapletundo	Sand	3	Licensed
32	Kaplong- Ajiwa Shamji	Ballast/Stones	300	Licensed

Appendix V: Callibration Certificate for Air quality Monitor

3M Personal Safety Division

3M Oconomowoc
1060 Corporate Center Drive
Oconomowoc, WI 53066-4828
www.3M.com/detection
800 245 0779

Page 1 of 1

3M

Certificate of Calibration

Certificate No: [illegible]BMQ160015

Submitted By: SGS KENYA LTD VICTORIA TOWERS, 3RD FLOOR, UPPER HILL, KILIMANJARO AVE P.O. BOX 72118, 00200 - NAIROBI.

Serial Number:	BMQ160015	Date Received:	7/13/2017
Customer ID:		Date Issued:	7/20/2017
Model:	EVM-7 ENVIRONMENTAL MONITOR	Valid Until:	7/20/2018
Test Conditions:		**Model Conditions:**	
Temperature:	18 °C to 28 °C	As Found:	DAMAGED
Humidity:	20% to 80%	As Left:	IN TOLERANCE
Barometric Pressure:	890 mbar to 1090 mbar		

Subassemblies:

Description/Measurement Uncertainty:	Serial Number:
SENSOR CO2/±29%	3018579319
SENSOR PID/±6%	260160008

Estimated at 95% Confidence Level (k=2)

Calibrated per Procedure: 074V708

Reference Standard(s)

I.D. Number	Device	Last Calibration Date	Calibration Due
712430	CARB CALIBRATION GAS	4/6/2017	4/6/2020
796009	CO2 CALIBRATION GAS	3/15/2017	3/15/2020
MPD00248	DUST ISO 12103-1 A2 FINE		

Calibrated By: BRYAN [illegible] Service Technician 7/20/2017

This report certifies that all calibration equipment used in the test is traceable to NIST, and applies only to the unit identified under equipment above. This report must not be reproduced except in its entirety without the written approval of 3M Detection Solutions.

038-331 Rev. B

Appendix VI:Publication

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ASSESSMENT OF OCCUPATIONAL HAZARDS AWARENESS AND SAFETY MEASURES AMONG QUARRY WORKERS IN BOMET COUNTY, KENYA

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