IMPACT OF PUBLIC WORK NIGERIA LIMITED QUARRY ACTIVITIES ON PHYSICAL ENVIRONMENT OF VWANG DISTRICT, JOS SOUTH LOCAL GOVERNMENT AREA OF PLATEAU STATE, NIGERIA

Construction activities at all levels depend to a large extent on quarry stone aggregate for structural and none structural-developmental activities. The environmental implication of some of these quarry industries is often not considered. This study assessed the impact of public work Nigeria Ltd quarry activities on physical environment of Vwang area, of Plateau State, Nigeria. Observational method was used to assess the environmental consequences of quarry mining on the environment. Probe Toxic Gas Analyser model TG/501 and ATP 901A Sound meter were used to measure ambient air quality and noise level. Quantitative method was equally used to examine resident's perception of the impact of quarry on their environment. The results obtained were compared with the FMEnvs and WHO reference standards and this showed that the air quality and noise level during operation hours was above the acceptable limits of SO_2 (100µg/m^3)/(80µg/m^3), NO_2 (60µg/m^3)/(40µg/m^3), CO (11.4µg/m^3)/(10µg/m^3), SPM_{10} (250µg/m^3)/ (50µg/m^3) and (70dB for day) (60dB for night) in air. While the result of dust and vibration shock affect the air quality and 42.4% of buildings within the study area. It is therefore recommended that modern technology/instruments and effective protective measures like (tree planting and water sprinking on stones before crush) should be adopted in the quarry company to mitigate the impact of quarry pollutants on humans and their physical environment.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

The exploitation of mineral resources has been presumed a crucial stage in many developed and developing countries. Nigeria as one of the developing countries is blessed with massive natural resources that have supported the economic growth of the nation. Thus, the extraction of these resources usually passes through the exploration stages of mining and processing (Peter *et al.,* 2018). Oyinloye and Ajayi (2014) described quarry exploitation as open-pit mining from which raw materials like limestone, clay, potash, dolomite, kaolin, bentonite, silica, barite, gypsum, measurement stone, building aggregate, sandstone, and gravel are mined for construction industries. These raw materials are usually combined with concrete and asphalt plants because they contain large amounts of aggregates. However, the extraction and processing of these materials for manufacturing industries usually pose a negative impact on the surroundings that lead to environmental damage.

Quarrying is an activity that helps in the manufacturing of materials that can be used to develop infrastructures like roads, dams, bridges, drainages, and houses (Oyinloye and Ajayi, 2014). Lameed and Ayodele (2010) described a stone quarry as a process which involves excavation/blasting of stones with chemical explosives to mine construction materials that can be used in the development of infrastructures. However, this process usually gives rise to environmental challenges such as sound/vibration shock, air/water pollution, and land degradation. Eshiwani (2014) reported that quarry is an activity that creates a serious disturbance on and beneath the earth because the processes involved include drilling, blasting and crushing of stones into aggregate for construction purposes. Thus, this disturbance usually affects both the physical and biological environment.

According to Mabogunje (2008) cited in Lameed and Ayodele (2010) was of the view that quarrying activities have the capacity of destroying the environment and its species through the release of dust particles into the air, water, and soil. These particles are in gaseous form and when settled on the water body or vegetal cover, releases chemical substances like Particulate Matter (PM_{10}), Nitrogen Dioxide (NO_2) Carbon Monoxide (CO) and Sulphur Dioxide (SO_2), which are harmful to plants and animals and can destroy the inhabitants either directly or indirectly. Directly is through noise pollution and land degradation, while indirectly is through changes in surface/groundwater and ambient air quality. Lameed and Ayodele (2010) also revealed that dust particles from quarry activities are one of the key causes of airborne disease although it depends on the issues like the local microclimatic situations. The amount of dust particles concentration in the air, the extent of the dust particles and their interaction, for example, sandstone quarry produces high alkaline dust, while coal mining produces acidic dust. Air contamination is not only a pest on health, particularly for those with respirational issues but also on the vegetal cover such as destroying the inner structures, the scuff of the greeneries and cuticles as well as chemical substance which may affect the long-term existence of the plants.

Quarry activity regardless of its degree fundamentally has environmental consequences due to large numbers of chemical substances discharge during the process, especially if non-standard control measures are used. Nartey *et al*. (2012) established that about four million death cases related to acute respirational snags are reported annually from emerging countries, resulting from worse environmental pollution originating from quarry/mining and heavy construction activities.

Noise pollution harms plants and animals and their reproduction. But, with effective preparation and systematic management control of the environment, through tree planting and the use of equipment/technology that can generate lesser noise, it is possible to lessen the consequence of quarry on biodiversity and also offer a good chance to create and restore the affected environment (Tanko, 2007).

Plateau state is one of the most protuberant places for stone mining and this activity has been going on since the 70s. Today the region has developed massively and there is serious competition between different land-use practices. The abundance of rock in Vwang District has explicated the reason for quarrying activities, and this has been going on for over 20 years with little or no major impact assessment carried out due to socio-political reasons, and yet the host communities are exposed to the quarry pollutants. Public Work Nigeria Limited (PW), is a construction company that is into the construction of roads, bridges, dams and houses. The PW Company has a quarry site located at Vwang District surrounded by 6 villages as, Dandyes I, Dandyes II, Dabwang A and B, Heita and Company. The site was established in 2000 and commenced operation in 2001. Today, the company has over 1 million cubic meters of rock blasted and crushed stones.

1.2 Statement of Research Problem

Quarry activity has provided abundant resources used in the hard flooring/construction finishing such as limestone, granite, marble, sandstone, slate, and clay for ceramic tiles. Quarry products encouraged solid/quality infrastructural development in towns and cities, which is also connected to employment opportunities and economic development. However, on the other hand, these activities have also led to environmental damage such as air, water, soil, and noise pollutions, damage to plants and land degradation (Siachoono, 2010). Over the past few decades, mining activities have deteriorated the environment in many countries accounting for over/exploitation of resources and poor methods of technology employed in mining which in turn has left the landscape in a derelict condition. The resultant impact of quarry on the surrounding environment has been so significant that the very existence of life is vulnerable. Haule *et al*. (2016) also elaborated that limestone and granite mining in Tanzania caused extensive losses of soil and vegetal covers as a result of vibration shock and some acidic substances released on farmland from quarry activities. Osuocha *et al*. (2016) revealed that quarry activities have increased the concentration of heavy metals in soil and water in the host communities.

Mallo (1999) cited in (Mallo, 2012) revealed that the effects of cutting down trees in the Jos Plateau due to quarrying/mining activity have numerous ecological and economic consequences such as erosion, deforestation, desertification and increase in watercourses siltation. Others are loss of biodiversity, loss of farmland, and vegetal cover in the region, accounting for the rise in carbon dioxide and climate change. The concentration of carbon dioxides in the air contributes to climate change and an increase in population led to cutting down of trees for fuelwood, which increased the rate of evaporation and change of fluvial competence capability, as parts of the consequences of deforestation in Jos Plateau. According to Mallo (2012) the extraction and exploitation of tin, metal ore, Columbine and allied minerals on the Jos Plateau started as far back as 1928 during the then Nok culture of Benue, Plateau and Northern Zaria of Nigeria which was known for Iron smelting. Later, the European miners located informal mining activities that mined tin, galena, gold, and other minerals that were traded internationally. Fagg (2014) the increase in mining activities has brought about urbanization and encouraged man’s desire for new infrastructural development which in turn affects the physical environment.

Several research works (including Ukpong, 2012) were conducted to measure the impact of quarry activities on the physical environment such has the concentration of physiochemical substances (NO_2) and (CO) in air and water at Akamkpa. Ukpong (2012) found out that the concentration of these substances was above the permissible limits and therefore, detrimental to the host community. Haule *et al.* (2016) assessed the concentration of cadmium (Cd), Lead (Pb) and Chromium (Cr) in the soil and vegetal covers at Mbeya. Osuocha *et al*. (2016) equally assessed the Concentration of heavy metals like Aluminium (Al), Zinc (Zn) and Copper (Cu) in soils and vegetable plants. Ndoke *et al*. (2012) also examine the quantity of Carbon dioxide (CO_2) concentration in Kaduna and Abuja environments. He concluded that CO_2 concentration is high enough to cause serious health effects on people. Others are concentrations of Chloride, Nitrate, ($SPM_{2.5}$) and (VOC)} in water, soil and air.

In Vwang District, PW Quarry Company seems not to observe environmental legislation and regulation. It is against this backdrop that this research seeks to assess the compliance level of the company to Environmental Impact Assessment Act and other provided National Environmental Standards and Regulations Enforcement Agency (NESREA) laws and regulations under the Federal Ministry of Environment. To know whether the company has developed and implemented some of the key policy instruments and tools that are commonly adopted for managing the environmental impacts. Also, the reviewed literature showed that there is little or no direct research in the area of Particulate Matter (PM_{10}), Sulphur Dioxide (SO_2) and Noise Level which this study is trying to fill using Public Work Nigeria Ltd (PW) Quarry Company.

1.3 Research Questions

i. What are the characteristics of the PW quarry site?

ii. What are the effects of the quarry activity in Vwang district?

iii. How do people perceive the impact of quarry activity on their environment?

iv. What is the compliance level of the PW quarry company?

1.4 Aim and Objectives of the Study

1.4.1 Aim of the study

This study aimed to assess the impact of quarry activities on the physical environment of Vwang district to proffer planning solution, through the following objectives:

1.4.2 Objectives of the study

i. Examine the site characteristics of the PW quarry and map the specific distribution of the settlement around the quarry operation site.

ii. Assess the impact of the quarry activities on-air quality and noise level.

iii. Examine people's perception of the impact of quarry on their environment.

iv. Examine the compliance level of the PW quarry company to the (NESREA) and Nigeria Mineral and Mining Regulation Act 2011.

1.5 Limitation of the Research

The 2006 National Population Census does not account for the population of the study area at the neighbourhood level. It was difficult to acquire the population of the study area. However, the population size was determined using a surrogate approach, through the satellite image. 357 questionnaires were administered but only 309 were retrieved due to poor responses from the respondents, as a result of the clashes between farmers and Fulani herdsmen. Literature has shown that numerous pollutants are emitted at the quarry site during operation. However, getting an instrument that measures a reasonable amount of these gasses was difficult. Therefore, the researcher was only limited to Particulate Matter (PM_{10}), Sulphur Dioxide (SO_2) and Noise levels.

1.6 Significance of the Study

Quarry activities are the major environmental challenges globally, and in particular, the impact of mining in developing countries is more pronounced due to the poor regulatory monitoring. This research will add to the growth of knowledge on the evaluation of the environmental impact of quarry activities and also serve as reference material to government and individuals in this field. This study will help with better information on the characteristics and distribution of the surrounding settlements. This study will also reveal the major environmental consequences of the quarry industry that are deteriorated to man and his environment which include air, soil and water pollution, damage to vegetal cover and biodiversity, noise pollution and vibration shock. It will also serve as a solution to the gaped in knowledge discovered in this study and reference material to other researchers or academia.

1.7 Scope of the Study

The physical environment comprises air, water, soil/land, vegetal cover and ecology. But for this study, emphases were made on the effect of the PW quarry industry on air, noise level and buildings within a 1.5km radius.

1.8 Study Area

The PW quarry site is situated between latitudes 9° 41′ 38″ N to 9° 42′ 0″ N and longitudes 8° 42′ 36″ E to 8° 43′ 2″ E and covered 2,338162m^2 of land in Vwang District Jos South LGA, Plateau State Nigeria. Comprises 6 villages, Dandyes I, Dandyes II, Dabwang A and B, Heita and Company as indicated in Figures 1.2 and 1.3.

1.8.1 Geopolitical background of Jos south

Jos South Local Government Area (LGA) is one of the 17 Local Government Areas of Plateau State. Created in 1991, it lies between latitudes 9° 40′ 0″ N to 9° 52′ 0″ N and longitudes 8° 40′ 0″ E to 8° 56′ 0″ E and it comprises of four districts Du, Gyel, Kuru, and Vwang. Jos South is bordered with Bassa in the North-West, Jos North in the North, Riyom in the South, Barkin Ladi, and in the North-East Jos East. It had a population of 306,716 (NPC, 2006) and a projected population of 404,902 for 2018 at a 2.5% population growth rate as indicated in Figure 1.1.

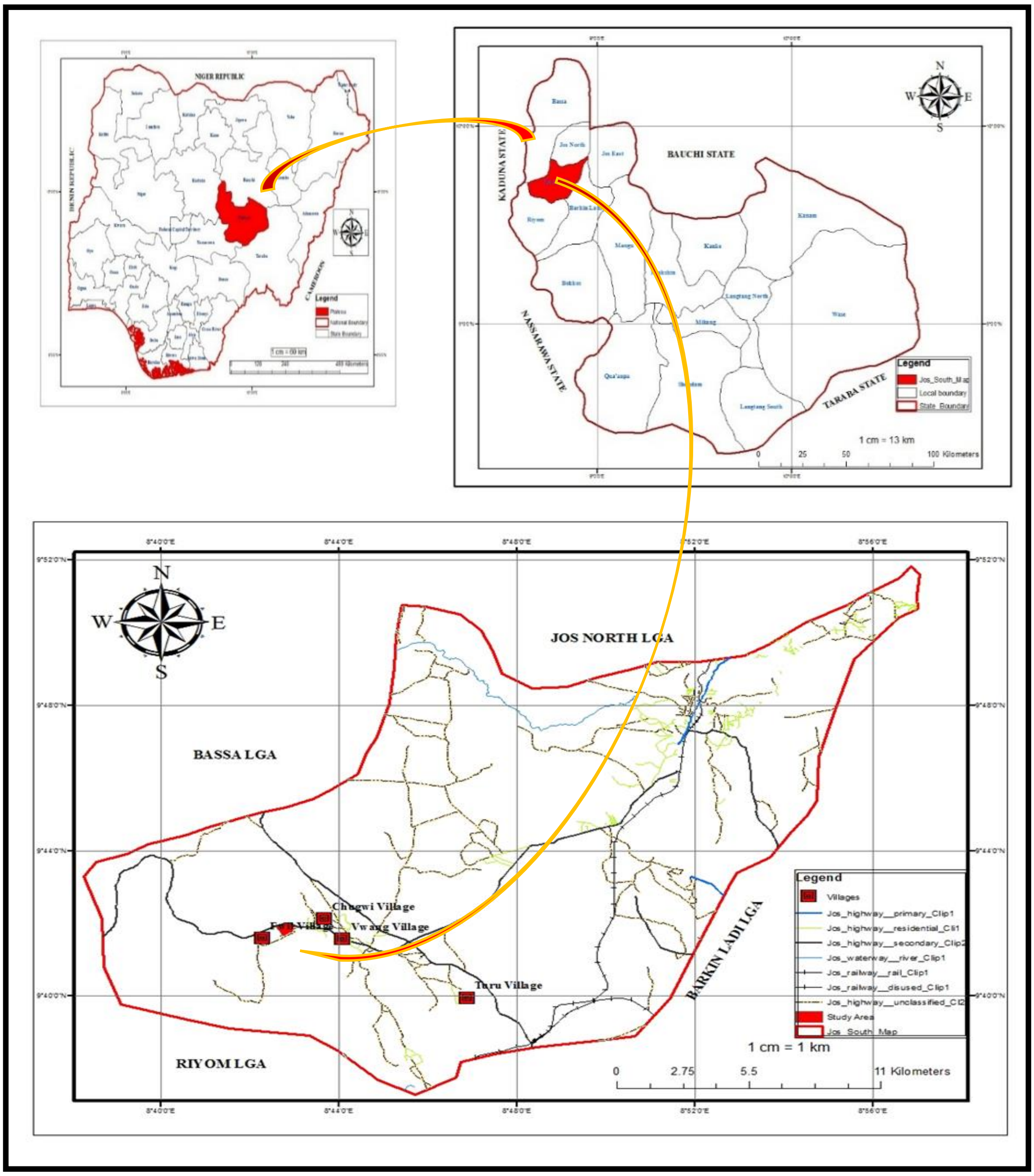


Figure 1.1: Vwang District in Jos South, Plateau State, Nigeria
Source: U.R.P Department FUT Minna, GIS Analysis (2019)

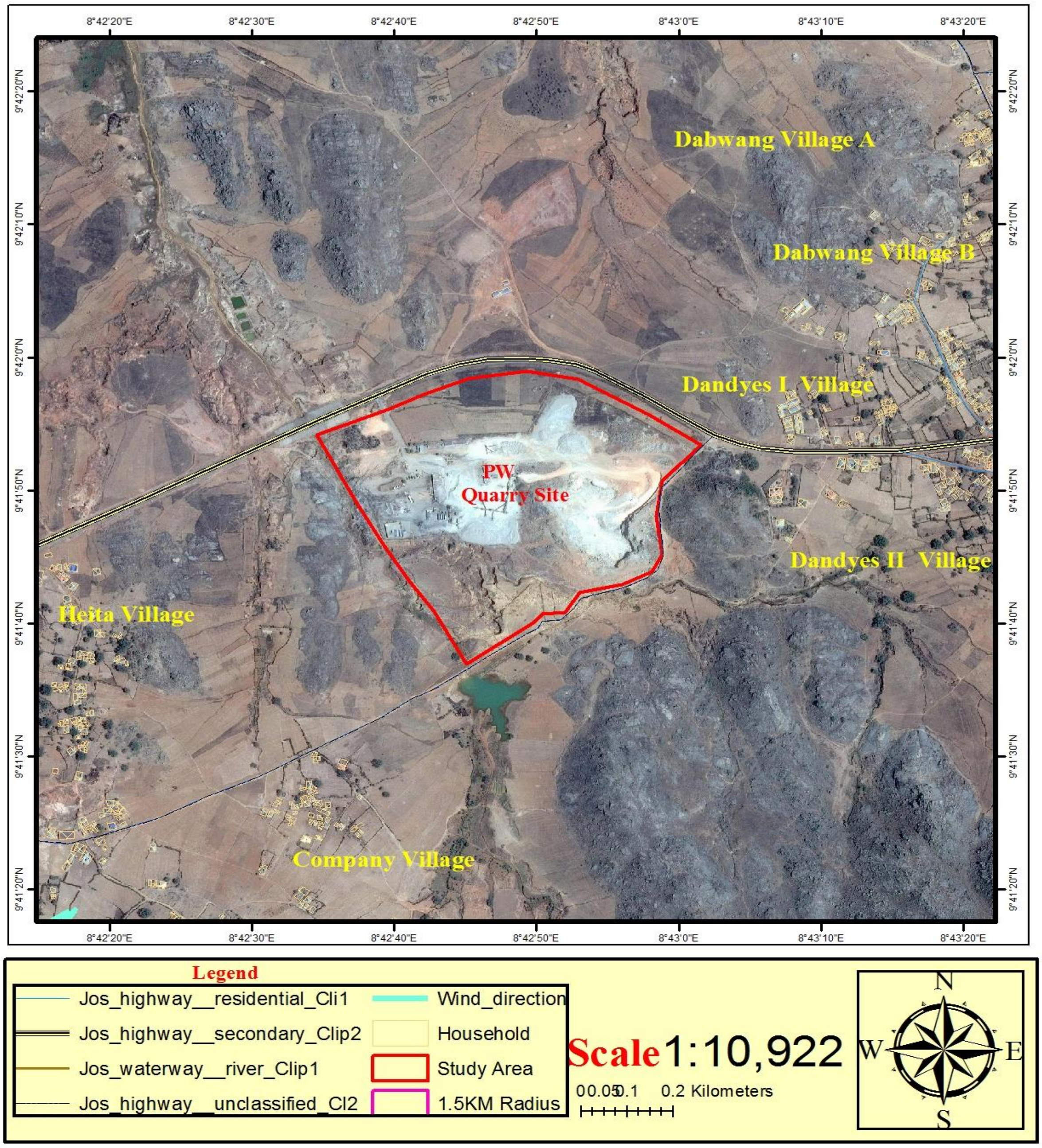


Figure 1.2: Satellite Imagery of PW Quarry Site in Vwang District
Source: Author's Field Survey (2019)

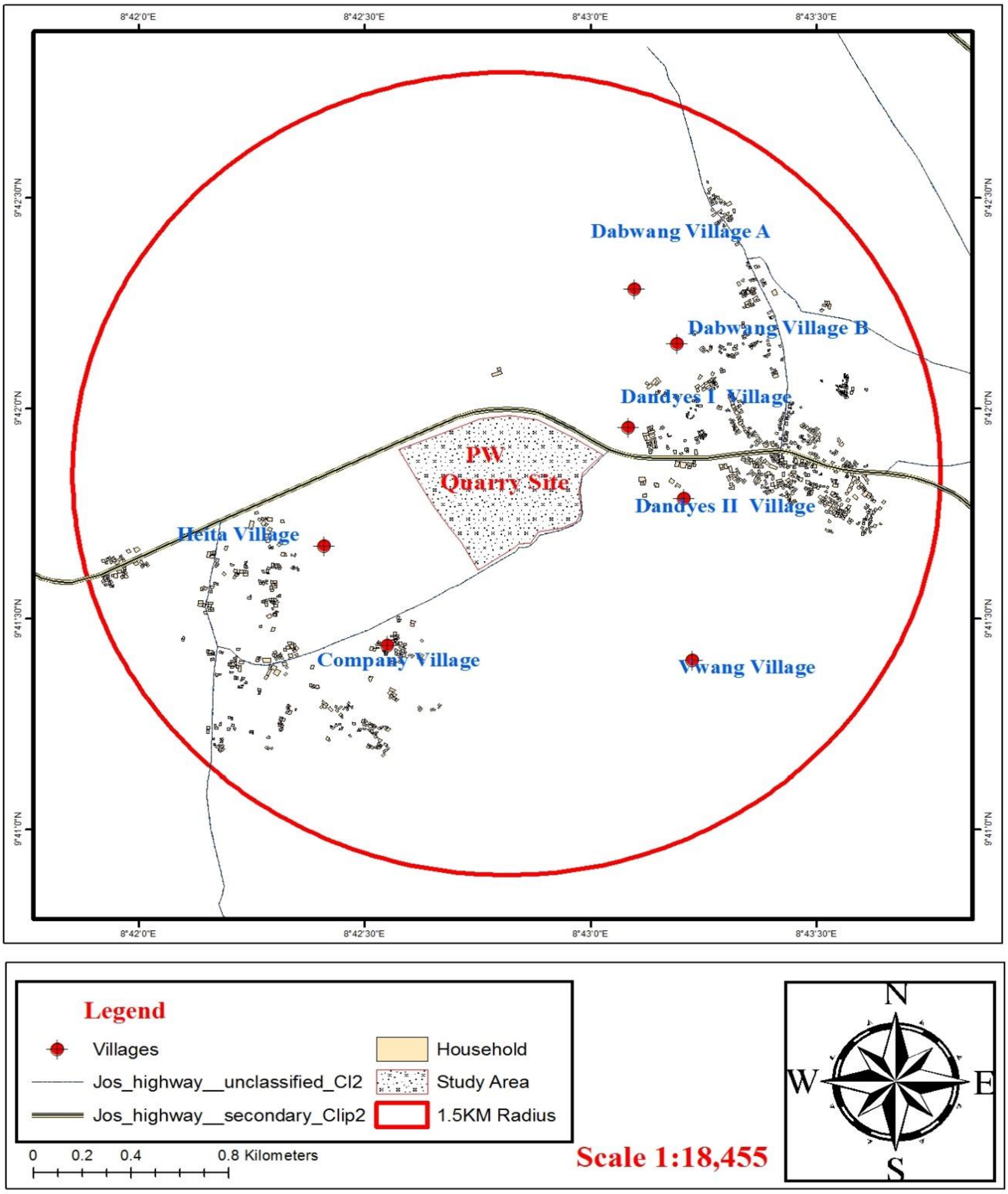


Figure 1.3: Public Work Nigeria Ltd Quarry Site in Vwang District and the Host Community
Source: Author's Field Survey (2019)

1.8.2 Historical background of the study area

The area was discovered by a game hunter that started at Naraguta of the old Anaguta village. Vwang (Jos South) is as old as during the Nok culture. The findings of metal ore and tin deposits within Jos Plateau led to the discovery of the first immigrants of the

Anaguta ethnic group by the colonial Government in 1900. Colonel, H. W Laws an engineer with the Royal Niger Company was sent as a mining engineer with 600 workers to work. Colonel laws were lovingly referred to as ‘king of Jos Plateau’ by his people. Due to his effort of the massive discovery of metal ore and tin/columbine deposits in Naraguta hill, Jos Plateau (Krause, 2011). In search of different ethics groups on the Plateau, the Colonel became more confused and disorderly due to language differences that he can no longer understand. So he was encouraged to move to the next neighbourhood or territory belonging to the different colonial government and served there as a cooperation and brainpower officer.

The organic neighbourhood was known as ‘Gwash’, originated from the name first migrant, and the word ‘Gwash’ was hard for the Europeans to pronounce and spelled the word, so they called it Jos, and on that day mark the beginning of the name ‘Jos’. There are other small tribes within the Anaguta Kingdom known as Buji, Berom, and Afizere (Krause, 2011).

The mining of tin and columbine on the Jos Plateau has attracted urbanization in the area from diverse parts of the world which qualified the area to a cosmopolitan city. The ideas behind Jos' development and transformation started during the colonial master, under the leadership of Lord Lugard, then Nigeria Governor-General in 1913-1918. That marks the beginning of the book that guides the establishment of the township ordinance, to create the European Reservation Area and Non-Europeans Reservation Area. Jos is among the second-class cities under the leadership of the British Government of then colonial masters, because of the abundance deposit of Tin and columbine. The problems associated with traditional towns and cities in northern Nigeria, which Jos happened to be one of them in 1914. That led to the past of 1917 townships ordinance law that created satellite towns to overcrowded cities that were caused as a result of population migration. The six new towns created known as ‘second class towns’ give room to people within and outside the country access to land for leaving (Krause, 2011).

1.8.3 Climate and weather of Vwang district

The study area is characterised by two distinct climate conditions; the wet and the dry season. The rainy season is between May to October and at the peak in September while the summer season started from November to March. The area has an average rainfall of 1347.5 and 1460 mm per annum. It has a cool climatic condition due to its altitude of the area, from November to February with an average temperature of 18^{0}C. The temperature of the town ranges from 16.69^{0}C-18.94^{0}C within the coldest and rainy season (Adegboye, 2012). The maximum temperature is beginning around March to April whereas the lowermost temperature occurs within December and January. Jos has the lowest temperature but has always been changing over some time due to global warming with an average temperature ranging from 21-25^{0}C (70-77^{0}F), from middays of November to late days of January, while in the night the temperature usually goes as low as 11^{0}C (52^{0}F). Storm does fall occasionally during the wet season due to the lowest temperatures of the Jos Plateau (Stocker, 2014).

1.8.4 Vegetation and soil

The area is made up of grassland and average vegetation cover (guinea Savannah trees), the vegetation has an average height of about 1.5-2 metres tall and above, such as Olive “Atile”, Acacia, Canarium Schweinfurth’s, Eucalyptus, and Cactus. The crops grown are Arish potatoes, maize, acha, millet and sweet potatoes (Hegazi, 2008).

1.8.5 Relief and geology

Vwang district (PW Quarry Site) lies on a Plateau terrain above sea level; with a maximum elevation of about 1800 metres with a rough landscape. The city is situated on the metal ore and rock outcrops which attracted quarries, the area is divided by watercourses that flow into River Benue. It is also a blessing with numerous water ponds and enclosures due to the mining activities. Jos Plateau is rich in crystal resources like Marble, tin, Granite, columbine, and limestone (Oyelana and Thakhathi, 2015).

1.8.6 People and culture of the project region

The major inhabitants of Vwang district (PW Quarry Site) are the Beroms. However, the abundance of the resource found explicated the reason for mining activities and other opportunities that encourage the influx of people with different ethnic backgrounds such as the Hausa, Igbo, Yoruba, and other smaller groups. The mild climatic condition and the accommodative nature of its people, as well as a tourist attraction, have continued to attract investors. Krause (2011) the people of Jos South were predominantly farmers and hunters, but with the coming of mining activities in the area, the early occupation has been overtaken by these mining activities.

1.8.7 History of quarry activities in Vwang district

In Vwang District, extraction of naturally occurring stone or tin from the earth is dating as far back as 7 to 10 decades, where the Nok culture of the Benue Plateau/Northern Zaria areas of Nigeria was understood to know Iron smelting (Mallo, 1999) cited in (Mallo, 2012). Later, it was an unorganised mining system set up by the European miners that were used to mine gold, galena, tin columbine and other minerals that were traded globally. The increase in the human population has led to man's desire for new infrastructural development that emerged in many quarry sites in the state, both organised and unorganised sites (National Bureau of Statistics, 2013). PW Nigeria Limited was established in 2000 and commenced operation in 2001. Today, the company has over 1 million cubic meters of rock blasted and crushed. The company used the open-pit mechanized method with a 5-7m vertical/horizontal bench. The site is divided into 3 sections: the quarry, crusher, and transportation.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Quarry and Method

A quarry is a process that involves different steps, the first step is the searching and discovery of areas that locate metal ore. This can be done through a physical survey at the field and discovering different types of rocks/minerals resources, to give the geologists/titleholders a focal point of where to set up a quarry/mining site. There are two methods or types of quarry namely, quarry with and quarry without blasting: Quarrying without Blasting: This method involves broken loose rock blocks from their natural ridges by the use of simple tools or single channelling engines. Without applying any volatile substance at any step. This technique of quarry mine, soft rocks and those that are in layers' structures are easily breaking down by hand tools (Civil-Seek, 2019). Quarry with Blasting: This technique involves the breaking of stones with the use of a volatile substance (explosives) from the very metal ore (rocks). It has been experiencing that quarry of quartzite, granites, gravels, traps, and basalts by wedging and other techniques are hard and expensive. Hard marble, however, can be untied easily using explosives substance. The basic aim of this methodology is to blast/crush stones into a small aggregate with explosive substance (Civil-Seek, 2019).

2.1.1 Technological process of quarry

The open-pit method is a technological method used to acquired marble blocks. There are two steps employed in acquiring marble blocks. Figure 2.1 shows various steps of achieving rough stone, the first step is through drilling and breaking stonework, followed by the use of a diamond chain and cutting machinery.

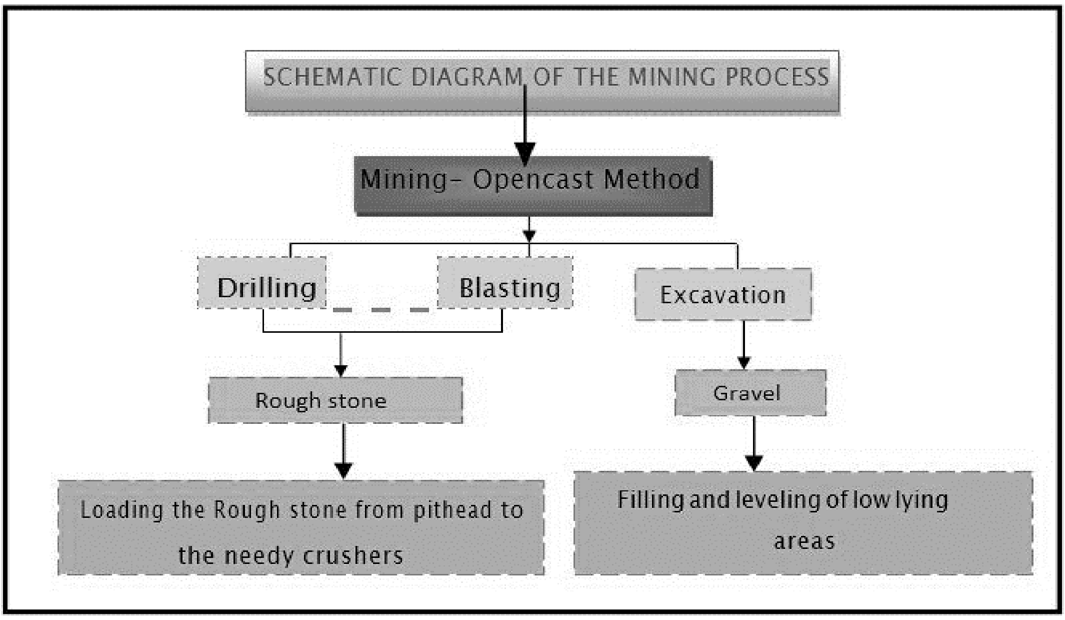


Figure 2.1: Method of Open-Cast Quarry Mining
Source: (Annadurai *et al*., 2010)

Table 2.1 shows normal materials acquired after the series of methods, the conditions for their rational use of marble blocks in percentage. This method shows the exploration stages of stone mining from the drilling stage to cutting machines respectively.

Table 2.1 Application of massive blocks of marble and methods of exploitation

Methods	Application of Blocks Marble massive (%)	Technology for Exploitation (Methods)
1	0 – 25	Drilling, blasting, and cutting
2	25 – 10	Breaking with diamond chain, saw, and machine
3	10 – 40	Use of machinery
4	40 and above	Exploitation with machinery

Source: (Dambov *et al*., 2013).

The following are the process of acquiring sandstone and granite blocks from the stiff rock:

1. Vertical and horizontal drilling holes and breaking charge
2. Joint extraction with drilling, blasting, and diamond chain dividing.

3. Combinations with cutting machines and diamond chains.

Benches within the open pit are at intervals of 6-8 metres high that are conditioned by the structural-tectonic. The option of geological formation, and the methodological characteristics of the equipment used throughout the excavation. The elevation of 1.2 height is actually in favour of the scale of the finished product with a 3.0 x 1.3 metre size of marketable blocks.

2.1.2 Stone drilling

After the operating trench and frontal quarry are done, the horizontal and vertical holes are trained. Vertical holes are trained within 15-35 centimetres subject to the features of the block and therefore the method of starting. The space within vertical drained holes is 30 centimetres and can only be applied to the front holes. And that space should not be less than half of the space of the frontal draining holes. The horizontal holes should be equal to the number of vertical holes. However, horizontal drained holes at intervals of zero angle of drilling (horizontal) should be between the earliest and second vertical front hole. This pattern is completed to abolish potential overlapping of strikes between the horizontal hole and vertical hole that will lead to the concentration of blasting substance (volatile substance and black powder) that can cause excessive damage to the block rock, Figure 2.2 shows the draining holes.

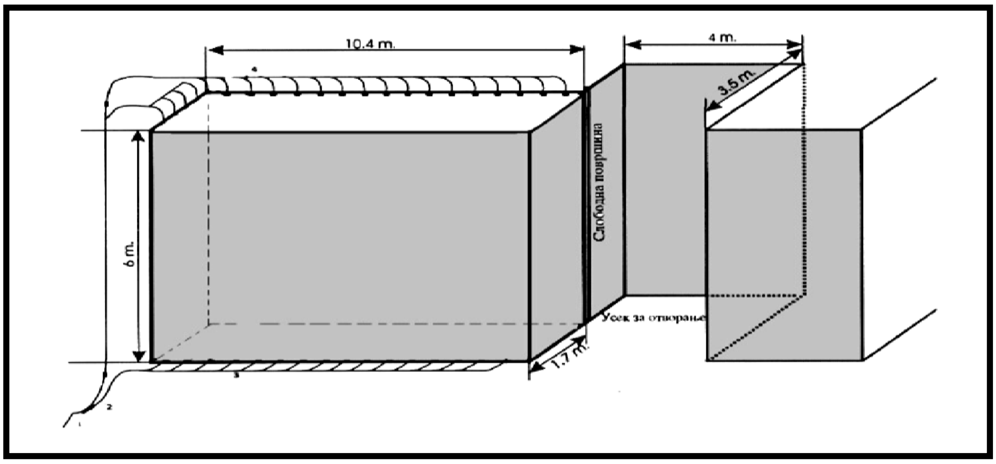


Figure 2.2: Method of Horizontal and Vertical Drianed Holes in Quarry
Source: (Dambov *et al*., 2013).

2.1.3 Blasting and vibration of quarry activities

Blasting is a general technique used to disintegrate rocks in open-cast quarry and excavation work. Blasting can also be defined as a separation technique used to break down hard rock from the larger part of the rock mass with the aid of blasting material that may offer fewer damages to the rock mass. In an equivalent stage, it should be divided (with rib cage - curve splitting) alongside the distance of the horizontal whole and vertical hole. The following are chemicals substance used in blasting rocks:

1. Powder ammonia - nitrate explosive with cartridge length of 28-32 millimetre
2. Explosion fuse class,
3. Black powder and
4. Explosive cap.

When employing a fuse, associate action is applied within the end or at the lowest hole by introducing many knots. Blasting is dispensed by connecting all the fuses with an explosive twine that is introduced by detonating cap No. 8, associated with a slow-burning fuse. Then follows the exploration of the rock, this process involves the discovery and determination of the extent and value of the metal ore. The methods also involve a different process which like site inventory/observation, remote detection, and drilling

(Dambov *et al*., 2013). While vibration is one of the foremost environmental disturbances that is made throughout quarry blasting. Therefore, the estimate of blast-induced vibrations is very important to spot the safety area of blasting (Faradonbeh *et al*., 2016). Vibrations rising from the quarry with blasting is one of the fundamental glitches in the quarrying company. Therefore, the forecast study of vibration mechanisms plays a vital role in the minimization of environmental challenges (Ozer *et al*., 2008). The forecast of impact vibration remains a routine problem for excavations, quarries, and construction. Many researchers have proposed equations to predict the impacts of vibration before blasting, but it is difficult to implement in all the blasting environments because ground vibration is influenced by several parameters, either manageable or non-manageable. For example, geometry, explosive types, rock strength properties and geological situations (Dino *et al*., 2015).

2.1.4 Modern instrumentation of quarry/mining

In modern times, technological advancement has brought about an improvement in the efficiency of quarry machinery. This improvement has led to the lesser effect of quarry on the environment through the reduction of sound/vibration shock produced. The following are examples of modern equipment used for quarry/mining activities.

2.1.4.1 Drilling machine (TBC SLOT)

It is used for drilling vertical holes on the metal ore, where explosive can be applied directly on the block of rock to obtain a small aggregate of stone from turning lamellae.

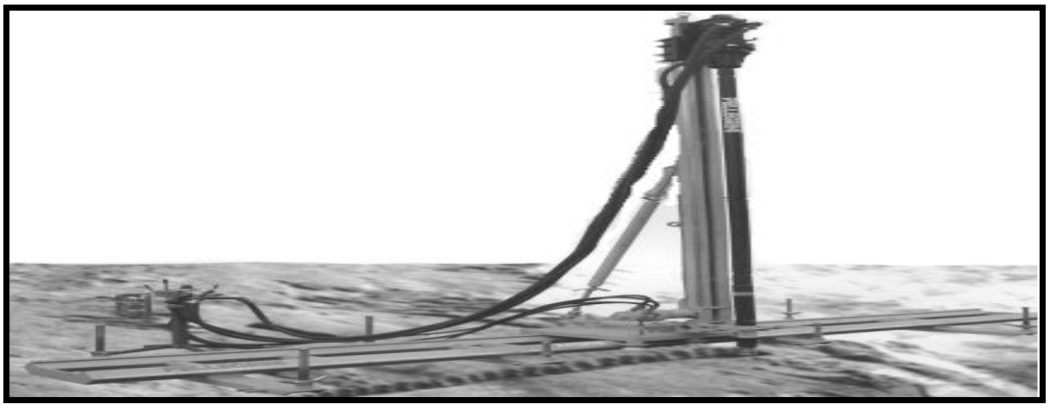


Plate I: Drilling machine TBC SLOT
Source: (Dambov *et al*., 2013).

2.1.4.2 PE jaw crusher

It is used for crushing in quarry production lines, it can be described as an obligatory machine, used for stone processing in mining and construction industries, such as crushing rocks, limestone, basalt, sandstone, granite, quartz, cobble, iron ore and copper.

Plate II: PE Jaw Crusher
Source: Shanghai Joyal Machinery Co Ltd (2019)

2.1.4.3 Ball mill of crushing machine

Is it a grinding machine in the quarry industry, especially in mineral ore dressing plants? It is commonly used for cement, silicate product and new-type building material. It is usually designed in standard sizes between 0.074 mm and 0.4 mm in diameter.

Plate III: Ball Mill of Crushing Machine
Source: Shanghai Joyal Machinery Co Ltd (2019)

2.1.4.4 Wharf belt conveyor

It is the most wide-ranging range of Heavy-duty conveyor belts, with over 30 years of experience, that are used for conveying protuberance materials from the quarry section to the crusher unit in a mining company, for example, coal, metal core, and hard-core.

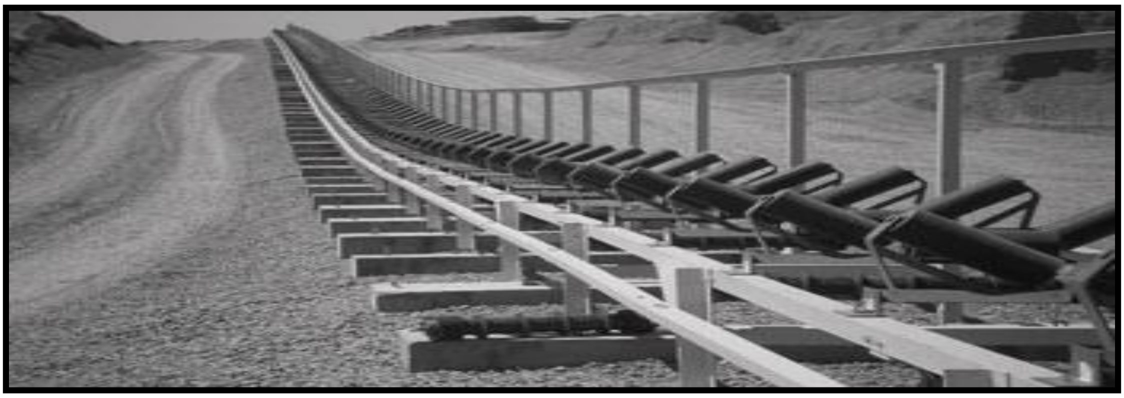


Plate IV: Wharf Belt Conveyor
Source: Shanghai Joyal Machinery Co Ltd (2019)

2.1.4.5 BWZ series heavy duty apron feeders

They are generally used in metal mining, construction, cement industry and coal industry and quarry site. For its deterioration resistance and devastating resistance, most of the materials can be transported by this machine and are suitable for short-distance transmission.

Plate V: BWZ Series Heavy Duty Apron Feeders
Source: Shanghai Joyal Machinery Co Ltd (2019)

2.1.4.6 Series cone crusher (CS)

This type of machine is mostly used in a cement factory, stone quarry, building construction, road, and bridge construction. Others are railway construction and metallurgy. For mining/mixing materials like iron ore, granite, limestone, quartzite, sandstone, and cobblestone. This crushing machine is extremely brilliant in terms of stone crushing and its final product has good sharpness.

Plate VI: Series Cone Crusher (CS)
Source: Shanghai Joyal Machinery Co Ltd (2019)

2.1.4.7 Hammer crusher

It is used for crushing stone aggregate, whose compression strength is within 320MPa, like coal, salt, and chalk. Others are gypsum, blocks, limestone, glasses, and phosphate. This machine adopts modern concepts of crushing machines and grinding mills.

Plate VII: Hammer Crusher
Source: Shanghai Joyal Machinery Co Ltd (2019)

2.1.4.8 High-frequency screen

This machine is used for screening and grading the fine particles of mineral ores. The High-Frequency Screen machine can perform a large-scale duty when it comes to applications of tantalum ore, dolomite sand, metal ore, tin ore, quarry mining, and tungsten ore.

Plate VIII: High-Frequency Screen
Source: Shanghai Joyal Machinery Co Ltd (2019)

2.1.4.9 Sand washer

This machine is employed to be used for the removal and cleaning of dust in mineral resources, in the mining/construction industries such as quarry, minerals, building materials, transportation industries, and cement mixture stations.

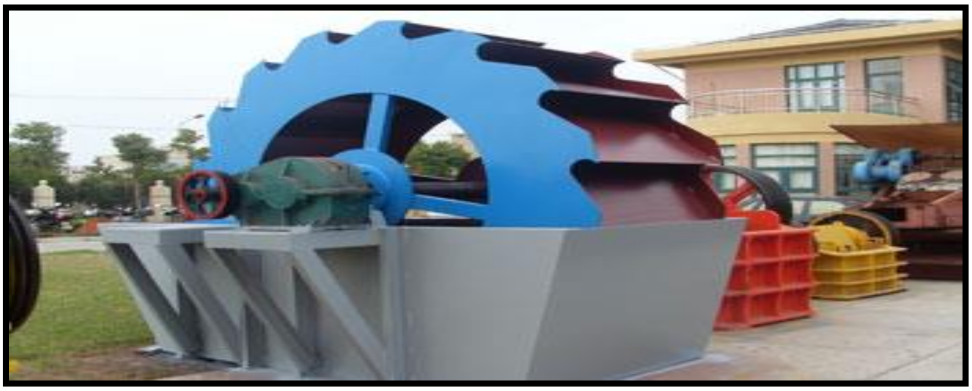


Plate IX: Sand Washer
Source: Shanghai Joyal Machinery Co Ltd (2019)

2.1.4.10 STKC delivers

It is the foremost comprehensive sort of Heavy-duty conveyor belt that conveys and delivers a rough aggregate of stone from the crusher to the storing point. STKC has exceptional belt systems that meet definite consumer supplies for quality performance and cost management.

Plate X: STKC Delivers
Source: Shanghai Joyal Machinery Co Ltd (2019

2.2 Conceptual Framework of Quarry Activities

Rock mining is an activity that affects the ecosystem. The biotic environment is the major asset of nature, and yet has always been the first casualties when the environment is affected. The impact of over/exploitation of resources received positive and negative outcomes on the environment which some are wonderful and some are terrible. Some of these outcomes are job opportunities, modernization of houses, noise and air pollutions. While others are water and soil pollutions, desert encroachment, asthma, coughing, and sneezing. The environmental challenges are accommodating alteration of landscape/natural beauty, and soil erosion as indicated in Figure 2.3 (Mbandi, 2017).

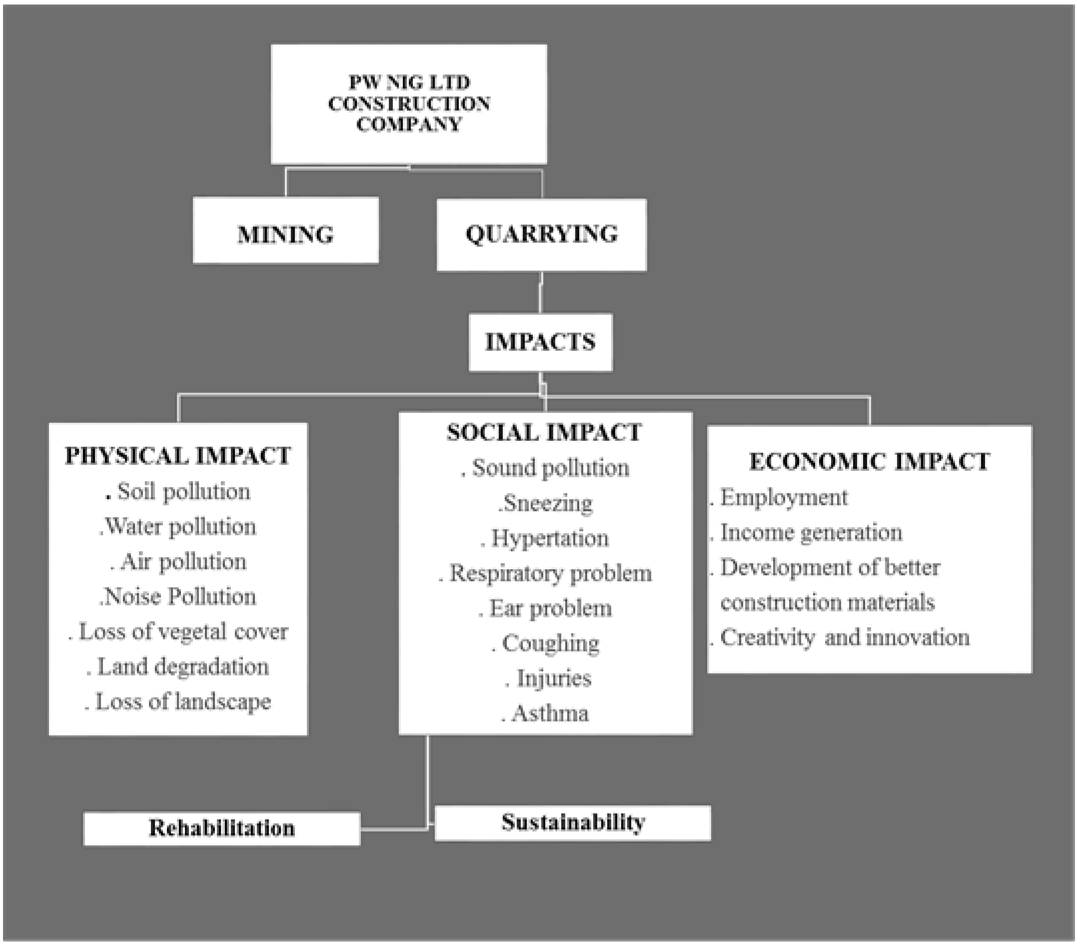


Figure 2.3: Conceptual Framework of Quarry Activity in Vwang Area
Source: Mbandi (2017) Modified by Author (2021)

2.2.1 Impact of quarry activities on soil quality

Adebisi *et al.* (2017) saw soil pollution as a change within the structure of soil due to the concentration/accumulation of metal and particulates on the soul. Soil pollution is additionally called land pollution; this occurs due to a combination of undesirable chemicals substance within the soil. The emission of dust from quarry activities and mining also exploits the soil. Since plants cannot be rooted very well and this leads to soil erosion.

Mishra and Singh (2010) state that ascent in the urban population, attract globalization which leads raised in demands for energy and automobile that in turn increased the levels of pollution in the city. He further observes that these issues of pollution are also attributed to poor environmental act/regulation, economical technology of production, traffic system that caused traffic jams, and poor vehicle maintenance. This hazardous substance can also be a result of natural and anthropogenic activities such as smoking, burning of fuelwood for cooking food, heating-room, and pesticide industries process. Other are poor road maintenance, poor environmental by-law, less economical machinery for production, and poor vehicle service. While the natural sources are fossil fuel/gas flame, waste disposals and forest/wildfire (Paget *et al.*, 2010).

2.2.2 Impact of quarry activities on water quality

It is known that mining waste discharged into the water body causes water pollution, which can be equally led to water bored-disease. Like malaria, river-blindness, cholera, and diarrhoea (Jung *et al*, 2018). Twerefou (2009) water is the basic necessity for man's survival, every living thing depends on water; Thus pollution is another major constraint of life that needs more attention to prevent.

2.2.3 Impact of quarry activities on ambient air quality

Adeola *et al*. (2015) used a questionnaire method to measure the effect of quarry on humans and their environment in different locations of Ikere-Ekiti, Ekiti State. Revealed that dust, noise, and vibrations from stone blasting are very destructive to eco-diversity in Ikere-Ekiti. A related study was conducted by Ukpong (2012) using a scientific base method to measure CO and NO_2 concentration in air and water in Ikere-Ekiti. The results were subjected to a table of standards and revealed that the concentration of CO and NO_2 in air and water is above the permissible limits. According to Langer (2009) dust is characterised as dangerous particles scattered in a gaseous form in the air. They are associated with quarry, blasting of stones, screening, and crushing.

Nwibo *et al*. (2012) observed that dust particles are the agent of respiratory diseases in the human environment, added that respiratory problems are the foremost causes of health issues globally. Kim *et al*. (2015) the dust particle we inhaled into our breathing organs speed the rate of lung infections. This research proved that over 4000 employees of cement factory/road construction in developed countries were vulnerable to adhesive dust that confirmed the account significant obstruction of airways is equal to dust experience. Inhaling of dust particles causes serious respiratory illnesses (Nwibo *et al*., 2012). It is also confirming that breathing issues as a result of air pollution led to health hazards, due to the level of dust exposure on labourers. Dust infiltrates inhalation canals to prompt problems (Kim *et al*., 2015).

The air we take in, is a vital component of our health and wellbeing. However, the air has been polluted by human activities throughout the world, especially in developed nations (Asake and Ayele, 2009). The air contains a more gaseous substance that creates harm to human health (Smith *et al*., 2013). The polluted air that we take contains particulate matter, such as PAHs, lead, ground-level gas, significant metals, carbon monoxide gas, pollutants, benzene, and dioxide (EPHA, 2009). Contamination in an urban area affects Stagnates and the well-being of the people and reduces the lifespan of the dwellers (Progressive Insurance 2005) (Jee Smith *et al*., 2005).

Horwell *et al*. (2012) revealed that crystalline silica is regarded as a considerable crystal that constitutes a great percentage of the earth's mined substances and it is related to lung sickness referred to as silicosis. Esswein *et al*. (2013) reported that Crystalline Silica endangers human life, as confirmed by the National Institute for Occupational Health in the year 1987. The International Agency responsible for Research on Cancer (IARC) named Silicon dioxide as a potential agent of cancer (Borm *et al*., 2011). However, in the year 1997 Silicon dioxide was a group and named as cancer number one fasting agent (Borm *et al*., 2011). Ugbogu *et al*. (2009) also confirmed that iron dust, cadmium, zinc, and barium, amongst other crystals, cause pneumoconiosis, pores and skin damage in sub-Sahara African (Nigeria) through taking in the dust. Aliyu & Shehu (2007) added that physical injuries are associated with stone quarry, in their study affirmed that there is a 68.9% issue of stone injuries and cuts in Nigeria. Adams *et al.* (2013) recommended that to reduce such occurrences there is a need for schooling on security and sporting protection clothing.

The study revealed that over 300 cases of accidents from stone quarry have been recorded within Norway, Finland and Sweden every year which have caused the workers over 3 days off from work (Pietila *et al*., 2018). The research shows must accidents are associated with movement and guide work, and it is confirmed that accidents take place due to negligence at work. Ersoy (2013) study 10 different marble quarry sites within

Anatolia, established an opposite correlation amongst protection guides and hazards risk mentioned in quarry/mining sites.

Adams *et al*. (2013) discovered 10% - 20% harm from quarry site affect employees of mining in India. Nartey *et al*. (2012) and Ugbogu *et al*. (2009) assessed some communities who raised alarm on effects of dust danger on the environment, using not affected communities as control points, established symptoms of respiratory, ear and eye infections.

2.2.4 Noise pollution from quarry activities

Noise is associated with the unwanted sound produced during blasting and crushing of stones, known as sound/vibrations within the medium radius (Olukanni and Akinyinka, 2012). LI and Tian (2012) unwarranted sound causes hearing disorder when prolonged exposure. Kirchner *et al*. (2012) discovered that 10 dB averages at 2000Hz, 3000Hz and 4000 Hz will hypothetically induce hearing disorder in people. WHO (2015) revealed that more than 1 million people world while suffered from hearing problems due to regular exposure to unacceptable sound, particularly in the quarry area. Neghab *et al*. (2009) categorized Noise-Induced Hearing Inquiry as a widespread risk within the factory workers. The assessed the impact of noise pollution on one hundred forty (140) people, of which 85 of them were exposed to and unexposed from the sound. The results show that hearing of thirty-eight percent between the open and unexposed become very incapacitated respectively distinction amongst the groups.

Ismail *et al*. (2013) in Malaysia carried out research using the direct questionnaire method to compare Noise-Induced Hearing conditions in six quarry sites, involved the young and old with a 6-months working experience without cases of ear diseases. The result shows that Noise-Induced Hearing Loss is 95%, 84% were slight and 62% were affected. Ali *et* *al*. (2012) assess the impact of a cement factory on workers at Obajana, Kogi State. The result showed that (67.1%) of the workers were liable to delicate Sensing of Neural Hearing Disorder (SNHD). A similar study was conducted by Omubo-Pepple *et al*. (2009) on Sensing of Neural Hearing Disorder (SNHD) in Rivers state international airport Nigeria, which revealed that sound from the Port has an undesirable impact on human and is liable for ear problem and other psychological and pathological effects.

The most common challenges related to sound pollution are more significant at the night, causes an inability to rest. Interrupted nights can lead to permanent physical and psychological activeness in fit persons. Luxton *et al*. (2011) worked in the USA, established a relationship between night disturbances among military men and symptoms of depression. Found out that, those with a high level of disturbances at night showed signs of post-traumatic stress and behaviours as well as multiplied abuse of medicine.

2.2.5 Impact of quarry activities on vegetal cover

Akanwa *et al*. (2017) opined that quarry activities occupied 0.1% of the total study area of 402.855 hectares of vegetal cover loss in Ebony State. Quarry has destroyed economic trees, arable lands, and forests in many countries. This indicates that there is a need for strict devotion to sustainable quarrying laws/regulations and constant monitoring. Haule *et al*. (2016) has also observed that quarry in Tanzania has affected the topsoil and green cover. According to Ukpong (2012) in Nigeria observed that open-handed excavations destroyed the neighbourhoods to a higher magnitude as averse to one huge quarry, which means that environmentally sensitive mineworkers have a possibility of amalgamating their processes and capitalise on deep quarries alternatively than sprinkling to limit environmental damage such as the ground geomorphology.

Dooley and Rossato (2010) have noted that deposition of mining, quarry and construction dust on the vegetal cover has been determined to inhibit plant boom when dust burdens exceed 7g m^3 but there are few quantitative facts on the outcomes of dust deposition at usual costs for industrial or agricultural environments. Another study also conducted by Prasad *et al*. (2013) and Nanos *et al*. (2015) shows that dust particles generated from the quarry site have negatively affected plants. As shown in plate 2.1, the study indicated that greeneries photosynthetic are affected by dust concentrated on plants owing to the decrease in stomata, transpiration rates, and water use proficiency feasibly due to apertures' obstacle and another impact on greenery cell.

Plate XI: Dust Accumulation on Vegetation
Source: Eshiwani (2011)

Paoli *et al*. (2015) assess the impact of adhesive dust from the cement factory on the vegetal cover that affects the physical developments of lichen vegetal classes using an experimental method to expose plants to dust for serial numbers of days within Slovakia found out how it damages the plant. A rectilinear correlation between the time of exposure and the energy of the lichen plants was established. Accumulation of dust installation in the air led to a different increase in phospholipid drops and the humility of cell structures that matured the cells. In Ekefa village and Orphanage home of Ibadan metropolis, Nigeria. Adewuyi *et al*. (2015) carried out work on the impact of heavy metals in soils and waterleaf, using analytical-grade reagents and metal stock standard solution ($1mgL^{-1}$) at 100 metres distance, 900 metres distance, and 500 metres distance. The result shows that a complex variety of emissions from the blasting, which include acidic gases, and particulate matters that increases soil acid near the site.

2.2.6 Impact of quarry activities on land (degradation)

Most environmental adverse, such as soil erosion and loss of Eco-diversity, are commonly associated with active and uncontrolled quarry sites (Mwangi, 2014). Langer (2009) this issue extends as a result of poor environmental knowledge during quarry functioning. Phillips (2012) also described it as a major cause of uncontrolled mining/quarry sites in the world that is related to poor funding of excavation equipment compelling quarrying companies to move from one location to another leaving the latent track to ecological risk.

Quarry impact is common on the land. Quarry destroyed the ecosystem through the disturbance of the earth's crust, which leads to alteration of the major landscape and distraction of the basic environmental families (Mbandi, 2017). Mbandi (2017) also assessed the eco-friendly effect of quarry within Kenya. Using a descriptive method to analysed data. The study revealed that there is a significant correlation between quarrying, environmental degradation, splitting of buildings and human health respectively.

Similar research work was also carried out by Menta (2012) shows that open quarry is a key factor that contributes to the natural landscape disturbance or destruction, which has a negative significant impact on the loss of fauna and flora. Quarry activities are very destructive to vegetal cover in Nigeria and many other countries (Ata-Era, 2016). Akanwa *et al*. (2016) vegetation removal is the major cause of ecological decay and the collapse of greenery groups globally. Another study was conducted by Zelalem (2016) in Addis

Ababa, Ethiopia, shows that although quarry activities are economically in a semi-urban area of Addis Ababa, the irreversible exhaustion of natural resources concerned the environmentalists.

2.2.7 Impact of quarry activities on landscape

Landscape in every environment serves as an agent of restorative to the nature that creates rooms for leisure activities, (enjoying beautiful sceneries, peace and the quiet/attractive part of the environment (Caspersen and Olafsson, 2010). According to Choumert and Salanie (2008) landscape is an important part of nature that attracts economic value to land, which is driven by the perception of the natural features, often referred to as space, and the cultural features often referred to as place? However, anthropogenic activities (Mining and Quarry) have affected the terrain of the environment leading to loss of landscape like land slate/land degradation, deforestation, and loss of rocks (Gasparovic *et al.*, 2009).

The physical and chemical impact of the quarry is more pronounced in the slopes of hills and mountainous areas, and the resultant degradation of the landscape may last longer even after decommissioning the quarry activity (Hempen *et al.*, 2007). Ming'ate and Mohamed (2016) in Kenya, assess the impact of quarries on the land. Revealed that although quarry activities are the major financial support to Quarries Company and some residents, it has destroyed the environmental landscape in high magnitude on the other hand. This study also revealed that unauthorised earth mining and disrespect of nature harm the environment.

2.3 Conceptual Method of Dust Mitigation

Tree planting is a mitigation process for controlling dust impact on human health, they are known as a carbon sink, Legwaila *et al*. (2015) reconstruction of mined regions is a vital part of gravel mining. To achieve suitable mining with a lesser impact on the environment, there must be reconstruction, robust corporation amongst the company holders, Government and the people is very critical. Reconstruction methods that start from designing to aftercare allow the dilapidated land and environment to revert to its original stage such as agriculture/afforestation transformed into a realisation area (Tongway and Ludwig, 2011).

2.3.1 Dust barriers (tree planting)

Dust control varies from the act of pouring water on stone before crushing or planting of trees in place of appropriate barricades to help safeguard residential areas. The totals, rock quarrying in California Company made trees fence partitions around the quarry site to remove/adsorption dust particles from getting to the rural settlement. Reuben (2014) also validated a version of how '*pennisetum purpureum'* vegetation could be used as a carbon sink to trap dust from the quarry site. Figure 2.3 shows the energetic quarry site and dust produced during numerous activities. Wind carrying dust particles in the direction of a residential neighbourhood can be prevented by trees.

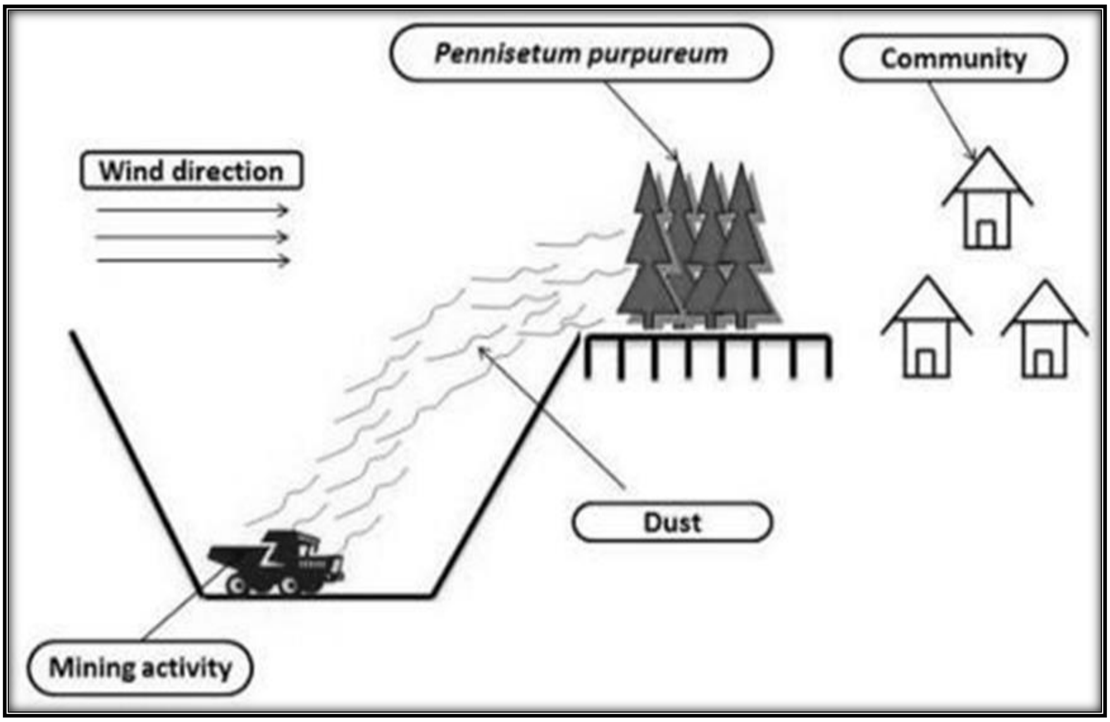


Figure 2.4: Dust Barrier Model
Source: Mbandi (2017)

2.4 Environmental Policy in Nigeria

National Environmental Policy (1989), spelled out the following goal/objective of the environmental standard to be considered by developers, before the commencement of any development on the environment (Anago, 2002) cited in (Ndayako, 2018)

1. Safeguarding the environmental quality for healthy and human wellbeing,

2. Saving the environmental resources for the generation to come,

3. The functionality of any region depends on the safety of bio-diversity. Therefore, the maintenance, restoration, and enhancement of natural resources become an optimum priority of policy,

4. Promoting public awareness on the link between development and the environment and

5. Universal co-operation with national and international organizations within the protection of the atmosphere is also the aim of this policy.

The environmental laws/policy in this context covered; both bi/multi-lateral agreement/convention on regulations and bye-laws which is applied in the human environment. These laws can also be seen as a National and International Agreement/ Convention of environmental protection. The following are some conventions held to protect the environment from harmful human activities, such as:

1. 1968 African Convention on conservation of Nature and National Resources,

2. 1972 UN Conference on the Human Environment (Stockholm Declaration) integrity,

3. 1976 Vancouver Conference on Human Settlement,

4. 1985 Vienna Conference on Protection of the Ozone Layer,

6. The 1993 Lugano Annual Convention on Civil Liability, was held to control human dangerous activities that are capable of destroying the environment and

7. (Habitat II) Conference has held in Instanbul in 1996, title Humanoid Settlements which links to excellence living with the construction of environment and drinking water.

2.4.1 1999 Constitution on environmental protection

Section (20) of the constitution charge all state of the Federation with the responsibility to safeguard and protect the environmental components, such as land, forest/vegetal cover, water, air, and wildlife to increase the value of the environs. Also, section 16, sub-section 2 of this constitution said the State will guide its plan concerning safeguarding a sustainable environment. In 1979 Nigerian environmental legislation act was established, to regard the prevention and control of pollution. However, this law today has so far recorded several numerous achievements. In the area of environmental resource deployment and ecological protection in Nigeria (Nwachukwu *et al.*, 2013).

2.4.2 Regulatory control measures on mining/quarry

Nigerian Mineral and Mining Regulation Act 2007 as Amended in 2011, and National Environmental Standard and Regulations Agency (NESREA) Act 2011 provide regulation to control mining activities. The objective of these regulations as provided for under regulation 2 which is to control the effect of mining/quarrying and blasting operations on the environment and human health.

Section: (67) of Plateau State/Nigerian Mineral and Mining Regulation Act 2007, as Amended 2011, provide guidelines for quarry lease/application, Section (68) provide guidelines for quarry application, Section (69) provide guidelines for restrictions on the quarry grant lease, Section (70) provide form of quarry lease, Section (71) duration of the lease, Section (72) Renewal of quarry lease, Section (73) term of validity of quarry lease, Section (74) relinquishment of quarry lease area, Section (75) enlargement of the quarry lease area, and (76) quarry lease reports.

Section: (1-4) of this Act and Part VI of Quarrying Section (76-78) itemized the regulation control measures for Mining/Quarry titleholder under section (21) of the Act. The ministry/agency subject to this Act shall make regulations in respect of any matter required to the prescribed control measures and shall be headed by an establishment department, purposes of carrying out his functions under this Act such as mines inspectorate department, (NESREA) and mines environmental compliance department respectively. The Regulations aim to: (a) Prevent environmental degradation, (b) Ensure the use of environmentally friendly technologies in quarrying operation and (c) Sustain the quarrying capacity of the Nigerian land in particular and the environment in general (Ezekwe *et al.*, 2016).

2.4.3 Setback and buffer control laws

EIA Decree (1992) cited in Gbite (2004) any titleholder seeking a permit to mine raw/construction materials like sandstone, silica, aggregate quartzite, marble, and limestone, for construction of dams, roads, railway lines, and other engineering works. Must have a minimum of 500 metres radius setback from the existing residential and commercial land use.

The Federal Ministry of Environment (FMEvn's) and National Environmental Standard and Regulations Agency (NESREA) are responsible for any mining permit/licenses, as stated in decree 86, of 1992 EIA law, section 64, subsections 11 and 14 of (EIA Law, 1992). This Decree established that Quarry Permit shall be granted for the quarrying of all quarry minerals such as china clay, marble, asbestos, limestone gypsum, sand, stone, and gravel as may be indicated in the permit issued. The quarry permit is granted to an area of 5 square kilometres for 5 (Five) years which is also subject to renewal, each of 5 (Five) years and there is no limitation to the number of renewals.

2.4.4 Environmental standard (WHO and FMEvn)

Standard is referring to as a permissible level of gases allow in the air, water, and soil, for example, the amount of deposition level, that is approved by a governing body. The formulation of the standard involves the following elements: policy measure**,** information control techniques**,** the data used to derive information, and the value to be linked by the regulation. The mathematical assessment of a standard might contain a permitting number of the above names (WHO, 2015). Table 2.2 shows that 250 (µg/m3) have the highest substance permissible level of particulates in the air, Non-methane Hydrocarbon has 160 (µg/m3) permissible emission substance into the air, CO has 0.0114 (ppm) emission level, SO_2 has 0.1 (ppm) emission limit and NOX have 60 (µg/m3) limit.

Table 2.2 Ambient air quality standard in Nigeria

Pollutants	**Emission Limits**
(SPM)	0.25 (ppm)
(SO_2)	100 (µg/m3)
NMH	0.16 (ppm)
(CO)	0.0114 (ppm)
(NO_2)	60 (µg/m3)
Photochemical Oxidant (PO)	60 (µg/m3)

Source: FMH 2008

Table 2.3 shows that suspended particles' acceptable limit in the air is 75 (µg/m3), when 76-230 (µg/m3) is moderate and when 231-600 (µg/m3) the air is polluted.

Table 2.3 Classification based on total suspended particles (TSP) values

Series of Total Suspended Particles Standards (µg/m3)	**Level of Ambient Air Quality**
0 – 75	High Quality
76 – 230	Moderate Quality
231 – 600	Poor Quality

Source: FMH 2008

Table 2.4 shows that effects on health, soil and materials damage, climate and visibility effects and non-human biological effects of SO_2, SO_4 and other particulate matter in the air have been represented respectively.

Table 2.4 **Alternative potential benefit categories of SO_2 national ambient air quality standards**

	SO_2	**SO_4**	**Other Particulate Matter**
Direct effects on health			
• Mortality due to chronic exposure	NP	NP	NP
• Mortality due to acute exposure	E	NP	NP
• Morbidity due to chronic exposure	NP	NP	E
• Morbidity due to acute exposure	E	NP	E
Soiling and materials damage			
• Residential facilities	E	NP	E
• Commercial and industrial facilities	NP	NP	NP
• Government and institutional facilities	NP	NP	NP
Climate and visibility effects			
• Local visibility	NU	E	NP
• Non-local visibility	NU	NP	NP
• Climate	NP	NP	NP
• Visibility at parks	NU	NP	NP
• Transportation safety	NU	NP	NP
Non-human biological effects			
• Agriculture	E	NP	NP
• Forestry	NP	NP	NP
• Fishing	NP	NP	NP
• Ecosystem	NP	NP	NP

Source: Bachmann (2007).

Table 2.5 shows the permissible decibel (dB) level of noise in the environment are 109 dB (C) for hospital, school and convalescent home area, 14 dB (C) for any residential buildings used and 70 dB for any industry, commerce or small scale production area in the day time, while in the night 60 dB is permissible.

Table 2.5 Permissible limit for noise level

Facility	Limit Value in dB (C)
For any building used as a hospital, school, Convalescent home, old residential building	**109 dB (C)**
For any building in an area used for Residential	**14 dB (C)**
Commerce, production, entertainment or any residential apartment in an area that is used for purposes of industry, commerce or small scale production, or any building used for the industry, commerce or small scale production	**70 dB Day** **60 dB Night**

Source: NENVSCR (2013)

2.5.1 Method of environmental impact assessment

There are several methods of assessing the impact of human activities on the environment which include: Mathematical models, Matrices and interaction diagrams, Expert judgment, and Quantitative physical. These models are fully discussed below.

2.5.2 Mathematical model for impact assessment

A mathematical model is a technological approach used to determine the extent of the impact or effect of human activities on the environment. Table 2.6 shown the components of the environment, their possible physical effects and the available models for assessing the impact.

Table 2.6 Physical effects of quarrying activities on the environment and their impact model assessment

Issue	Physical Effects	Available Model Of Assessing Impact
Noise	Noise production by excavation and transport; air blasting	Empirical distance-based algorithms, analytical models or numerical integration of the wave equation (for non-impulsive sources); acoustical equivalence modelling for impulsive sources
Air pollution	Production and dispersion of particulate	Box models, Gaussian models, lagrangian or eulerian integration of the dispersion-advection parabolic equation
Surface/groundwater	Hydrological and hydro-morphological effects; increase in sediment load to streams; potential pollution due to wastewater from mineral treatment plants	Empirical models(e.g. Universal Soil Loss Equation); mass balances; distributed physical models in hydrology; quality models in surface and groundwater (e.g. QUAL2E, MT3D)
Soil/land	Slope instability in the waste disposal and excavation sites, induced slope instability due to morphological modifications; vibrations	Geo-mechanical models for slope stability (probabilistic, deterministic); empirical vibration propagation models (es. IRSM)
Landscape perception	Visual impacts due to excavation fronts and plants	DTM analysis and view shed extraction; projective geometrical analysis; photographic simulation and virtual reality
Landscape ecology	Ecological disturbance due to modifications in landscape pattern	Analysis of landscape ecological patterns and their modifications based on synthetic indicators; disturbance and resilience predictive modelling; multi-criteria transformation evaluation
Socio-economics	Employment and socio-economical induced effects	Ad hoc analyses, descriptive statistics.
The stock of natural resources	Reduction of local stocks (soil, geo-mass, biomass)	Mass balances, ad hoc evaluations

Source: (Berry and Pistochi, 2015)

2.5.2 Matrices and interaction diagrams

This is commonly applied in impact assessment matrices. The method is shaped in a table form for a simple/easy impact within the issue in the vertical line and horizontal line. This technique assesses the effect of projects at all levels that is their procedure and conclusion of all the components surrounding the environment. This method is capable of showing measurable data, like the quantity of waste created, water quality records in a classification representative such as higher impact, moderate impact, and low impact. Data entering is strictly based on the already mentioned technique and the benefit of using that is to give a straight understanding illustration on all the impacts.

Environmental Impact Assessment (EIA), have various categories of matrices used to assess impact-related problems that are associated with construction industries. These types can be recorded as 88 environmental characteristics, 100 diverse project activities within one axis and stipulations along with the other, consisting of factors of bio-physical and socio-economic environments (Impact Assessment Methods, 2011).

2.5.3 Rapid impact assessment matrix (RIAM)

Is it a methodical strategy that used subjective statistics to expressed data in a semi-quantitative technique? The RIAM technique makes use of a multi-punitive group to establish the method that is communicating and logical to encourages input at some point in time (Inter-American Development Bank, 2010) cited in (Impact Assessment Methods, 2011).

This scheme is feasible and capable of creating an effect on the profile he licenses the expert to improve in the development of this section. RIAM used environmental factors like biological, physical and chemical to analysed and classify huge positive and negative changes caused by the development and established a standard for checking plan, mitigation techniques and assessment structure to control the efficiency of the mitigation techniques. Based on this system, community input is considered in the data collection and implementation phases of the development. These phases are immediately accompanied by way of exceptional regulatory measures at some point in the examination and database checking steps.

The multi-disciplinary group accepts information within special areas to be analysed at an equal period in one frequent matrix. An assessment between the two most significant effects project may consequently end possible. This matrix is also used to compare group distinctive development decisions on how the environmental factors of the surroundings can be added to action (Impact Assessment Methods, 2011).

2.5.4 Cumulative impact assessment

It is used to assess the accumulative effects of the already mentioned impacts. Various and common impacts from the current trends of environmental consequences surrounding the people than every one of the developments separately. This can also end the enormous cumulative impacts; such as increases in pollutant concentrations in the air the flora and fauna (USAID, 2011).

2.6 Reviewed of Relevant Studies on Quarry Impacts

Abdul-Wahab *et al*. (2014) studied the impact of Miller Brae's side Quarry expansion on-air in Ontario Canada, used the flowchart to classify the diffusion of the total suspended particulate (TSP), and then compared concentrations of (TSP) with Ontario's Ministry of Environment (MOE) standard. The result revealed that the wind sprinkling designs on a daily wind frequency by the winding track, with coloured bands demonstrating wind rapidity variety. The distance of each bar shows the airstream frequency raging from that exact track. The various coloured hue shows the diverse wind rapidity variations that happened in that direction during the day and the segment of those that blew at a positive rapidity. Thus, the longest bar shows the wind direction with a peak concentration and the longest band on the bar shows its main wind rapidity as indicated in Figure 2.5.

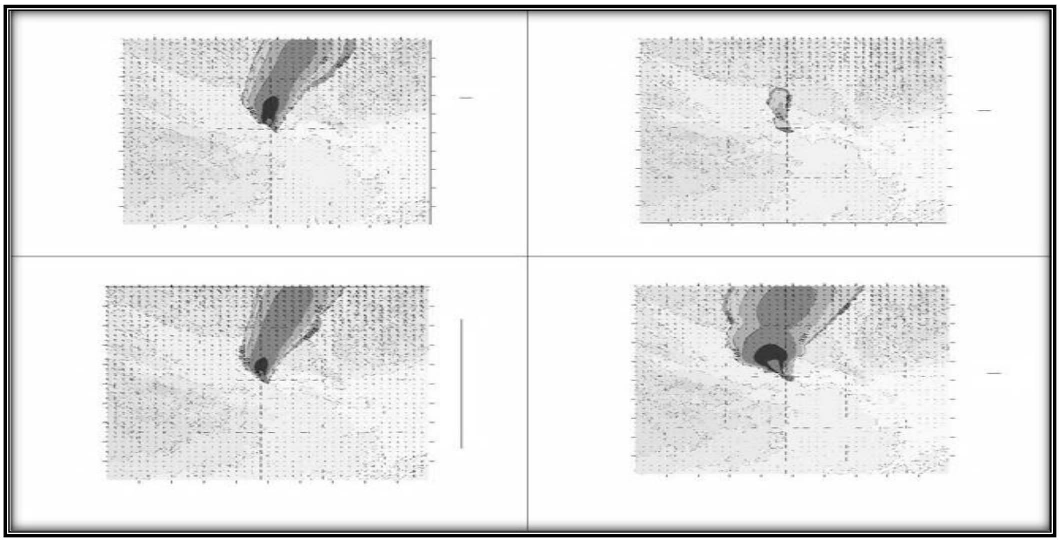


Figure 2.5: Wind Frequency Direction Coloured Bands Indicating Speed Range
Source: (Adul-wahab *et al.*, 2014).

The diffusion modelling, classification was used to assess the extreme ground-level concentrations of TSP discharged from the quarry location. The discharges for 4 days in one year were observed for different periods. The results were compared with the total suspended particulate permissible limits of (MOE) standard, shows that concentrations TSP result significantly exceed the standard limit. Therefore, the settlements are liable to be affected by the quarry activities TSP emission. Mbandi (2017) worked on the impact of Quarry in Kenya. Aimed at assessing the resultant effects of stone mining on the physical environment. Through determining the impact of stone mining on the flora and scenery, inspect health issues persistent among the quarry workers and the residence and provide positive steps to moderate ecological outcomes caused by quarry activities in Kitengela. The study shows that there is a negative correlation between quarry activities and environmental degradation and no significant relationship on the severity of buildings and residence health respectively. This study also shows that environmental degradation in Kenya is associated with quarry activities, therefore recommended that strict enforcement of regulatory measures should be adhered to, to mitigate the impact of quarry on the environment.

Oyinloye and Ajayi (2015) carried out a similar study in Ondo State, Nigeria. To examine the impact of quarry on the environment and health of the residents, in Oba-Ile, with control of 1km radius. Used Structured questionnaire, field observations and ArcGIS software to acquired information on socioeconomic; building damages, vibration shock effects, and health effects and the extent of land affected by the pollution were assessed. The result revealed that the impact of quarry in air, water, and soil in the study area is highly significant and refers to a major cause of the environmental problem in Oba-Ile.

2.7 Lesson Learnt from the Reviewed Literature

The case study reviewed shows that there are no human activities on earth that are free of impact on the environment, so environmental consciousness is important when harking on the environment and its components.

2.8 Summary of the Reviewed Literature

Many researchers have come up with different concepts in diverse areas of quarry activity and impact on the environment, which have been grouped into; Theoretical and conceptual frameworks. However, for this study conceptual framework was adopted, to explain the impact of stone mining/crushing on the physical environment as indicated in Figures 2.3 and 2.4. Impact assessment can be traced back to the Environmental Protection Act of 1969 and other international and national laws of Environmental Impact Assessment. The impact of the quarry can be assessed using Matrices and interaction diagrams, Expert judgment, Quantitative physical and mathematical models, Cumulative impact assessment, Rapid Impact Assessment Matrix (RIAM) and Battelle Environmental Evaluation System.

This study reviewed the literature on the impact of quarry activities on human health, air, soil, eco-diversity, dust, vegetal cover, and vibration shock, using techniques, methods, and models. However, the techniques, methods, and models used are absolute instrument system (AIS), purposeful sampling techniques, and structure questionnaire techniques. The analysis was done using quantitative, qualitative, scientific base, Laboratory, Analytical-grade reagents, metal stock standard solution and descriptive. While the impacts were determined with the box model, expert judgment, and mathematical models and subjected to a table of standards for the check. The summary shows that the revealed literature plus or minus, quarry have a significant impact on the environment. Therefore, a need to revisit the regulatory frameworks on mining/quarry, to introduce new mitigation measures and a buffer zone of 2-3km radius, to barricade human settlement from any mining/quarry pollutant, since a gap has been established by (Oyinloye and Ajayi, 2015) that even at 1-km buffer pollutants from the quarry are significant.

2.9 Gaps Identified as they Relate to the Study

The reviewed literature identified that in the area of regulatory measures/compliance, (Sulphur Dioxide (SO_2), and Suspended Particulate Matter (PM10) there is little or no direct research in the area of which this study is trying to fill. Because it gives the most reliable result for the gap identified in the knowledge breach.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Research Design

This study is descriptive research that involved the use of quasi-experimental and quantitative data. Data were collected through field surveys with a structured questionnaire, interview guide and android phone for subjective information like people's perception of the impact of quarry on the environment. While quasi-experimental data were also acquired through measurement with handheld GPS Germime 79, Probe Toxic Gas Analyser model TG/501, and ATP 901A Sound meter (Dosimeter) to acquired objective information. Such as coordinates of the site, air quality test, and noise level test. The data acquired were sorted and analysed according to the standard.

3.2 Sources of Data

The data used for this study are processed and unprocessed data, from biodata, remote sensing data, ambient air quality data, population data, relief profile data, site characteristics data, sound/vibration data, soil data, and noise level data. This data was sourced from primary and secondary.

Primary Data Required

Primary data that was used for this research are;

i. Biodata: Village name, sex, age and occupation of the residents.
ii. Impact of quarry activities on the environment: such as air pollution, sound pollution, and vibration effect.
iii. Quarry company/site characteristics: coordinate, soil characteristic, relief profile, level of compliance of the quarry industry and method of mining.

Secondary Data Required

Secondary data that was used for this study are;

i. The population of the study area: Sourced from building count on Google earth.
ii. Satellite/Landsat images and digital elevation model (DEM): Sourced from the United State Geological Survey (USGS)
iii. Standards and regulation control measure: Sourced from the World Health Organisation (WHO), National Environmental Standard and Regulation Agency (NESREA).

3.3 Instruments for Data Collection

The data for this study were collected with the following instruments: Such as structure questionnaire, guide interview, android phone, handheld GPS Germime 79, Probe Toxic Gas Analyser model TG/501, Internet, and ATP 901A Sound meter (Dosimeter). All the instrument is detailed discussed below:

(i) Structured questionnaire

Open and closed-ended questionnaires were designed to collect data for this study and it was grouped into two sections; named A and B. Section "A" which is the closed-ended questionnaire covered the bio-data information while section "B" which is open, covered the people perception on the impact of quarry activity on their environment.

(ii) Interview guide

The interview guide was designed to collect useful and direct information on the company compliance level to regulatory measures, year of establishment and method of the quarry. This information was acquired through a checklist approach.

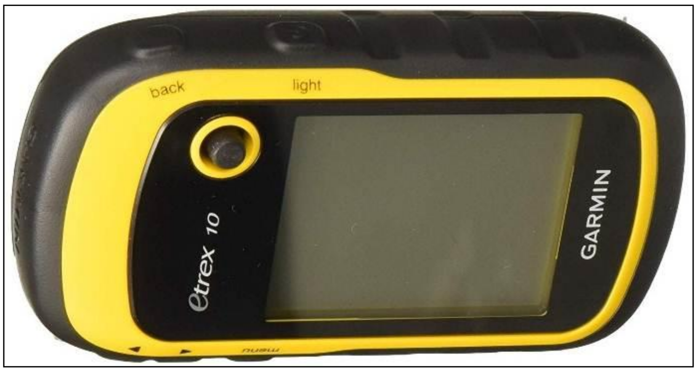
(iii) Android Phone Nokia 5

Nokia 5 is an android phone with a camera device that was used to snap pictures of the affected buildings and other environmental features damaged by the activities.

Plates XIII: Nokia 5
Source: Author’s (2019)

(iii)Handheld GPS

Garmin Etrex 10 is a geophysical positional system device that is used for taking coordinate information of features or locations. This instrument was used to take coordinates of the six villages, air sample location, noise sample location and buildings affected by the vibration.



Plates XIV: Garmin Etrex 10
Source: NESREA (2019)

(v) Plates XV: Probe Toxic Gas Analyser Model TG/501

Probe Toxic Gas Analyser is a portable gaseous device with a probe, for assessing the level of pollutants in the air. This analyser assesses gases and suspected particles in the air the device is known of capable of detecting eight sensors, which can be shown on the screen the readings for eight different gases such as Nitrogen Dioxide (NO_2), Sulphur Dioxide (SO_2), Suspended Particulate Matter (SPM $_{10}$ and $_{2.5}$), Ammonia (NH_3), Hydrogen Sulphide (H_2S), Carbon Monoxide (CO), and Volatile Organic Compounds (VOCs). Probe Toxic Gas Analyser model TG/501 was used to measure the concentration of chemicals substances in (ppm/ ug/m3).

Plates XV: Probe Toxic Gas Analyser Model TG/501
Source: NESREA (2019)

(vi) ATP 901A Sound Meter (Dosimeter)

A dosimeter is a device which was used to measure the noise decibel level generated by quarry drilling, blasting and crushing using the ATP 901A Sound metre. The reading was measured in decibel (dB) and subjected to the NESREA standard.

Plate XVI: ATP 901A Sound level metre
Source: NESREA (2019)

3.3 Study Population

The 2006 National Population Census does not account for the household population at the neighbourhood level, rather at the LGA level. Therefore, it is difficult to generate a population of the study area. However, the sample frame was determined using a surrogate approach, to estimate the numbers of buildings in the study area and the process is discussed below:

The Google image of the study area was acquired buffered at a 1.5 km radius and digitised to count the number of buildings, using Geographical Information System Software (ArcGIS). The number of buildings counted is 1078. Using 80% of the total buildings count for residential use and 20% for other uses. The 80% of 1078 buildings is calculated below and multiplied by the national household of 6 to acquire the population of the study area as shown below: $80 \times 1078 \div 100 = 86240 \div 100 = 862.4$

$$862.4 \times 6 = 5174.4$$

3.5 Sample Size

Using Dillman *et al.* (2007) sample formula to obtain a sample size.

$$Ns = (Np)(p)(1-p) \div (Np-1)(B \div C)2 + (p)(1-p)$$

Where:

Ns = is the sample size,

Np = is the population size (5174.4)

P = is the proportion expected to answer a certain way (0.5)

B = is the acceptable level of sampling (0.05)

C = Z static associated with confidence interval (1.960=96%)

Ns = (5174.4) (0.5) (1-0.5) ÷ (5174.4-1) (0.05÷1.96) 2+ (0.5) (1-0.5)

Ns (1293.6) ÷3.61669616826323 = 357.62

Ns (Sample Size) = 357

357÷6 = 59.5 which arrived at 59.5 questionnaires per village.

3.6 Sampling Techniques

Three hundred and nine (309) questionnaires were retrieved out of 357 administered due to poor responses from the respondents, as a result of the clashes between farmers and Fulani herdsmen. Using a random sampling technique in the selected households within a 1.5 km radius. The questionnaire was administered to household heads and where there is no household head the first child fills the questionnaire. The questionnaire was administered directly to the respondents, while in some cases where the respondent is busy we leave the questionnaire with him and when he is done we get back. The fieldwork was done by the researcher and two research assistance (well trained), for an effective and better understanding of Beroom language which helped communicate with farmers of low level of English language in the study area and addresses the bio-data of respondents, the effect of quarry activities on their physical environment and health. The questionnaires were administered. All data collected were carefully analysed with Computer-Aided Packages (CAP), such as Statistical Package for Social Sciences (SPSS) software.

3.6.1 Air quality and noise level sample location

Probe Toxic Gas Analyser TG/501 model was used to assess the ambient air quality and ATP 901A Sound metre was used to measured decibel (dB) level. The concentration of particulate and noise level in the study area was measured in eighteen (18) different sample locations, at an interval of 100 meters respectively, using four cardinal points, such as N-1, S-1, E-1, W-1 and N-2 respectively during operation hour in the morning, as indicated in Table 3.1. While in the evening after the operation hour the concentration of gasses and noise level in the study area was also measured in twenty (20) different sample locations, at the same interval of 100 meters respectively, using also the same four cardinal point, such as N-1, S-1, E-1, W-1 and N-2 respectively as indicated in Table 3.2.

Table 3.1: Coordinates for air quality test and noise level during operations

Location code	Easting	Northing	Interval (m)
N-1	8.717976	9.699101	100m
S-1	8.716	9.694	100m
E-1	8.711	9.695	100m
W-1	8.712	9.701	100m
N-2	8.719247	9.699681	200m
S-2	8.714	9.703	200m
E-2	8.709	9.696	200m
W-2	8.716	9.692	200m
N-3	8.720572	9.70029	300m
S-3	8.715	9.69	300m
E-3	8.708	9.693	300m
W-3	8.709	9.702	300m
N-4	8.722073	9.701007	400m
S-4	8.706	9.694	400m
E-4	8.714	9.689	400m
W-4	8.713	9.706	400m
N-5	8.724	9.699	500m
S-5	8.722	9.704	500m

Source: Author's Field Survey (2019)

Table 3.2 **Coordinates for air quality test and noise level after operations**

Location code	Easting	Northing	Interval (m)
N-1	8.71039	9.695233	100m
S-1	8.716	9.694	100m
E-1	8.711	9.695	100m
W-1	8.712	9.701	100m
N-2	8.709592	9.694706	200m
S-2	8.714	9.703	200m
E-2	8.709	9.696	200m
W-2	8.716	9.692	200m
N-3	8.708699	9.694084	300m
S-3	8.715	9.69	300m
E-3	8.708	9.693	300m
W-3	8.709	9.702	300m
N-4	8.70778	9.693462	400m
S-4	8.706	9.694	400m
E-4	8.714	9.689	400m
W-4	8.713	9.706	400m
N-5	8.724	9.699	500m
S-5	8.722	9.704	500m
E-5	8.705	9.694	500m
W-5	8.709	9.689	500m

Source: Author's Field Survey (2019)

The control was taken at a 1.5km radius, and the instrument was held at 1.5m above the ground and stability. Figures 3.1 and 3.2 show the sample location of ambient air quality and noise level measured during and after operation hour, using the four cardinal points North, East, South, and West, at an interval of 100 meters each. The Noise Level, Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Suspended Particulate Matter (PM10), and Carbon Monoxide (CO) concentration in the air was measured during and after the operation hour. During the operation hour, the air quality was measured around 10:25 am-2:25 pm, and after the operation hour, the air quality was also measured around 3:20 pm-6:25 pm, because the company operate from 8 am-12 pm and from 1:30 pm-3:00 pm daily, 5-6 days per week. The results were compared with the WHO and FMEVEN standards.

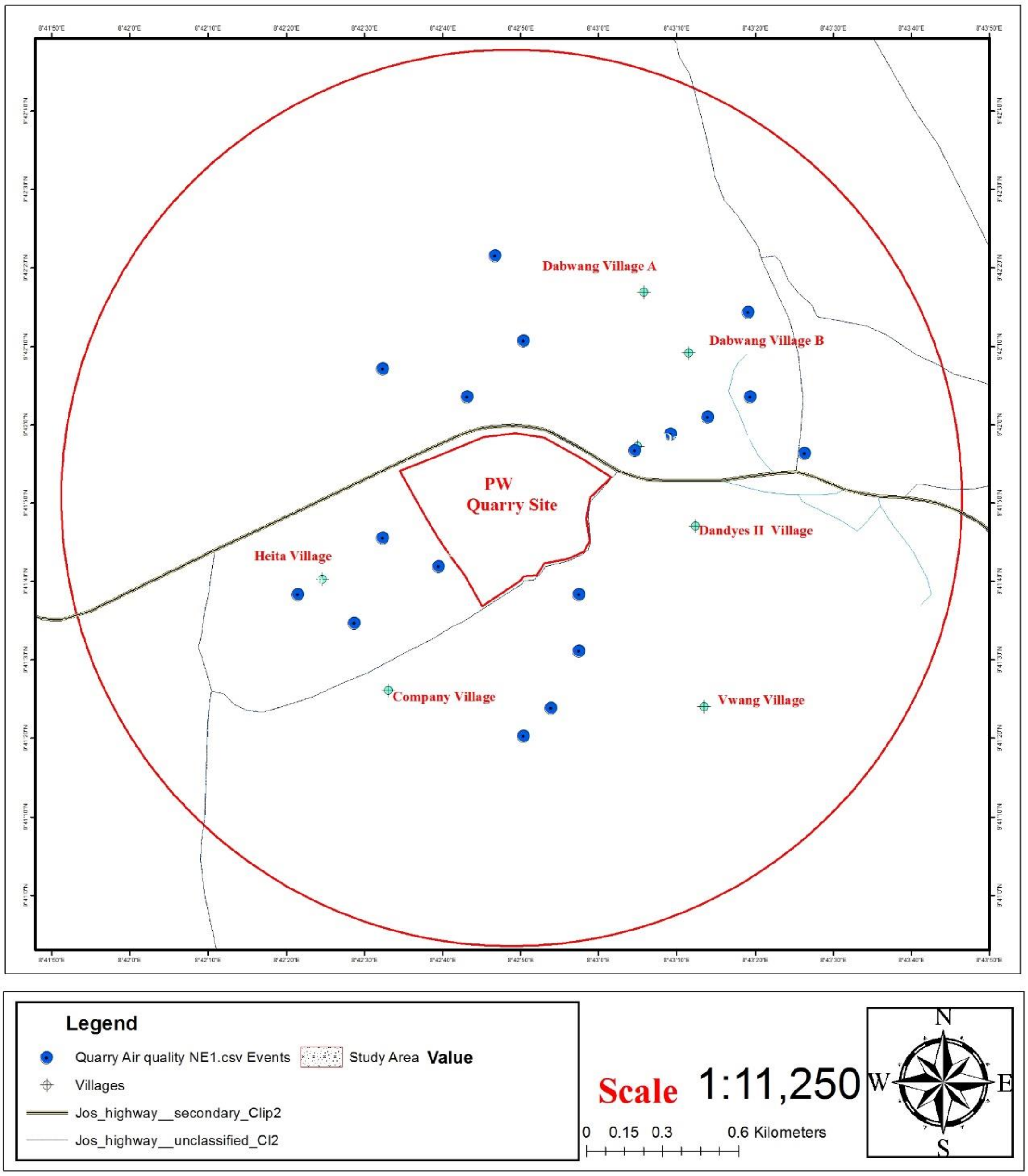


Figure 3.1 Air Quality and Noise Level Sample Locations during Operation Hours
Source: Author's Field Survey (2019)

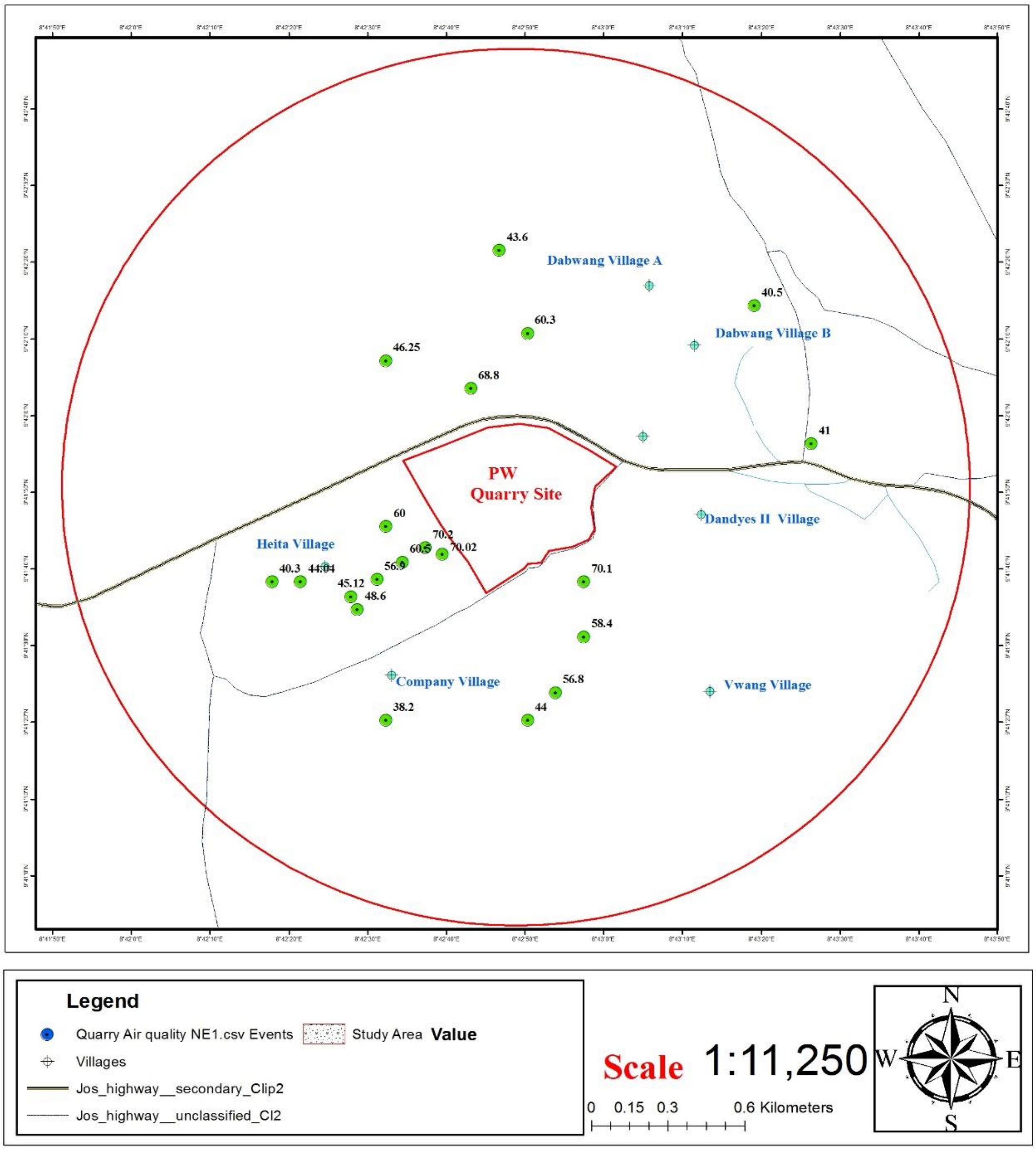


Figure 3.2 Air Quality and Noise Level Sample Locations after Operation Hours
Source: Author's Field Survey (2019)

3.7 Methods of Data Analyses

The data collected were analysed based on the objectives of the study, using descriptive analysis through the Statistical Package for Social sciences (SPSS), on-screen image interpretation Kriging model symbology (ArcGIS) software and comparative analysis was used for air quality and noise level, the results were compared with WHO and

FMEnv's standards as indicated in Table 3.3. The selections of these methods are from the revealed literature, in other to achieve reliable results.

3.8 Methods of Data Presentation

The result of this study was presented in maps, tables, graphs, and plates as indicated in Table 3.3.

Table 3.3 Methods of data analysis and data presentation

S/N	OBJECTIVE	DATA TO BE ACQUIRED	INSTRUMENT OF DATA COLLECTION	METHOD OF DATA ANALYSIS	METHOD OF DATA PRESENTATION
i.	Examine the site characteristics of the PW quarry and map the specific distribution of the sounding settlement.	Coordinate, the site/ surrounding settlements, satellite image and DEM of the Quarry site.	Handheld Garmin eTrex 10 GPS Unit (space platform)	GIS Maps/data plotting (on-screen image interpretation)	In Maps
ii.	Assessing the impact of the quarry activities on-air quality and noise level.	Air and noise data of the site	Probe Toxic Gas Analyser model TG/501 and ATP 901A Sound meter	Descriptive Statistics and Kriging model symbology	In Tables and map
iii.	Examine people's perception of the impact of quarry on buildings.	Information on the affected buildings and pictures	GPS, Android Phone and Questionnaires	Descriptive Statistics (SPSS).	In Tables and plates
iv.	Examine the compliance level of the PW quarry company to the (NESREA) and Nigeria mineral and mining regulation Act.	Relevant available laws and regulations on quarry/mining activities.	Secondary data, by reviewing relevant laws that protect the environment at International, National, State, and Local levels.	Frequency percentage of tables/signs and theme analysis.	In Tables

Source: Author’s Field Survey (2019)

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

This chapter is based on the discussion and presentation of data from the descriptive statistical tools and on-screen imagery interpolation method used for the analysis and the discussion, which are based on the itemized objectives.

4.1 Site Characteristics of the PW Quarry and Mapping of the Specific Distribution of Settlement around Quarry Operation Site

4.1.1 PW Quarry site and distribution of the surrounding settlement

The PW quarry site is located on the metal ore and granite outcrop is characterized by rocky area at the east, rocky/water body at the south, the rocky and gentle slope at the west, and flat/undulating land at the north pole. Figure 4:1 shows the site and surrounding 6 villages comprises Dandyes I at Northeast, Dandyes II at East, Dabwang A and B at North, Heita at Southwest and Company in the South. The settlements were mapped out using Handheld GPS coordinate data acquired during the site inventory.

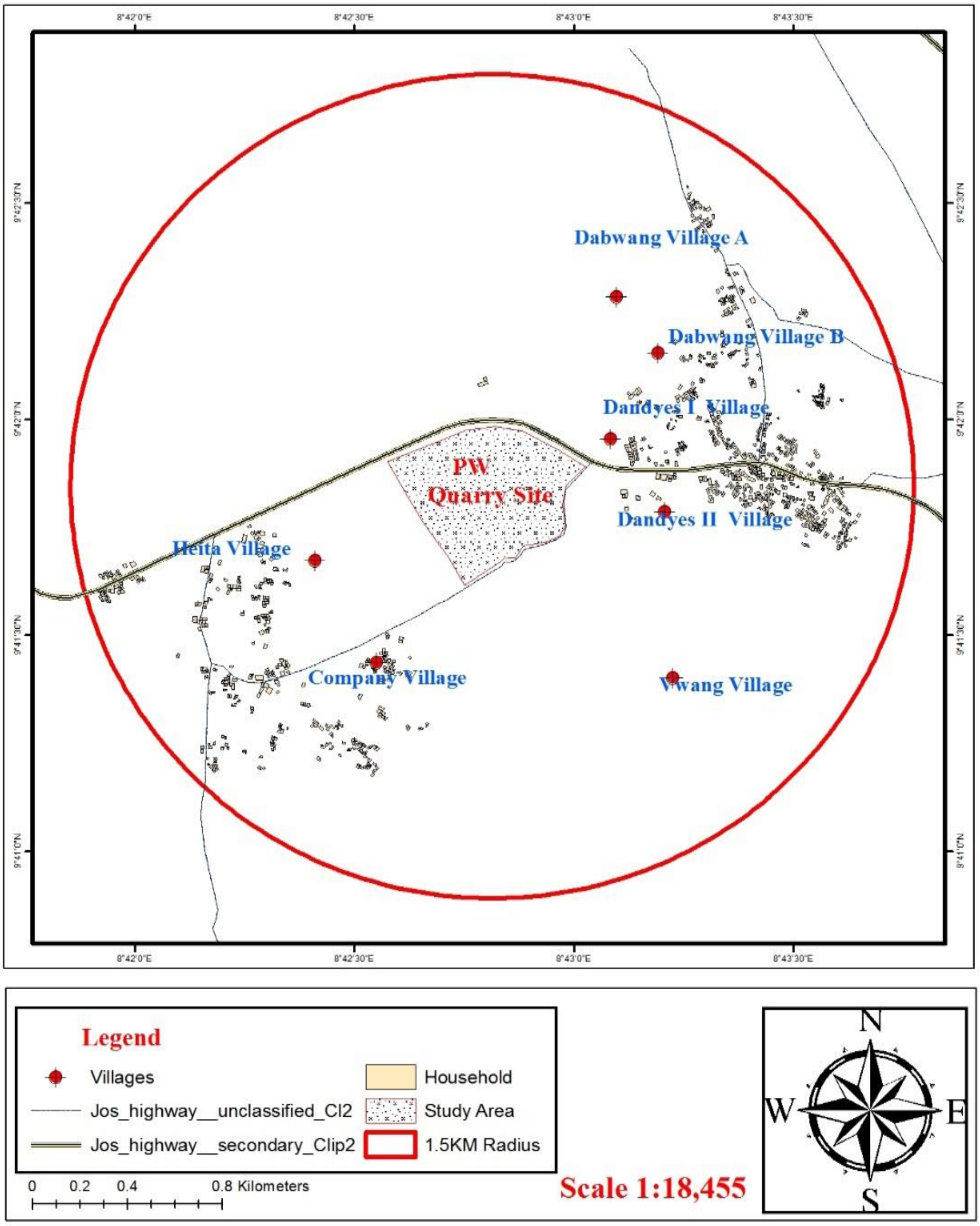


Figure 4.1: Distribution of the Adjoining Settlement
Source: Author's Field Survey (2019)

Table 4.1 shows the distance of the quarry site to the adjoining settlements, noise level, farmland loss, and water dumps. The site is capable of releasing sound (noise) and polluting the air.

Table 4.1 Effect of quarry on the nearby villages and their distance

S/N	Villages	Distance(M)	Noise(dB)	Water Dumps(m^2)	Farm Loss(m^2)
1	Dabwang A	785.4	35.2	0	122.31
2	Dandyes II	454.3	58.5	13.5	304.2
3	Dandyes I	106.9	87.3	8.2	406.8
4	Heita	845.8	25.4	22.3	410.6
5	Company	509.9	31.2	35.9	722.48
6	Dabwang B	1005.8	20.34	0	0
Total			40.57(MdB)	79.9	1966.39

4.1.2 Site characteristics of the PW quarry

The topography of the study area was divided into 4 sections A-A, B-B, C-C, and D-D across the surrounding settlements to show the relief profile of the quarry site and its relation to the as indicated in Figure 4.2.

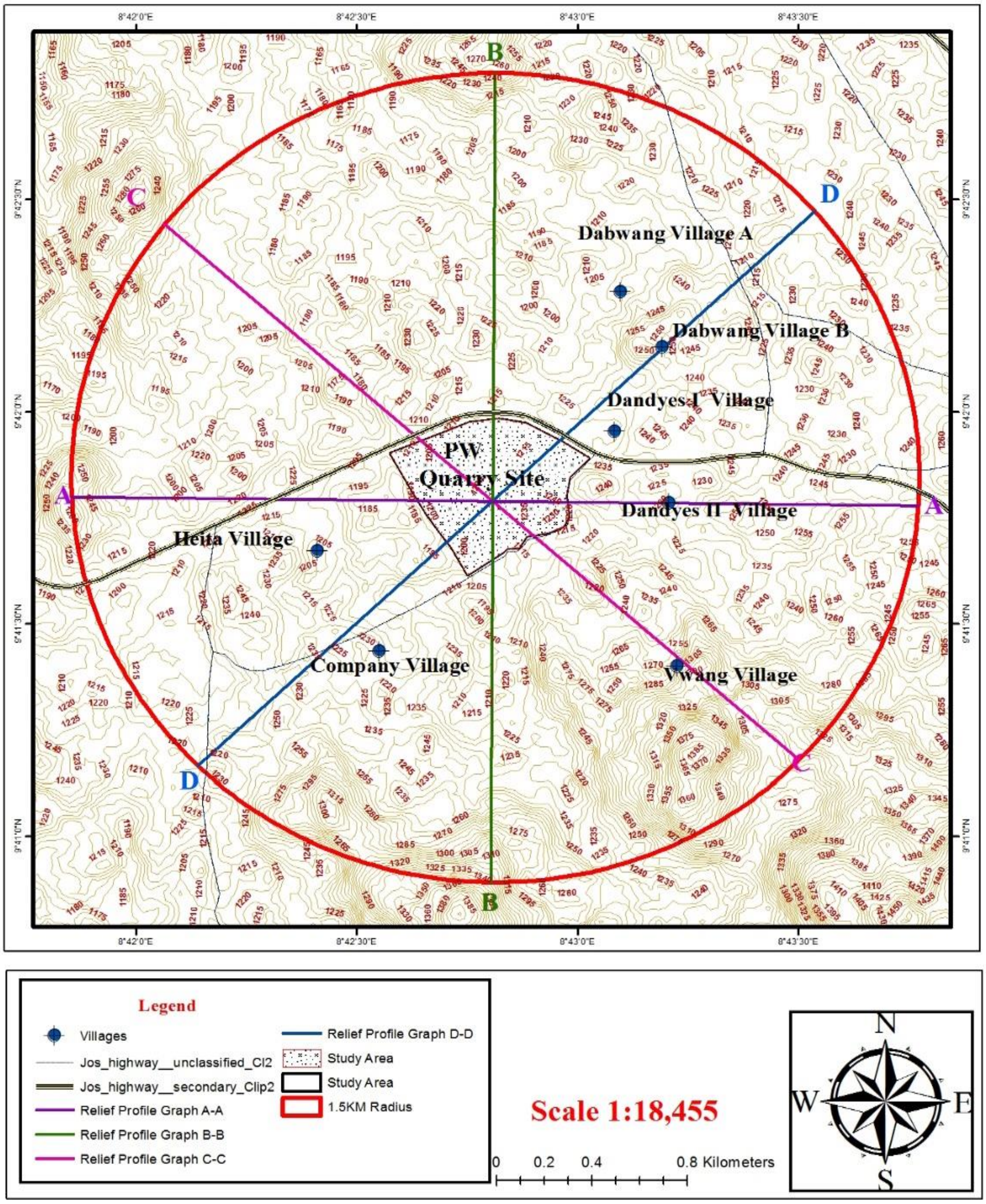


Figure 4.2: Topography of the Study Area
Source: Author's Field Survey (2019)

Figure 4.3 shows the relief profile of the quarry site and the adjoining settlement across section A-A. The profile was drawn from 8.6950038760E, 9.6966653251N to 8.7265770285E, 9.6966239448N at 1186.0 to 1238.3 metres height. It has a minimum elevation path of 1185.1 metres and a maximum elevation path of 1259.9 metres with a slope tilt of 0.87°.

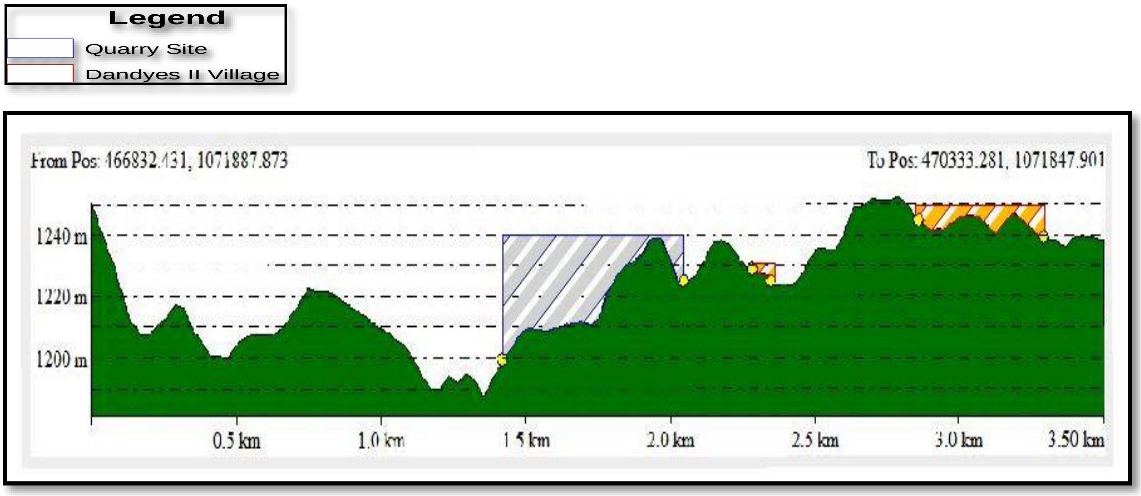


Figure 4.3: Relief Profile Graph Section A-A
Source: Author’s Field Survey (2019)

Figure 4.4 shows the relief profile of the quarry site and the adjoining settlements along section B-B. The contour was drawn from 8.7137491422E, 9.7130519154N at 1253.8 metres to 8.7130870577E, 9.6855340302N at 1230.5 metres, with a minimum elevation path of 1187.8 metres and maximum elevation path of 1253.8 metres with a slope tilt of -0.44°.

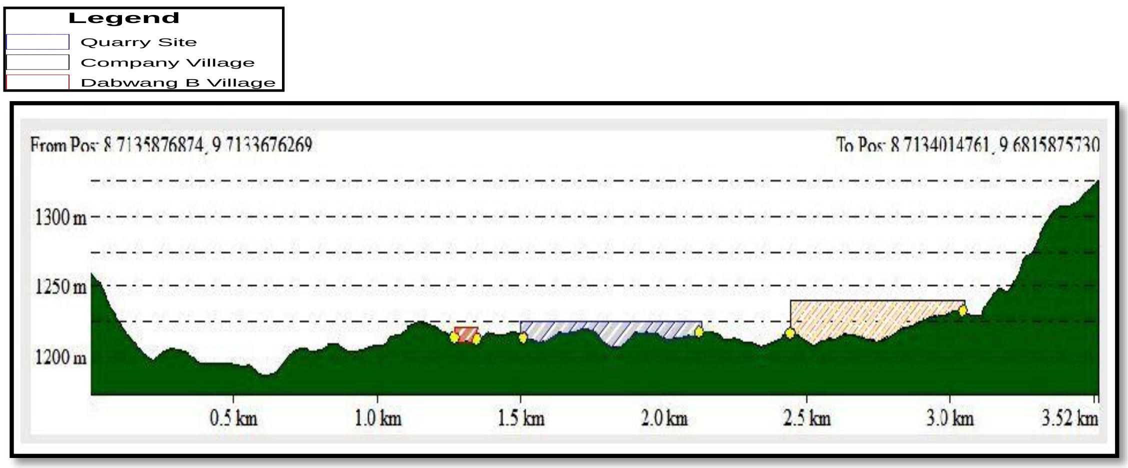


Figure 4.4: Relief Profile Graph Section B-B
Source: Author’s Field Survey, (2019)

Figure 4.5 shows the relief profile of the quarry site along section C-C. The relief was drawn between latitude 8.69438317188 and longitude 9.6873547624 at 1171.4 height to latitude 8.7316254225 and longitude 9.7063483103 at 1245 height, with a minimum elevation path of 1171.4 metres and maximum elevation path of 1246.5 metres and a slope tilt of 0.92°.

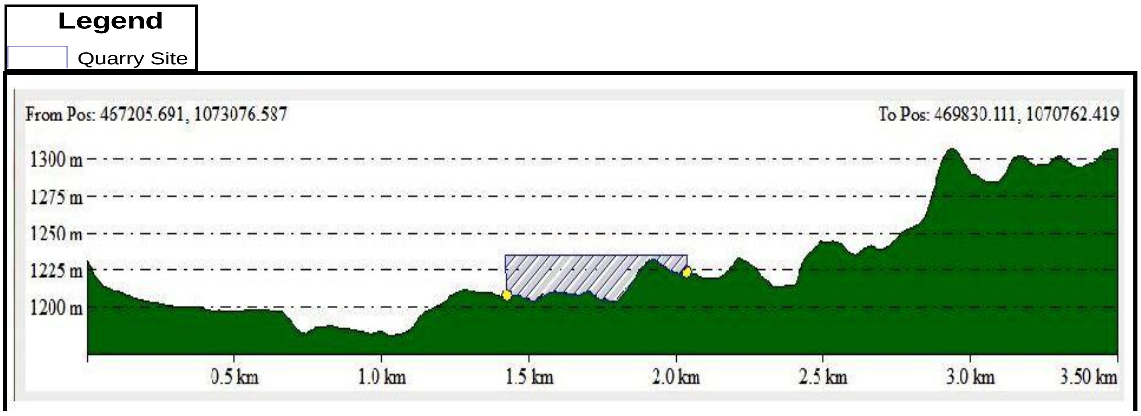


Figure 4.5: Relief Profile Graph Section C-C
Source: Author's Field Survey (2019)

Figure 4.6 shows the relief profile of the quarry site and the surrounding settlements along section D-D. The relief was drawn from 8.6972384111E, 9.7080862820N at 1181.7 metres to 8.7310047183E, 9.6862374949N at 1304.9 metres, with a minimum elevation path of 1174.1 metres and maximum elevation path of 1304.9 metres and a slope tilt of 1.60°.

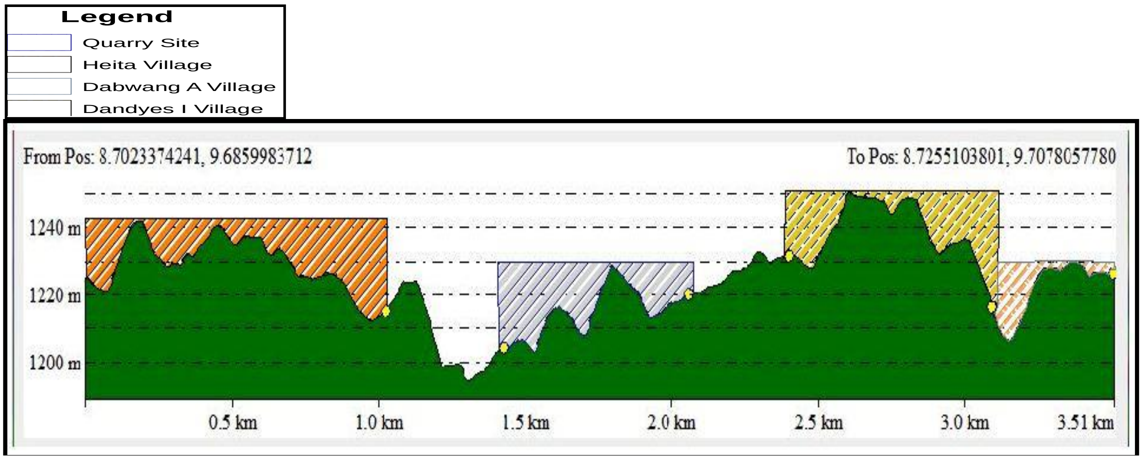


Figure 4.6: Relief Profile Graph Section D-D
Source: Author's Field Survey (2019)

4.2 Impact of Quarry Activities on Air Quality and Noise Level

4.2.1 Air quality assessment of the study area

The concentration of NO_2, SO_2, M10, and CO measured at each sample location shows the level of pollutants in the air. The field measurements were compared with the (FMEnv's) standard and the (WHO) standard. Table 4.2 shows the comparison between the field measurement and the permissible limit of each parameter (gaseous) in air. The results revealed that within the first sample location of the morning readings, which is during operation (N-1), (S-1), (E-1) respectively the concentration of NO_2, SO_2, and CO in the air is above the maximum permissible limit of (FMEnv's). While for SPM_{10} the concentration is within (N-1), (S-1), (E-1) and (N-2), (S-2) (E-2) respectively, the concentration in air is also above the permissible limit for (FMEnv's) standard. However, in the case of WHO standard almost all the parameters are above the permissible limit from sample location except for (CO) that is above the permissible limit at (N-1), (S-1), (E-1) respectively. The comparison result shows that the host communities have a high tendency of environmental pollution.

Table 4.2 Summary of ambient air quality assessment during operation

S/L	Interval (M)	SO_2 (μg/m³)			NO_2 (μg/m³)			CO (μg/m³)			SPM_{10} (μg/m³)		
		Fm	Me	Wh	Fm	Me	Wh	Fm	Me	Wh	Fm	Me	Wh
N-1	100m	**116.5**	+	+	**67.8**	+	+	**13.1**	+	+	**290**	+	+
S-1	100m	**114.2**	+	+	52.2	-	+	**13**	+	+	**286**	+	+
E-1	100m	**111.6**	+	+	43.01	-	+	**12.71**	+	+	**270**	+	+
W-1	100m	**113.5**	+	+	40	-	+	**12.94**	+	+	**275**	+	+
N-2	200m	93.18	-	+	40.2	-	+	7.56	-	-	**260**	+	+
S-2	200m	92.8	-	+	38.09	-	-	5.96	-	-	**257**	+	+
E-2	200m	90.18	-	+	38.01	-	-	6.81	-	-	228	-	+
W-2	200m	88.4	-	+	36.2	-	-	7.56	-	-	240	-	+
N-3	300m	70.26	-	-	35.01	-	-	2.07	-	-	185	-	+
S-3	300m	70.15	-	-	33.95	-	-	2.01	-	-	177	-	+
E-3	300m	68.55	-	-	30.04	-	-	1.87	-	-	180	-	+
W-3	300m	65.78	-	-	25.45	-	-	2	-	-	165	-	+
N-4	400m	56.06	-	-	27.23	-	-	1.15	-	-	130	-	+
S-4	400m	52.56	-	-	23.45	-	-	1.05	-	-	120	-	+
E-4	400m	55.04	-	-	23.08	-	-	1.16	-	-	125	-	+
W-4	400m	48.23	-	-	22.02	-	-	0.98	-	-	118	-	+
N-5	500m	39.06	-	-	21.33	-	-	80.5	-	-	100	-	+
S-5	500m	40.45	-	-	21.15	-	-	80.1	-	-	104	-	+
Mean Record		**77.03**	-	-	**34.35**	-	-	**14.03**	-	-	**195**	-	+
FMEnv's (ME)		**100 μg/m³**			**60 μg/m³**			**11.4 μg/m³**			**250 μg/m³**		
WHO (Wh)		**80 μg/m³**			**40 μg/m³**			**10 μg/m³**			**50 μg/m³**		

Key: where is (+) show that the concentration is above the permissible limit,
Where is (-) show that the concentration is within the permissible limit,
Where is (Fm) mean-field measurement?
Where is (Me) mean (FMEnv's) standard and
Where is (Wh) mean (WHO) standard?
Where is (S/L) mean Sample Location?

Figure 4.7 shows the spatial kriging interpolation model concentration of SO_2 measured during operation hours at an interval of 100 metres radius each by sample location. The results were shown in ‘stretched colour’ (red, yellow, light green and green). The red represents higher concentration, yellow minimum concentration while light green and green represented lower concentration.

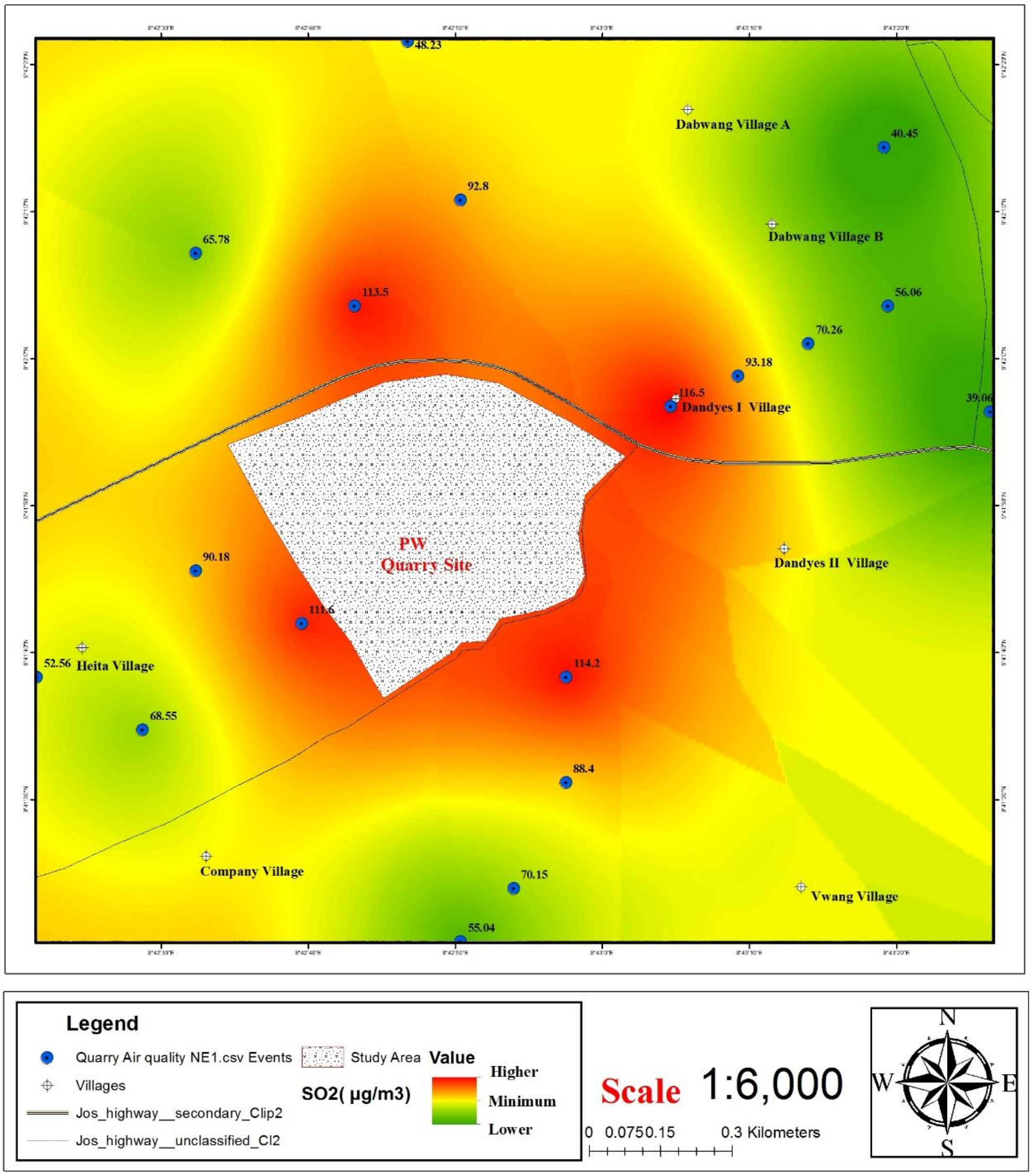


Figure 4.7: Spatial Kriging Interpolation of SO_2 Concentration in Air during Operation
Source: Author’s Field Survey (2019)

Figure 4.8 shows the spatial kriging interpolation model concentration of NO_2 measured during operation hours at an interval of 100 metres radius each by sample location. The results were shown in 'stretched colour' (red, yellow, light green and green). The red represents higher concentration, yellow minimum concentration while light green and green represented lower concentration.

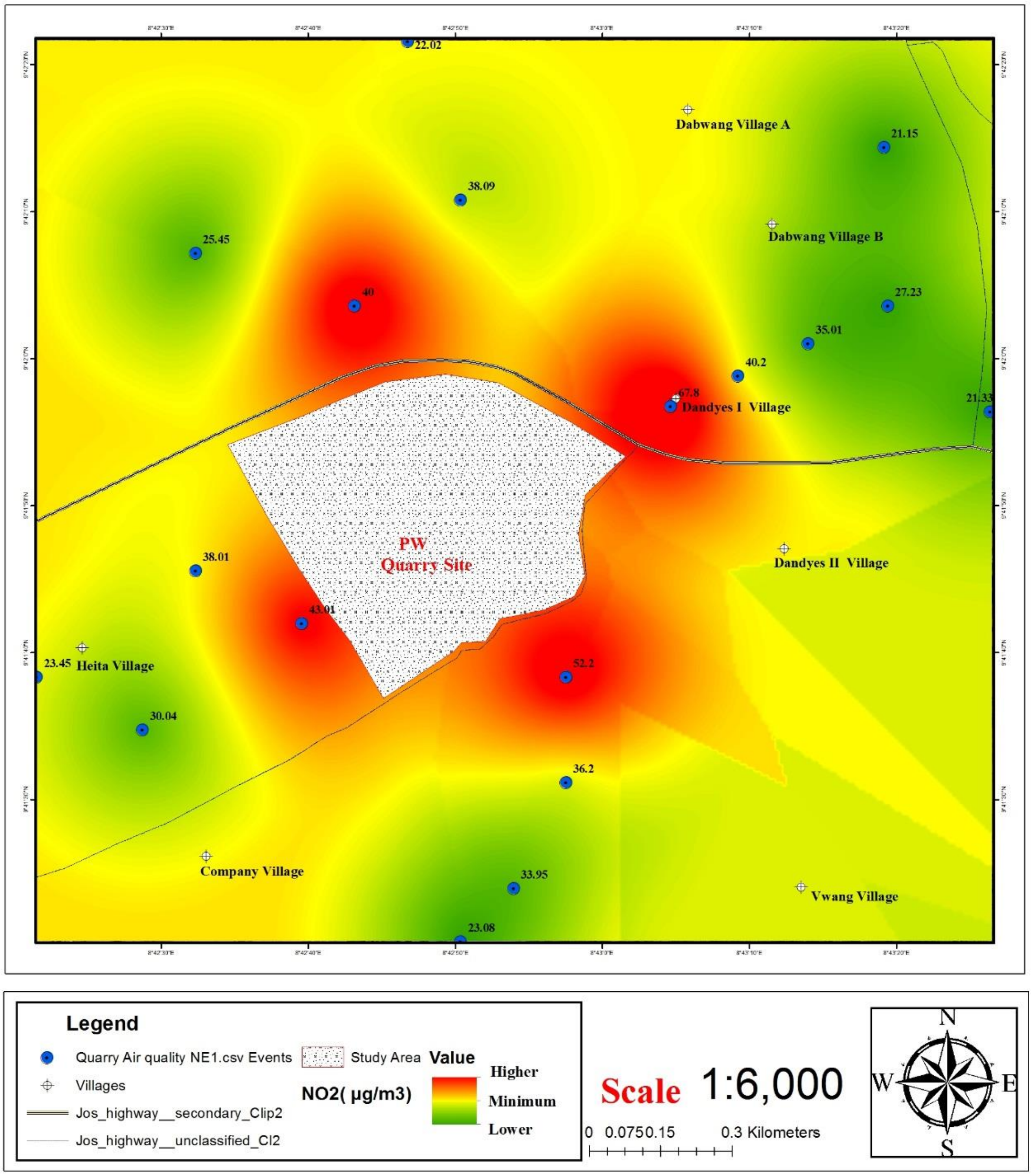


Figure 4.8: Spatial Kriging Interpolation of NO_2 Concentration in Air during Operation
Source: Author's Field Survey (2019)

Figure 4.9 shows the spatial kriging interpolation model concentration of CO measured during operation hours at an interval of 100 metres radius each by sample location. The results were shown in 'stretched colour' (red, yellow, light green and green). The red represents higher concentration, yellow minimum concentration while light green and green represented lower concentration.

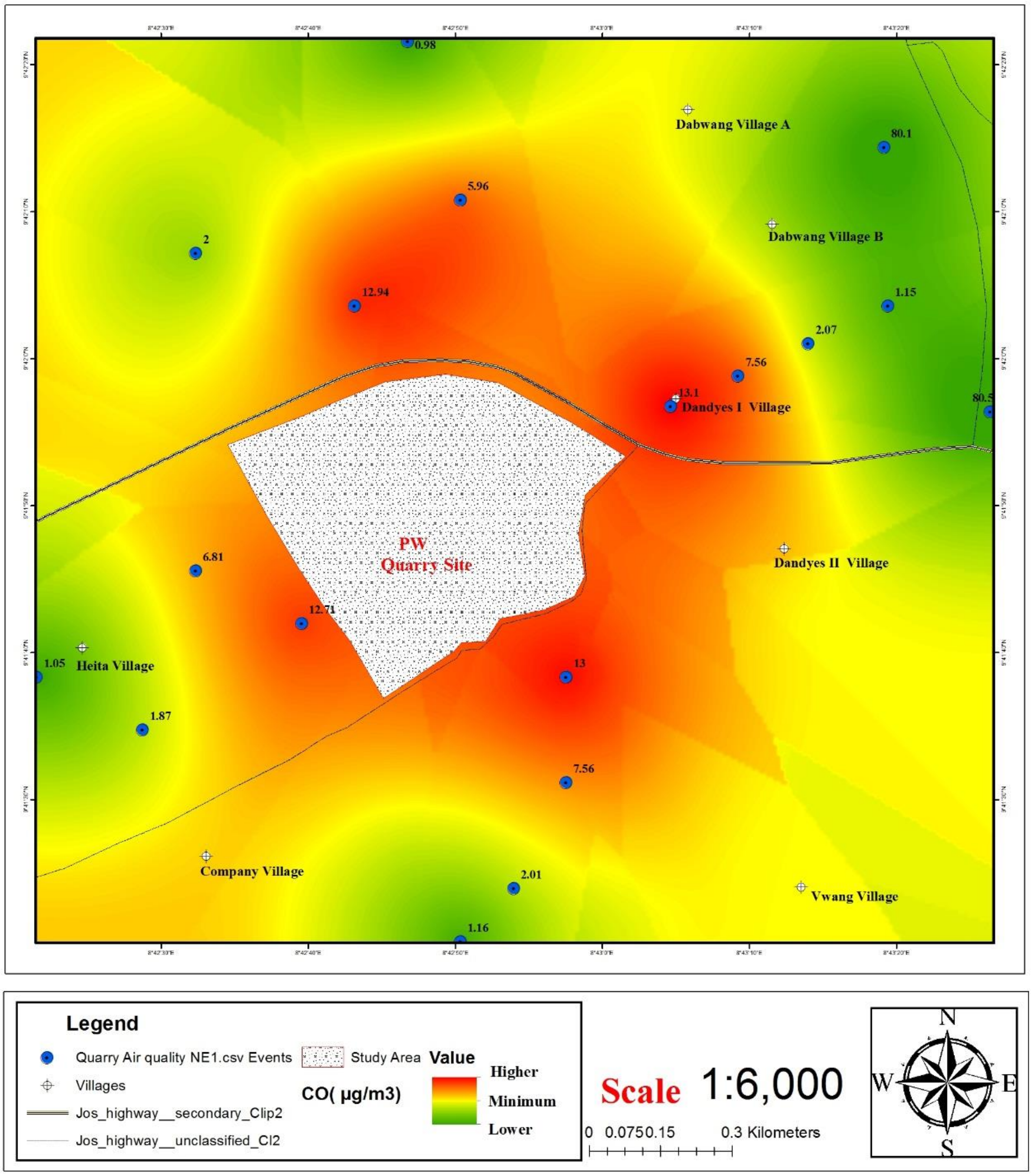


Figure 4.9: Spatial Kriging Interpolation of CO Concentration in Air during Operation
Source: Author's Field Survey, (2019)

Figure 4.10 shows the spatial kriging interpolation model concentration of SPM10 measured during operation hours at an interval of 100 metres radius each by sample location. The results were shown in 'stretched colour' (red, yellow, light green and green). The red represents higher concentration, yellow minimum concentration while light green and green represented lower concentration.

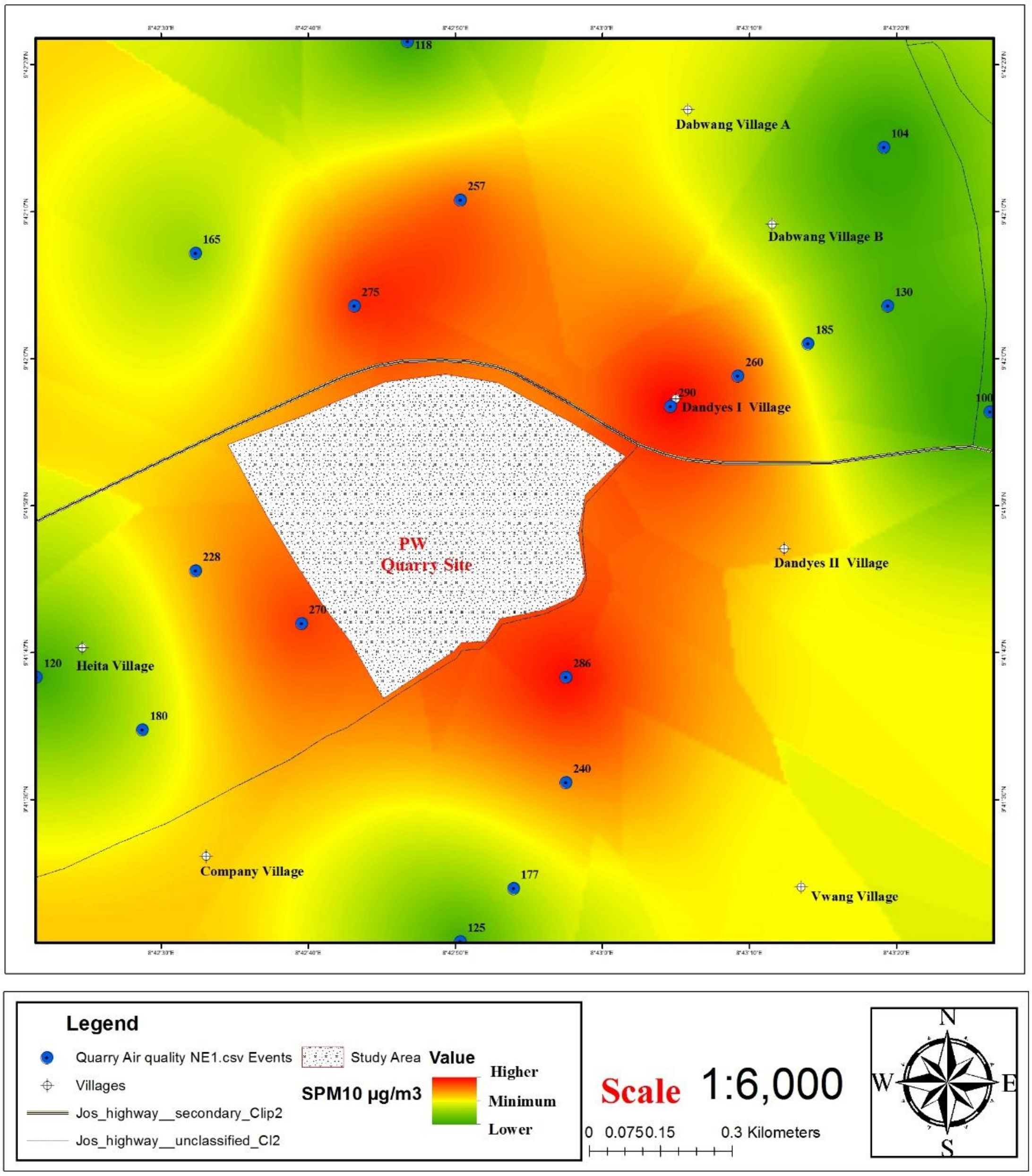


Figure 4.10: Spatial Kriging Interpolation of SPM10 Concentration in Air during Operation
Source: Author's Field Survey (2019)

Tables 4.3 show the comparison between the field measurement and the acceptable limit of each chemicals substance release in the air. The results revealed that from the first sample location of the readings to the last sample location after the operation (N-1 to W-5) respectively the concentration of $NO_2$and CO in the air is within the permissible limit of (FMEnv's) standard, while the concentration of SO_2 and SPM_{10} in the air within (N-1) to (W-1) sample location is above the permissible limit of (FMEnv's) standard. While in the case of WHO standard NO_2, SO_2 and SPM10 concentration in the air are above the permissible limit from sample location (N-1) to (W-4), while for (CO) is within the permissible limit at (N-1) to (W-5) sample location. The comparison result shows that the host communities are also liable for NO_2 and SPM10 impact.

Table 4.3 Summary of ambient air quality assessment after operation

S/L	Interval (M)	SO_2 (µg/m^3)			NO_2 (µg/m^3)			CO (µg/m^3)			SPM_{10} (µg/m^3)		
		Fm	Me	Wh	Fm	Me	Wh	Fm	Me	Wh	Fm	Me	Wh

N-1	100m	113.5	+	+	56.0	-	+	8.9	-	-	250.6	+	+
S-1	100m	111.2	+	+	50.4	-	+	8.5	-	-	250.3	+	+
E-1	100m	100.6	+	+	50	-	+	8.2	-	-	250.2	+	+
W-1	100m	100.05	+	+	48	-	+	8.3	-	-	250.1	+	+
N-2	200m	90.18	-	+	40	-	+	8	-	-	250	-	+
S-2	200m	88.8	-	+	39	-	-	7.8	-	-	240.8	-	+
E-2	200m	85.18	-	+	36	-	-	7.58	-	-	238	-	+
W-2	200m	85.11	-	+	30.7	-	-	7.56	-	-	235	-	+
N-3	300m	76.26	-	-	28.1	-	-	7.1	-	-	134	-	+
S-3	300m	70.15	-	-	20	-	-	5.9	-	-	197	-	+
E-3	300m	68.55	-	-	17	-	-	5.5	-	-	180	-	+
W-3	300m	65.78	-	-	16.6	-	-	5.3	-	-	165	-	+
N-4	400m	57.06	-	-	12.5	-	-	3.9	-	-	161	-	+
S-4	400m	52.56	-	-	12.1	-	-	3.6	-	-	140	-	+
E-4	400m	55.04	-	-	8	-	-	3.2	-	-	135	-	+
W-4	400m	48.23	-	-	8.2	-	-	2.6	-	-	128	-	+
N-5	500m	43.06	-	-	5.3	-	-	2.3	-	-	120	-	+
S-5	500m	40.45			2.45			2			114	-	+
E-5	500m	41.65			0.76			1.78			105	-	+
W-5	500m	38.23	-	-	0.34	-	-	0.92	-	-	96.4	-	+
Mean Record		71.58	-	-	24.07	-	-	5.45	-	-	182.02	-	+
FMEnv's(ME)		**100 µg/m3**			**60 µg/m3**			**11.4 µg/m3**			**250 µg/m^3**		
WHO (Wh)		**80 µg/m3**			**40 µg/m3**			**10 µg/m3**			**50 µg/m^3**		

Key: where is (+) show that the concentration is above the permissible limit,
Where is (-) show that the concentration is within the permissible limit,
Where is (Fm) mean-field measurement?
Where is (Me) mean (FMEnv's) standard and
Where is (Wh) mean (WHO) standard?
Where is (S/L) mean Sample location

Figures 4.11 show the spatial kriging interpolation model concentration of SO_2 measured after operation hours at an interval of 100 metres radius each by sample location. The results were shown in ‘stretched colour’ (green, light green, yellow and red). The green represents higher concentration, light green minimum concentration while yellow and red indicate lower concentration.

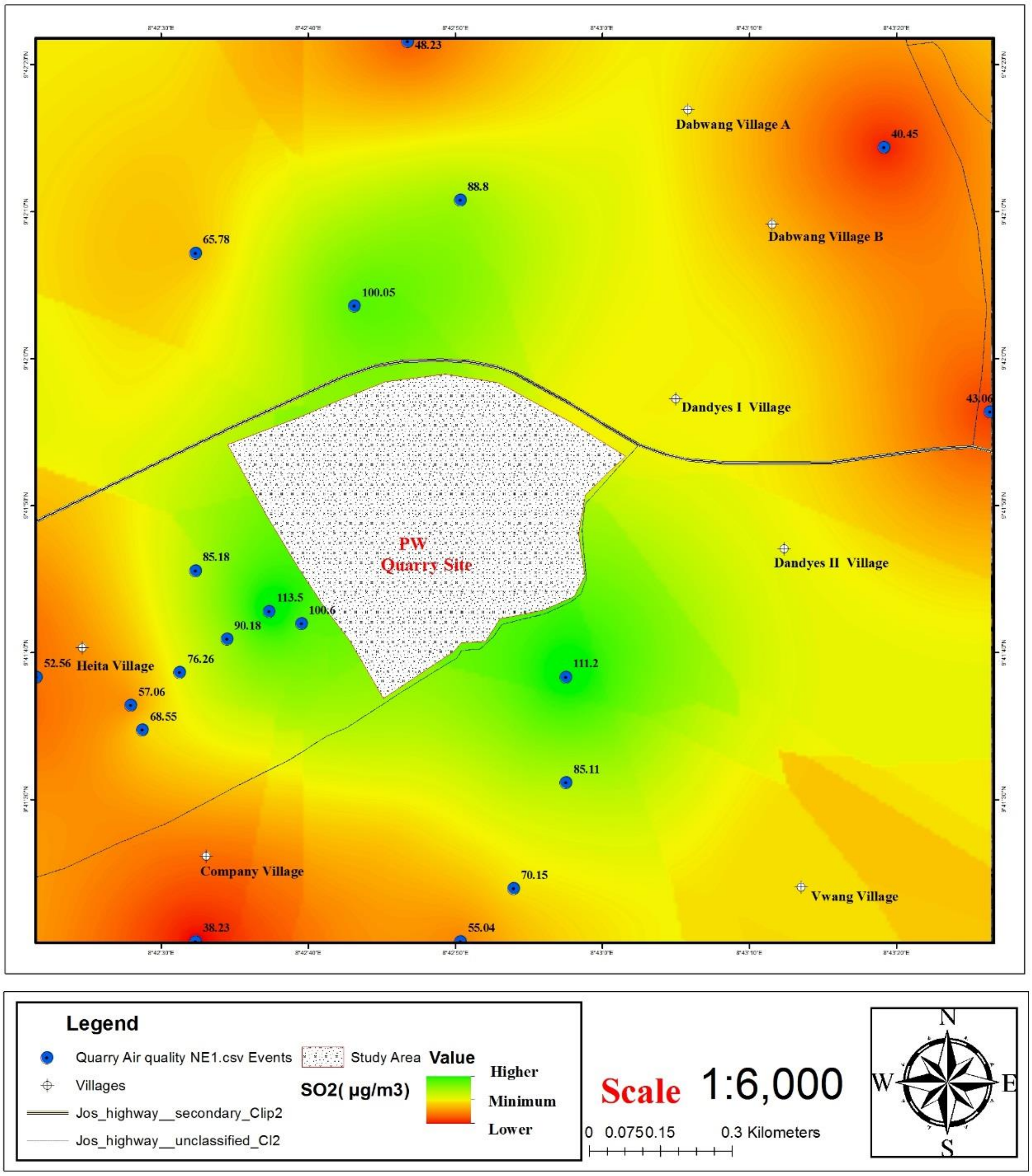


Figure 4.11: Spatial Kriging Interpolation of SO_2 concentration in Air after Operation
Source: Author's Field Survey, (2019)

Figure 4.12 shows the spatial kriging interpolation model concentration of NO_2, measured after operation hours at an interval of 100 metres radius each by sample location. The results were shown in 'stretched colour' (green, light green, yellow and red). The green represents higher concentration, light green minimum concentration while yellow and red indicate lower concentration.

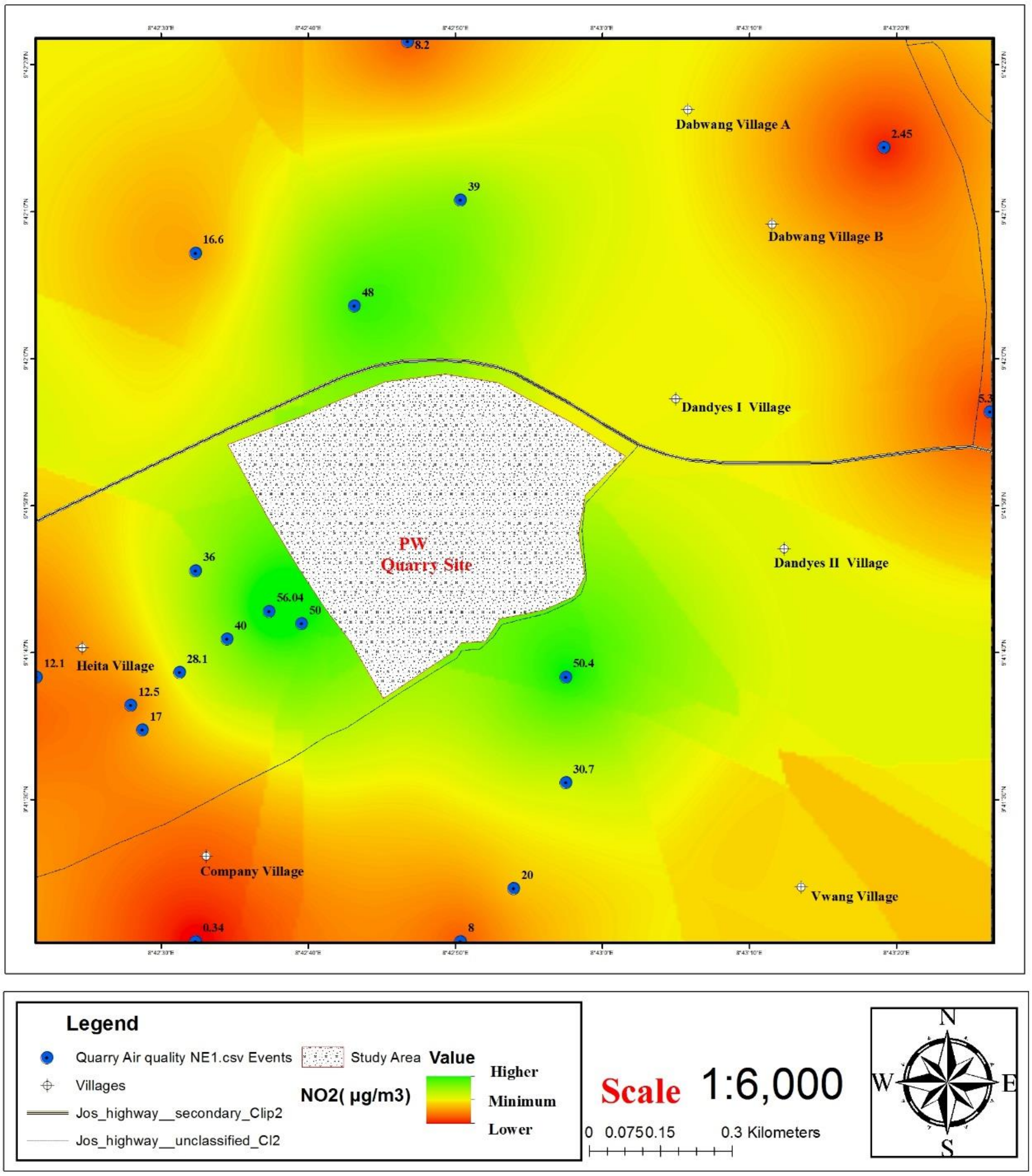


Figure 4.12: Spatial Kriging Interpolation of NO_2 concentration in Air after Operation
Source: Author's Field Survey (2019)

Figure 4.13 shows the spatial kriging interpolation model concentration of CO measured after operation hours at an interval of 100 metres radius each by sample location. The results were shown in 'stretched colour' (green, light green, yellow and red). The green represents higher concentration, light green minimum concentration while yellow and red indicate lower concentration.

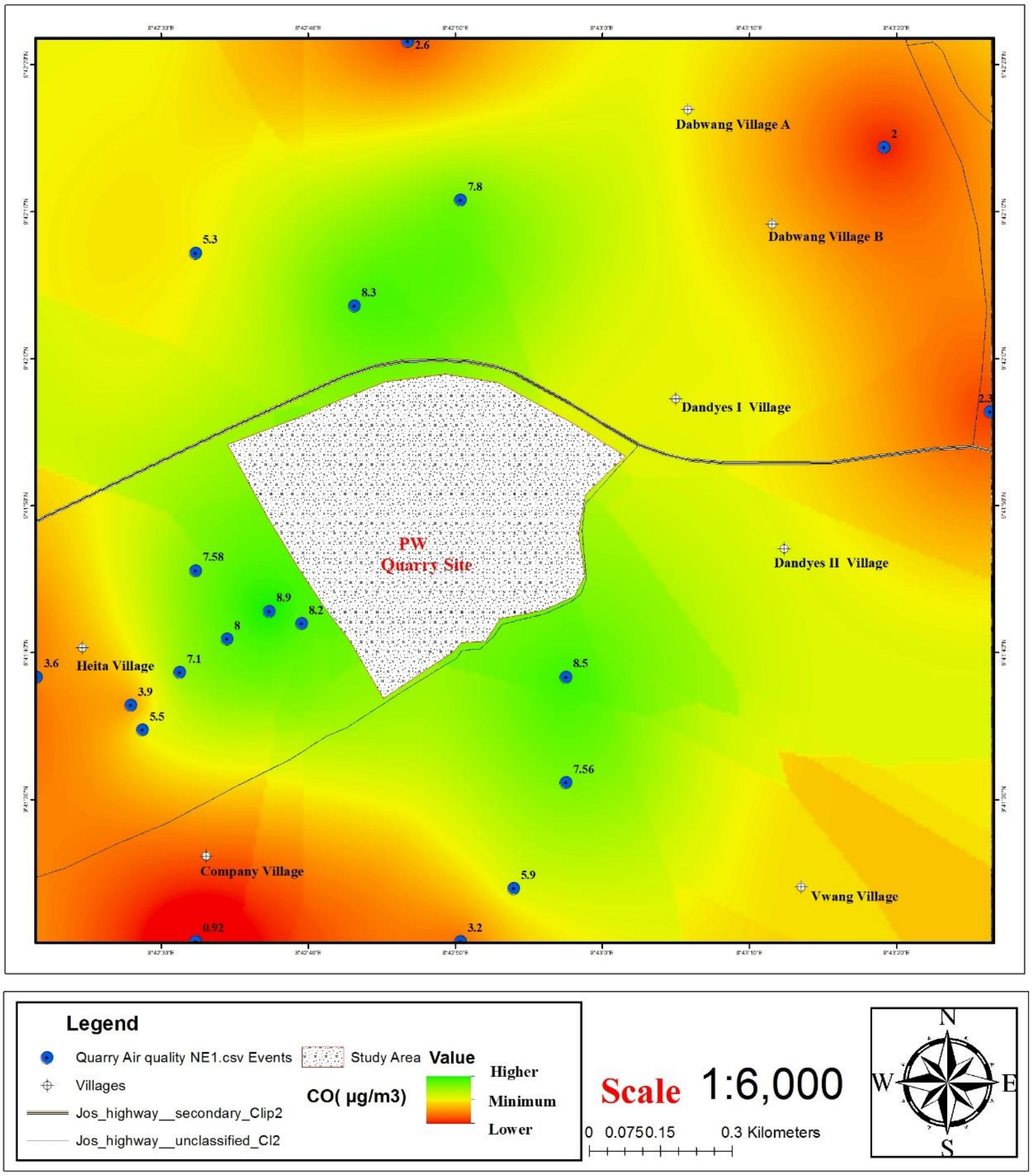


Figure 4.13: Spatial Kriging Interpolation of CO Concentration in Air after Operation
Source: Author's Field Survey (2019

Figure 4.14 shows the spatial kriging interpolation model concentration of CO measured after operation hours at an interval of 100 metres radius each by sample location. The results were shown in 'stretched colour' (green, light green, yellow and red). The green represents higher concentration, light green minimum concentration while yellow and red indicate lower concentration.

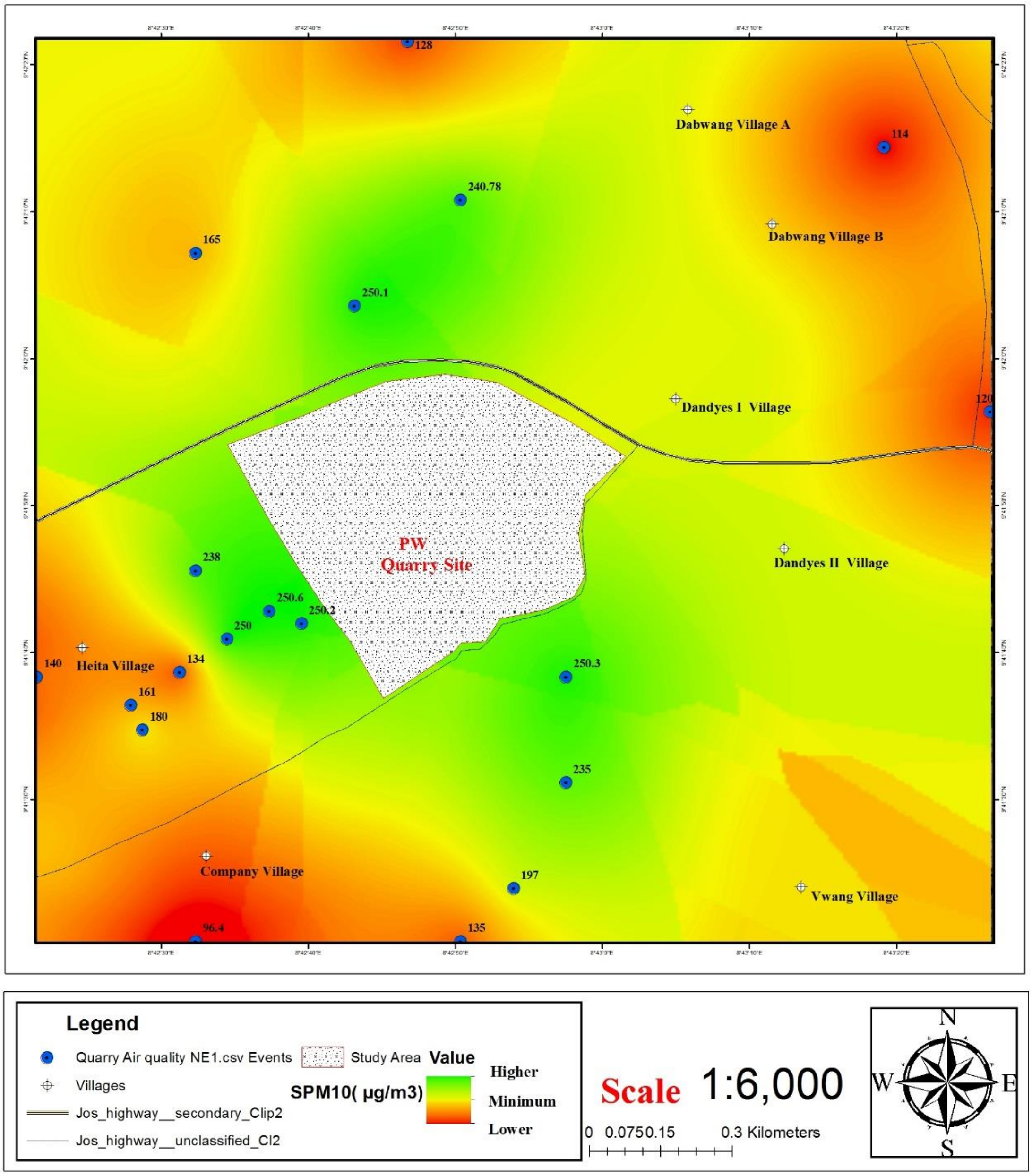


Figure 4.14: Spatial Kriging Interpolation of SPM_{10} concentration in the Air after Operation
Source: Author's Field Survey (2019)

4.2.2 Noise decibel level of the study area

The decibel in the study area was assessed during the same hours using the same sample location with an air quality test, which is during and after the operation hour. (During around 10:25 am-2:25 pm and after around 4:25 pm-6:25 pm at an interval of 100 meters each). Table 4.4 shows the noise decibel level measured during operation hours. The result revealed that at (N-1 to S-2 and W-2) sample locations, the noise level measured were above the maximum permissible limit of 70dB in the day time. The decibel level measured during operation hours at (N-1 to W-2) sample locations were also above the maximum permissible limit of 60dB in the night time as compared with NESERA standard.

Table 4.4 **Noise decibel measured and sample location during operation**

S/L	Interval (M)	Noise Level (dB)		
		(Fm)	(NERS) Day	(NERS) Night
N-1	100m	87.3	+	+
S-1	100m	85.3	+	+
E-1	100m	82.3	+	+
W-1	100m	78.3	+	+
N-2	200m	75.4	+	+
S-2	200m	75.1	+	+
E-2	200m	66.8	-	+
W-2	200m	70.85	+	+
N-3	300m	58.5	-	-
S-3	300m	56.8	-	-
E-3	300m	48.6	-	-
W-3	300m	50.25	-	-
N-4	400m	35.2	-	-
S-4	400m	34.4	-	-
E-4	400m	32.52	-	-
W-4	400m	28.32	-	-
N-5	500m	25.2	-	-
S-5	500m	23.4	-	-
Mean Record		**56.3633**	**-**	**-**
(NESREA) Noise Level Standard		**(Day70dB and Night60dB)**		

Key: where (+) is above the permissible limit noise level,
Where (-) is means permissible limit and,
Where is (Fm) mean-field measurement in (dB) and
Where is (NERS) mean (NESREA) standard for day and night?

Table 4.5 shows the noise decibel level measured along with the four cardinal points after the operation hour. The result revealed that at sample location (N-1), (S-1) and (E-1) the noise level measured is above the maximum permissible limit of 70dB in the day time as compared to NESERA standard and noise level measured within sample locations (W-1) to (W-5) are within the maximum permissible limit of 70dB in the day time. 60dB and. While at SW(dB)-2, SW(dB)-3, SW(dB)-4 and SW(dB)-5 sample locations the noise level measured were within the maximum permissible limit of 60dB and 70dB NESERA standard.

Table 4.5 Noise decibel measured and sample location after operation

S/L	Interval (M)	Noise Level (dB)		
		(Fm)	(NERS) Day	(NERS) Night
N-1	100m	70.2	+	+
S-1	100m	70.1	+	+
E-1	100m	70.02	+	+
W-1	100m	68.8	-	+

N-2	200m	60.5	-	+
S-2	200m	60.3	-	+
E-2	200m	60	-	+
W-2	200m	58.4	-	-
N-3	300m	56.9	-	-
S-3	300m	56.8	-	-
E-3	300m	48.6	-	-
W-3	300m	46.25	-	-
N-4	400m	45.12	-	-
S-4	400m	44.04	-	-
E-4	400m	44	-	-
W-4	400m	43.6	-	-
N-5	500m	41	-	-
S-5	500m	40.5	-	-
E-5	500m	40.3	-	-
W-5	500m	38.2	-	-
Mean Record		**53.1815**	**-**	**-**
(NESREA) Noise Level Standard		**(Day70dB and Night60dB)**		

Key: where (+) is above the permissible limit noise level,
Where (-) is means permissible limit and,
Where is (Fm) mean-field measurement in (dB) and
Where is (NERS) mean (NESREA) standard for day and night?

Figure 4.15 shows the spatial kriging interpolation model concentration of noise level during operation hours. The results were shown in ‘stretched colour’ (red, light red, yellow and blue). The red represents higher concentration, light red minimum concentration while yellow and blue presented lower concentration.

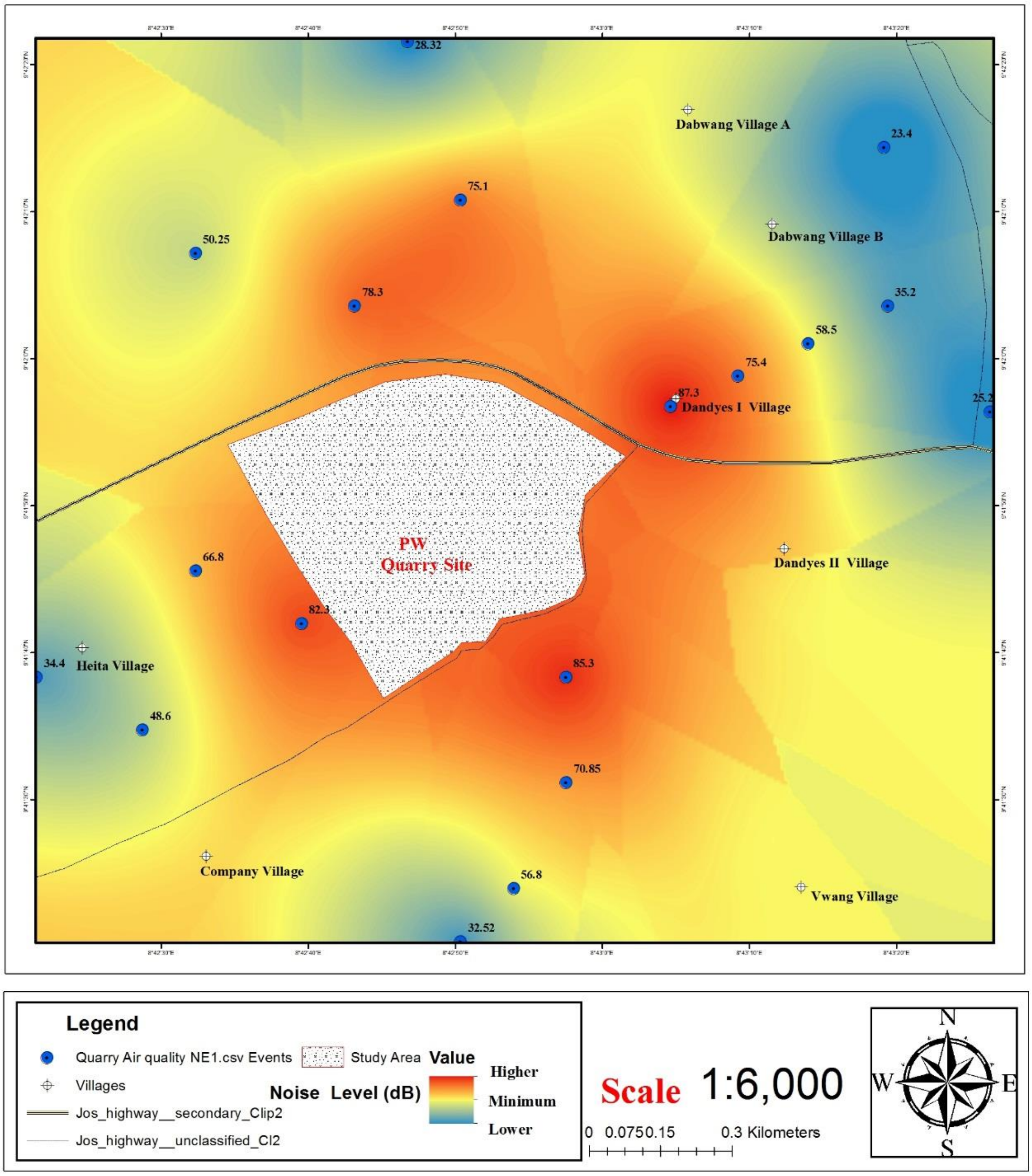


Figure 4.15: Spatial Kriging Interpolation of Noise Level during Operation Hour
Source: Author’s Field Survey (2019)

Figure 4.16 shows the spatial kriging interpolation model concentration of noise level during and after the operation hours. The results were shown in ‘stretched colour’ (red, light red, yellow and blue). The red represents higher concentration, light red minimum concentration while yellow and blue presented lower concentration respectively.

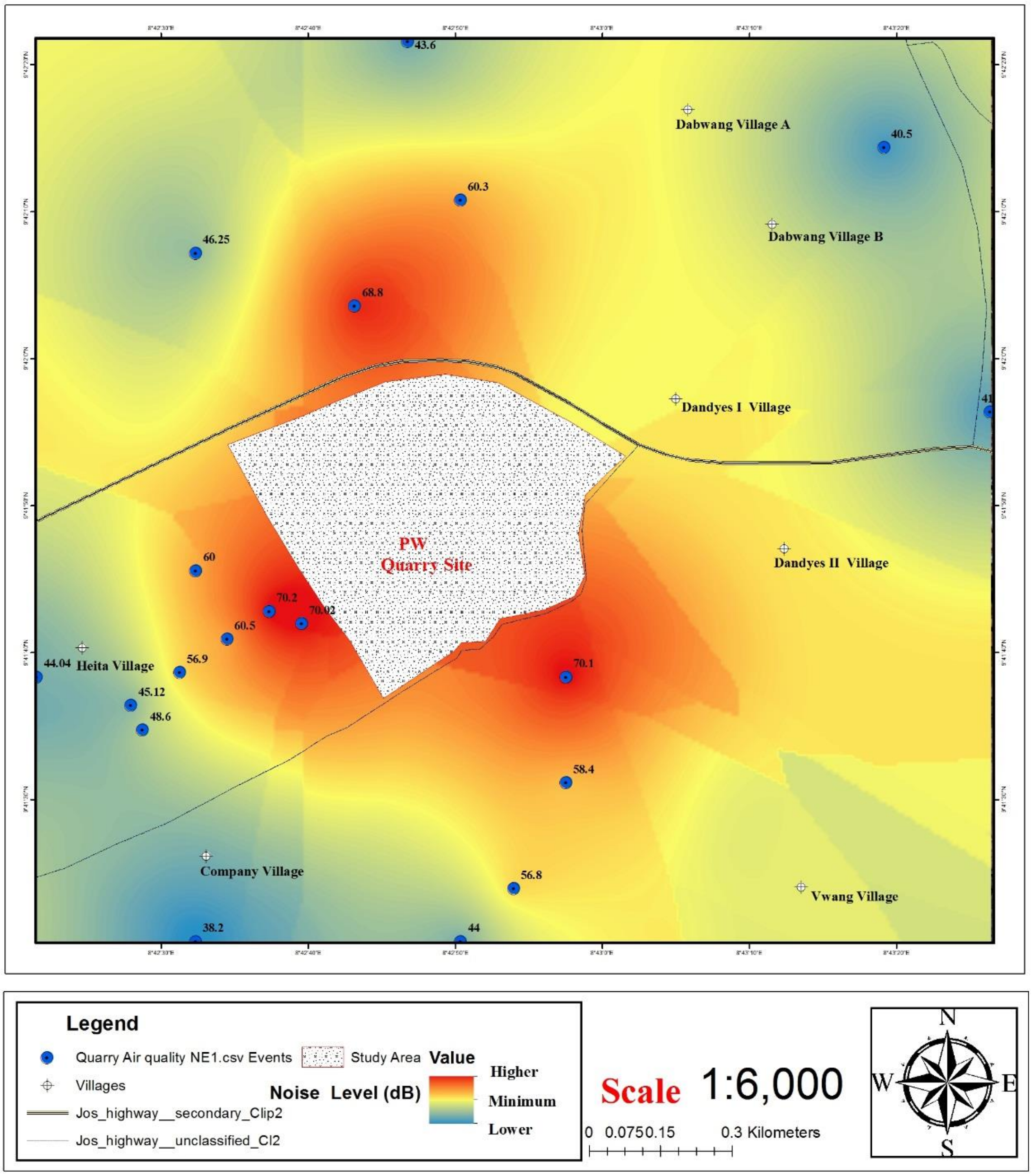


Figure 4.16: Spatial Kriging Interpolation of Noise Level after Operation Hour
Source: Author’s Field Survey (2019)

4.3 People's Perception of the Impact of Quarry on the Environment.

4.3.1 Environmental impact of the quarry

The sound/vibration generated from blasting and crushing of stones have affected human and their environment, as indicated in Table 4.6 which shows that 23.9% of the respondents complained of land degradation, 15.2% complained of water pollution, 42.4% complained of building crack from vibration shock, and 18.4% complained of dust on plants and farmland.

Table 4.6 Quarry impact on the host communities

Table 4.7 shows the respondents' view on the impact of quarry on the host community, 29.1% complaint of air/dust pollution, 23.3% complaint of vibration shock, and 47.6% of the respondent's complaints of Noise/sound pollution.

Effects	Frequency	Percent%
Land degradation	74	23.9
Water pollution	47	15.2
Building crack	131	42.4
Dust on plants/farmland	57	18.4
Total	309	100

Table 4.7 Environmental problems of quarry blasting

Impact	Frequency	Percent%
Air/dust pollution	90	29.1
Vibration shock	72	23.3
Noise/sound	147	47.6
Total	309	100

Plates XVII shows some of the buildings affected by the vibration at 350 metres east direction, 183 meters' northeast direction, 278 metres south direction and 552 metres southwest direction.

Plates XVII: Buildings Affected by Vibration at the Study Area
Source: Author's Field Survey (2019)

The discharge of dust particles and metals on plants/farmlands is liable for affecting soil quality. The growth processes of the plant get delayed due to the accumulation of dust on leaves stomata, Plate XVIII shows dust concentration on the leaves stomata in the study area.

Plate XVIII: Dust Accumulated on Acerbic Leave in Dandyes I (March 2019)
Source: Authors Field Survey (2019)

4.3.2 Impact of quarry on human health

Quarry activities have harmful effects on human health and the well-being of the host communities. Due to the dust generated by the activity. Table 4.8 shows the respondents' view on the effect of quarry on people's health, 46.3% of the respondents' complaint of cough, 6.8% of the respondent's complaint of asthma, 18.4%, of the respondents' complaint of eye problems, while 15.9% complaint of sore throat, and 12.6% of the respondents' complaint of heart problems.

Table 4.8 Disease of quarrying activity to the resident

Disease	Frequency	Percent%
Cough	143	46.3
Asthma	21	6.8
Eye problems	57	18.4
Sore throat	49	15.9
Heart problems	39	12.6
Total	309	100

4.4 Compliance Level of the PW Quarry Company to the Nigeria Mineral and Mining Regulation Act 2011/(NESREA) Act 2011

4.4.1 Compliance level

The Nigerian Mineral and Mining Regulation Act 2007 as Amended 2011 and (NESREA) Act 2011, was used to examine the company compliance level. The mining/Quarry operations objective of these regulations was provided to coordinate and regulate mining activities in the environment. Section (1-4) of this Act and Part VI of quarrying itemized the regulation control measures for Mining/Quarry titleholder. Under section (21) of the Act the ministry/agency subject to this Act shall make regulations in respect of any matter required to the prescribed control measures and shall be headed by an establishment department, purposes of carrying out these functions under the Act, such as mines inspectorate department, (NESREA), and mines environmental compliance department respectively. These Regulations aim to: (a) Prevent environmental degradation, (b) Ensure the use of environmentally friendly technologies in quarrying operation and (c) Sustain the quarrying capacity of the Nigerian land in particular and the environment in general. In the event of the suspension notice served on anyone with a permit, Regulation section 39(1) makes provision that upon such notice, the permit shall cease to affect as stated in the notice. Table 4.9 shows the compliance level of PW Nigeria Ltd Quarry Company in Vwang District. The assessment revealed compliance in four different levels**,** which are full compliance, compliance, partial compliance, and non-compliance. Given this assessment, the result shows that the host communities are liable for pollution risk and other forms of environmental challenges. Therefore, recommended that the regulatory body should step ahead to ensure proper compliance of all the control measures to prevent the host communities from deteriorating.

Table 4.9 Regulatory control measures

(NESREA)/(NMMRA) Acct 2011	Compliance Level			
MEASURES	**FC**	**C**	**PC**	**NC**
Setback 500m			✓	
Procedure for monitoring				✓
Safety and welfare of workers			✓	
Organized conference and workshop for workers and community	✓			
Provide information on incentive minerals				✓
Keep a record of the company activities and allied project		✓		
No trespass on stream, and watercourses or economic zone			✓	
Exploration and exploitation of mineral shall be done in the ratio		✓		
No Mining within 50 metres of road, reservoir, and clinic			✓	
Prepare and submit a Site plan	✓			
Prepare and submit a Site analysis plan	✓			
Prepare and submit EMP	✓			
Prepare and submit a health impact assessment plan	✓			
Prepare and submit EMS	✓			
Prepare and submit an environmental audit plan		✓		
Lay water pipes, watercourses, ponds, dams, and reservoir			✓	
Construct and maintain an electrical transmission line, and road				✓
No cutting down trees, unless with forestry officers consent			✓	
Prepare and submit an environmental impact assessment report	✓			
Embark on tree planting				✓
Update environmental protection and rehabilitation programme		✓		

Key: where is (FC) Full compliance?
Where is (C) compliance?
Where is (PC) partial compliance and
Where is (Me) non-compliance

4.4.2 Offenses and penalties to regulatory control measure

Section (115-127) of this Act, said any titleholder who failed to comply with the regulation itemized in the Act without the consent of the regulatory body is guilty of an offense and would be penalized under subsection (1) of the penalties section. The titleholder will be liable on conviction. While Section (125) made provision of the penalties under the Regulations, to the effect that any person convicted of an offense under the Regulations shall be liable to a fine of not less than #1,000,000 or imprisonment for a term not less than two years or both and an additional #20,000 for every day the offense subsists.

4.5 Summary of Findings

This research revealed the significant relationship between the PW quarry in Vwang District and the environmental consequences that were related to mining activities such as air, water, and soil pollutions. Others are noise pollution, vibration shock, land Slade/land degradation, and soil erosion. These challenges are capable of destroying the environment and bio-diversity. So, therefore, in other to prevent the environment from further deterioration there is a need for appropriate mitigation measures and severity to the regulation to reduce the impact of this activity on the host communities.

i. The site is situated on the metal ore and granite outcrop and is characterized by rocks, waterbody, gentle slope and undulating land at a minimum elevation path of 1174.1-1246.5 metres and above sea level, maximum elevation path of 1259.9-1304.9 metres, with slopes tilt of 0.87° from section A-A, -0.44° from section B-B, 0.92° from section C-C and 1.60° from section D-D, which resulted to the choice of location of the company. These characteristics show that the quarry site is located on higher terrain than the adjoining settlements, also the settlement buildings are so close that the effect of the quarry is possible.

ii. The ambient air quality measured during operation hours shows that there is a high concentration of (NO_2), (SO_2), (SPM10) and (CO) in air, more than was measured after the operation hours based on FMEnv's and WHO standard.

iii. This study also revealed that the highest noise level recorded in the study area was during the operation hours which is (88.6dB, 87.3dB, and 75.4dB) than after the operation hours of (70.2dB, 69.6dB, and 60.5dB), as compared to the (NESRA) standard of 70dB in the day and 60dB in the night.

iv. The sound/vibration generated from the blasting and crushing of stones has affected the human environment. This study revealed 45% of the respondents complained of buildings crack, 25.2% complained of land degradation, 15.2% complained of water pollution, and 14.6% complained of dust on plants and farmland, and over 1966.39 square metres (m^2) of farmland were affected.

v. The study revealed that PW Quarry Company compliance levels in four different stage, which is full compliance, compliance, partially compliance, and non-compliance. Given this assessment, the result shows that the host communities are liable for the risk of pollution and other forms of environmental challenges.

CHAPTER FIVE

5. 0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This study assessed the physical environmental quality of Vwang District in Plateau State, Nigeria. This study revealed that PW quarry activities have affected the host community in various ways such as air, noise, water and soil pollution, which disturbs the bio-diversity. The noise level and air quality measured and analysed, revealed the concentration of chemical substances and the decibel level in Vwang. And the results were subjected to international and national standards (WHO and FMEnv). This shows that suspected particulate matter (PM10), nitrogen dioxide (NO_2), Sulphur dioxide (SO_2), and carbon monoxide (CO) are the major contributing factors of pollution in Vwang District generated from the quarry activity. Furthermore, the study also revealed that noise levels within 200 meters from the quarry site are highly offensive, resulting from blasting, drilling, and crushing of rock that affected over 37.5% of the buildings.

In the same vein, this study also highlighted that the quarry company has put some control measures, like awareness and sensitization programmes before blasting. But in the aspect of dust, vibration shock, tree planting, erosion control, workers training and health, more is expected.

5.2 Recommendations

1. The Environmental agencies should ensure that the quarry company updates its Environmental Management Plan (EMP), to suit the situations/stages of their operations to minimize the consequence of the activities on the environment.
2. There is a need for close control measures on dust particles and other particulate matters resulting from the quarry activities, such as planting trees like

‘*Pennisetum purpureum'*, vegetation which can be used as a carbon sink to trap dust from the quarry and also wetting of stones with water before crushing.

3. The company is recommended to employ the use of modern technology/techniques of drilling and blasting of rocks. In this process, holes will be drilled with drilling machines, for example, TBC SLOT drill, before applying explosive powder as indicated in number 4 below. The area to be blasted should be covered with cement bags filled with sand to reduce the magnitude of the vibrations and shock on the nearby villages.
4. The use of the latest blasting materials that have a lesser impact during rock explosion like:
    i. Powder ammonia - nitrate explosive with cartridge length of 28-32 millimetre
    ii. Explosion fuse class,
    iii. Black powder and
    iv. Explosive cap
5. The use of the latest instrument that is of a lesser impact on the environment, like PE Jaw Crusher and Sand Washer is recommended as indicated in Plates I-X.
6. This study recommended that weekly monitoring activities should be carried out to ensure proper compliance of the regulation to reduced adverse effects of quarrying activities on the host community {environmental management system (EMS)}.
7. This study revealed that the existing setback around the study is 106.9 metres to the northeast, 454.3 meters to the east, while 209 meters to the north, 845.8 meters to the southwest, and 509.9 metres southward. However, there is a need to revisit the existing regulatory frameworks on mining, with a view of introducing a new

setback of 1.5km to 2km radius, to mitigate human settlements from direct mining/quarry pollutant.

8. This study also revealed that a cause of environmental degradation in the state is a result of poor regulatory compliance/unregulated stone mining. Therefore, recommends that active steps should be taken to penalize regulatory defaulters as stated in 4.4 pages 64.

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APPENDICES

Appendix A

URBAN AND REGIONAL PLANNING DEPARTMENT
FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA. NIGER STATE.
POSTGRADUATE QUESTIONNAIRE

Questionnaire to assess the impact of PW quarry activity on the physical environment of the Vwang area of Plateau State, Nigeria. This survey is strictly for academic purpose and any information obtained will be treated as confidential.

SECTION A: Bio Data

1. Street name…………………………………………………………………….
2. Village name …………………………………………………………………….
3. Sex (a) Male (b) Female.
4. Age (a) 5-20 (b) 21-35 (c) 36-50 (d) 50 and above.
5. Occupation (a) Civil Servant (b) General Business (c) Farming (d) Others.

SECTION B: Impact Quarry Activities

Vegetal Cover

6. Are you aware of any quarry activities in this area? Yes/No
7. If yes, how far is it from your house (a) 50-100m (b) 100-150m (c) 150-200m (d) 200-250m (e) 250-300m (f) 300-350m (g) 350-400m (h) 450-500m (I) 500m and above
8. Do the quarry activities affect the vegetal cover in your area? Yes/No
9. If Yes, how has it affect the farm

   ………………………………………………………………………………………

Environmental Pollution

10. How has the quarry activities encroached in your village (a) forests and swamplands;

    (b) Cultural monuments (c) buildings areas; (d) conflicts in waterways and (e) flooding and drainage hazards.
11. State the environmental problems related to quarrying that you are suffering from

    ………………………………………………………………………………………

12. Are there any sources of environmental pollution apart from the quarry activity (a) Yes (b) No?
13. If yes, state them

    ………………………………………………………………………………
14. Is there any attempt by the company to minimize the pollution (a) Yes (b) No?
15. If yes, what are the measures

    ……………………………………………………………….
16. How does the quarry activity affect your farm (a) Reduced the yield of plant (b) Land degradation (c) Low value of agricultural produce?
17. Do the quarry activities affect your water supply sources? (a)Yes (b)No
18. If yes, Please state how

    ……………………………………………………………………………………

Air Pollution

19. Which disease is related to dust from quarrying in your area?
    (1) Cough (2) Asthma (3) Eye problems (4) Sore throat (5) Sneezing (6) Heart problems
20. Is there any building affected by explosive and blasting of rock in your area?
    (a) Yes (b) No
21. If yes, state the related problems that are associated with quarry blasting

    ………………………………………………………………………………………
22. Please, indicate any related physical injuries that are associated with stone blasting

    ………………………………………………………………………………………
23. Please itemized the danger that this activity has caused on bio-diversity/livestock

    ………………………………………………………………………………………
24. How did the quarry activities affect the temperature of your village?

    ………………………………………………………………………………………
25. State the economic/social benefit of that quarry activities to you

    ………………………………………………………………………………………

URBAN AND REGIONAL PLANNING DEPARTMENT

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA. NIGER STATE.

POSTGRADUATE INTERVIEW GUIDE

Questionnaire to assess the impact of PW quarry activity on the physical environment of the Vwang area of Plateau State, Nigeria. This survey is strictly for academic purpose and any information obtained will be treated as confidential.

SECTION A: TO THE COMPANY/WORKERS

1. Location of the company……………………………………………………………
2. Area coverage in kilometre/meter

   …………………………………………………….
3. Year of establishment

   ………………………………………………………………….
4. Year of operation…………………………………………………………………….
5. Please, specify the period of operation

   ……………………………………………………
6. How many times per day: (a) Once, (b) Twice, and (c) Three times.
7. Do the company have a permit (a) Yes (b) No
8. If yes, from which ministry

   ………………………………………………………….
9. What method of quarries is your company using in your operation?

   ……………………………………………………………………………………
10. What is the gravitation level and radius of influence?

    ……………………………………………………………………………………
11. What level of education orientation was given to the nearby villagers on the quarry blast?

    ……………………………………………………………………………………
12. How do your organization carry out monitoring on the impact of the quarry activities on the neighbouring villages?

    ……………………………………………………………………………………

    What mitigation were stated in the permit for the company

    ………………………………………………………………………………
13. How has the company carried out each of them?

……………………………………………………………………………………..

15. Has any government agency carried out an environmental audit on your company (a) Yes (b) No.?

16. If yes, when and how

…………………………………………………………...

17. Do your organization has a certified environmental impact statement (EIS) (a) Yes (b) No

18. If yes, what are the key mitigation directives?

…………………………………………………………………………………......

19. What social responsibility do your organization carried out in those communities where the quarry site is located

…………………………………………………………………………………………

20. Are there any complaints from those villages? (a) Yes (b) No

21. If yes, what are those complaints?

…………………………………………………………………………………………

SECTION B: SAFETY AND HEALTH ISSUES

1. How long have you been working on this quarry site?

(a) Less than 5years, (b) 6 to 10 years, (c) 11to 20 years, (d) above 20 years

2. On average, how many hours do you work per day?

(a) Less than 5 hours, (b) 5 to 10 hours, (c) Over 10 hours

3. How would you best describe the work that you do in this quarry?

(a)Breaking stone, (b) Loading stones (c) Remove rock waste & spoilage (d) others (Specify)..

4. What safety instruments were issued to you

…………………………………………………………………………………………

5.Have you developed any ailment in this place of work? (a) Yes (b) No

6.If yes, please specify

…………………………………………………………………………………………

7.What are some of the challenges you experience with quarry activities?

Appendix B

Bio-Data of Respondents

Sex

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	194	62.8	62.8	62.8
	Female	115	37.2	37.2	100.0
	Total	309	100.0	100.0	

Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	5-20	25	8.1	8.1	8.1
	21-35	50	16.2	16.2	16.2
	36-50	79	25.6	25.6	25.6
	50 and above	155	50.2	50.2	50.2
	Total	309	100.0	100.0	

Occupation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Civil servant	94	30.4	30.4	30.4
	Business	47	15.2	15.2	45.6
	Farming	145	46.9	46.9	92.6
	Others	23	7.4	7.4	100.0
	Total	309	100.0	100.0	

How far is the quarry site from your home

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	100-200m	77	24.9	24.9	24.9
	210-300m	92	29.8	29.8	54.7
	310m-400m	23	7.4	7.4	62.1
	410-500m	21	6.8	6.8	68.9
	510-600m	39	12.6	12.6	81.6
	610 and above	57	18.4	18.4	100.0
	Total	309	100.0	100.0	

Appendix C

Others Quarry Impact and Benefit to the Residents

Does the quarry activities affect vegetal cover

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	309	100.0	100.0	100.0

If yes, how has it affect the vegetal cover

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Reduce farm produced	179	57.9	57.9	57.9
	Reduce soil porosity and affect plant growth	70	22.7	22.7	80.6
	Change plant colour	60	19.4	19.4	100.0
	Total	309	100.0	100.0	

Is there any sources of environmental pollution apart from the quarry activity

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	209	67.6	67.6	67.6
	no	100	32.4	32.4	100.0
	Total	309	100.0	100.0	

If yes, state them

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		88	28.5	28.5	28.5
	Local tin mining, that caused water pollution	113	36.6	36.6	65.0
	Sand mining , that lead to Land degradation	108	35.0	35.0	100.0
	Total	309	100.0	100.0	

Is there any attempt by the company to minimize the pollution

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		27	8.7	8.7	8.7
	yes	177	57.3	57.3	66.0
	no	105	34.0	34.0	100.0
	Total	309	100.0	100.0	

If yes, what are the measure

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		116	37.5	37.5	37.5
	Tree planting	131	42.4	42.4	79.9
	Sensitization campaign	30	9.7	9.7	89.6
	Awareness programme	32	10.4	10.4	100.0
	Total	309	100.0	100.0	

How does the quarry activity affect your farm

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Reduced the yield of plant	103	33.3	33.3	33.3
	Land degradation	73	23.6	23.6	57.0
	Low value of agriculture produce	133	43.0	43.0	100.0
	Total	309	100.0	100.0	

Do the quarry activities affect your water supply sources

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	197	63.8	63.8	63.8
	no	89	28.8	28.8	92.6
	3	23	7.4	7.4	100.0
	Total	309	100.0	100.0	

If yes please state how

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		89	28.8	28.8	28.8
	Water colour	49	15.9	15.9	44.7
	Water odor	45	14.6	14.6	59.2
	Water taste	83	26.9	26.9	86.1
	Water dryness	43	13.9	13.9	100.0
	Total	309	100.0	100.0	

Please itemized the danger that this activity have caused on bio-diversity/livestock

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Farm dryness	133	43.0	43.0	43.0
	Scarter cattle	137	44.3	44.3	87.4
	Kill goat	39	12.6	12.6	100.0
	Total	309	100.0	100.0	

How did the quarry activities affect the temperature of your village

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Increase the humidity of the area	186	60.2	60.2	60.2
	Increase the hotness	123	39.8	39.8	100.0
	Total	309	100.0	100.0	

State the economic/social benefit of quarry activities to you

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Job creation	127	41.1	41.1	41.1
	Improved quality of building material	70	22.7	22.7	63.8
	Improved quality of road provide	112	36.2	36.2	100.0
	Total	309	100.0	100.0	

Appendix D

Table 4.10 Air Quality Analysis during Production Hour

Location code	Easting	Northing	Interval (m)	SO2 µg/m3	NO2 µg/m3	CO µg/m3	SPM10 µg/m3	Noise Level (dB)
NE-1	8.717976	9.699101	100m	116.5	67.8	13.1	290	87.3
NE-1	8.716	9.694	100m	114.2	52.2	13	286	85.3
NE-1	8.711	9.695	100m	111.6	43.01	12.71	270	82.3
NE-1	8.712	9.701	100m	113.5	40	12.94	275	78.3
NE-2	8.719247	9.699681	200m	93.18	40.2	7.56	260	75.4
NE-2	8.714	9.703	200m	92.8	38.09	5.96	257	75.1
NE-2	8.709	9.696	200m	90.18	38.01	6.81	228	66.8
NE-2	8.716	9.692	200m	88.4	36.2	7.56	240	70.85
NE-3	8.720572	9.70029	300m	70.26	35.01	2.07	185	58.5
NE-3	8.715	9.69	300m	70.15	33.95	2.01	177	56.8
NE-3	8.708	9.693	300m	68.55	30.04	1.87	180	48.6
NE-3	8.709	9.702	300m	65.78	25.45	2	165	50.25
NE-4	8.722073	9.701007	400m	56.06	27.23	1.15	130	35.2
NE-4	8.706	9.694	400m	52.56	23.45	1.05	120	34.4
NE-4	8.714	9.689	400m	55.04	23.08	1.16	125	32.52
NE-4	8.713	9.706	400m	48.23	22.02	0.98	118	28.32
NE-5	8.724	9.699	500m	39.06	21.33	80.5	100	25.2
NE-9	8.722	9.704	500m	40.45	21.15	80.1	104	23.4

Appendix E

Table 4.11 Air Quality Analysis after Production Hour

Loation code	Easting	Northing	Interval (m)	SO2 µg/m3	NO2 µg/m3	CO µg/m3	SPM10 µg/m3	Noise Level (dB)
SW-1	8.71039	9.695233	100m	113.5	56.04	8.9	250.6	70.2
SW-1	8.716	9.694	100m	111.2	50.4	8.5	250.3	70.1
SW-1	8.711	9.695	100m	100.6	50	8.2	250.2	70.02
SW-1	8.712	9.701	100m	100.05	48	8.3	250.1	68.8
SW-2	8.709592	9.694706	200m	90.18	40	8	250	60.5
SW-2	8.714	9.703	200m	88.8	39	7.8	240.78	60.3
SW-2	8.709	9.696	200m	85.18	36	7.58	238	60
SW-2	8.716	9.692	200m	85.11	30.7	7.56	235	58.4
SW-3	8.708699	9.694084	300m	76.26	28.1	7.1	134	56.9
SW-3	8.715	9.69	300m	70.15	20	5.9	197	56.8
SW-3	8.708	9.693	300m	68.55	17	5.5	180	48.6
SW-3	8.709	9.702	300m	65.78	16.6	5.3	165	46.25
SW-4	8.70778	9.693462	400m	57.06	12.5	3.9	161	45.12
SW-4	8.706	9.694	400m	52.56	12.1	3.6	140	44.04
SW-4	8.714	9.689	400m	55.04	8	3.2	135	44
SW-4	8.713	9.706	400m	48.23	8.2	2.6	128	43.6
SW-5	8.724	9.699	500m	43.06	5.3	2.3	120	41
SW-5	8.722	9.704	500m	40.45	2.45	2	114	40.5
SW-5	8.705	9.694	500m	41.65	0.76	1.78	105	40.3
SW-5	8.709	9.689	500m	38.23	0.34	0.92	96.4	38.2

Appendix F

Table 4.12: Regulatory Measure

REGULATORY CONTROL MEASURE	COMPLIANCE
Area coverage	2,338162m2
Year of establishment	1999/2000
Year of operation	2000
Period of operation	8am-12pm and 1:30pm-6pm
Time per day	Twice a day
Mitigation stated in the permit	Sensitization awareness, Tree planting, dust tracker measure and Construction of drainage and riverbank
Site	Vom, plateau state (Chugwi village)
The company have license/permit	Yes
A ministry that issues the license	FMEvn/PSMSM
What method of the quarry the company is using	Open-pit quarry
Gravitation level and radius	156
What level of education orientation was given to the nearby villagers on the quarry blast	Effect of vibration and shock and Effect of the dust
How do you carry out monitoring on the impact of the quarry activities on the neighbouring villages	Twice a year
How has the company carry out each of them	Through community involvement effort
Has any government agency carry out any environmental audit on your company	yes
If yes when and how	2005
Do your organization have certified environmental impact statement (EIS)	yes
If yes what are the key mitigation directive	Awareness and Sensitization
What social responsibility do your organization carried out on those communities were the quarry site is located	Provide borehole, Construction of culvert and road repairs
Are there any compliant from those villages	yes
If yes what are those compliant	Building crack/fall, water pollution and air pollution

Appendix G

Table 4.13: Impact Assessment

Source: Authors Field Survey, (2019)

Quarry Activities Products and Services	Impacts	Impacts Physiognomies	Rating
Dust resulting from crushing, loading, and hauling of graded aggregate.	Air pollution on the workers, and the host community.	Negative	Very Significant.
Use explosives chemicals, like powder ammonium-nitrate explosives with black powder.	Depletion of water and soil quality.	Negative	Significant.
Noise from blasting, drilling machinery/equipment power generation.	Impact on quarry workers, and the host community.	Negative	Very Significant.
Use of packaging materials including cartons, bags, and sachets.	Depletion of natural resources.	Negative	Significant.
Waste generating and disposal from the quarry.	The potential risk of contamination of the environment (water).	Negative	Significant.
Provision of employment to workers.	• Income to workers. • Improvement in the local economy.	Positive	Very Significant.
Community benefit and growth	Road/culvert construction, waterways, and riverbank	Positive	Significant.

Appendix H

Table 4.14 Company Compliance Relevant Documentation

Document	Available	Not Available	Not Applicable	Comment
Corporate or/Management Policy.	+			
Environmental Policy				
Air quality policy.		-		Develop air quality policy
Noise control policy.	+			Update it
Health and Safety Procedure.	+			Improve on it
Staff Training Program.		-		Organise staff training
Corporate Social Responsibilities Plan.	+			Make it better than before
Operational Procedures and Records.	+			Improve on it
Environmental Monitoring Records.	+			Improve on it
Environmental Committee	+			Improve on it
Environmental Management System (EMS).	+			Improve on it
Environmental Management Plan (EMP).	+			EMP was previously developed alongside the Environmental Audit.

Source: Authors Field Survey, (2019)

Appendix I

Table 4.15 Conversion from Microgram per cubic meter to Part per million

Mg/m^3 1 mg/m^3 =	0.001 ppm	26 mg/m^3 =	0.026 ppm
2 mg/m^3 =	0.002 ppm	27 mg/m^3 =	0.027 ppm
3 mg/m^3 =	0.003 ppm	28 mg/m^3 =	0.028 ppm
4 mg/m^3 =	0.004 ppm	29 mg/m^3 =	0.029 ppm
5 mg/m^3 =	0.005 ppm	30 mg/m^3 =	0.03 ppm
6 mg/m^3 =	0.006 ppm	31 mg/^{m3} =	0.031 ppm
7 mg/m^3 =	0.007 ppm	32 mg/^{m3} =	0.032 ppm
8 mg/m^3 =	0.008 ppm	33 mg/m^3 =	0.033 ppm
9 mg/m^3 =	0.009 ppm	34 mg/m^3 =	0.034 ppm
10 mg/m^3 =	0.01 ppm	35 mg/m^3 =	0.035 ppm
11 mg/m^3 =	0.011 ppm	36 mg/m^3 =	0.036 ppm
12 mg/m^3 =	0.012 ppm	37 mg/m^3 =	0.037 ppm
13 mg/m^3 =	0.013 ppm	38 mg/m^3 =	0.038 ppm
14 mg/m^3 =	0.014 ppm	39 mg/m^3 =	0.039 ppm
15 mg/m^3 =	0.015 ppm	40 mg/m^3 =	0.04 ppm
16 mg/m^3 =	0.016 ppm	41 mg/m^3 =	0.041 ppm
17 mg/m^3 =	0.017 ppm	42 mg/m^3 =	0.042 ppm
18 mg/m3 =	0.018 ppm	43 mg/m^3 =	0.043 ppm
19 mg/m^3 =	0.019 ppm	44 mg/m^3 =	0.044 ppm
20 mg/m^3 =	0.02 ppm	45 mg/m^3 =	0.045 ppm
21 mg/m3 =	0.021 ppm	46 mg/m3 =	0.046 ppm
22 mg/m3 =	0.022 ppm	47 mg/m3 =	0.047 ppm
23 mg/m3 =	0.023 ppm	48 mg/m3 =	0.048 ppm
24 mg/m3 =	0.024 ppm	49 mg/m3 =	0.049 ppm
25 mg/m3 =	0.025 ppm	50 mg/m3 =	0.05 ppm

Appendix J

Table 4.15 Conversion from Part per million to Microgram per cubic meter

mg/m3↔kg/L	1 kg/L = 1000000000 mg/m3	Ppm↔lb/yd3	1 lb/yd3 = 593.27642110147 ppm
mg/m3↔g/L	1 g/L = 1000000 mg/m3	ppm↔lb/gal (UK)	1 lb/gal (UK) = 99776.397913856 ppm
mg/m3↔kg/m3	1 kg/m3 = 1000 ppm	Ppm↔lb/ft3	1 lb/ft3 = 16018.46336974 ppm
ppm↔g/m3	1 ppm = 1 g/m3	ppm↔lb/gal (US)	1 lb/gal (US) = 119826.42730074 ppm
pm↔mg/m3	1 ppm = 1000 mg/m3	Ppm↔oz/in3	1 oz/in3 = 1729994.0439319 ppm
ppm↔g/cm3	1 g/cm3 = 1000000 ppm	Ppm↔oz/ft3	1 oz/ft3 = 1001.1539606087 ppm
ppm↔mg/L	1 ppm = 1 mg/L	Ppm↔oz/yd3	1 oz/yd3 = 37.079776318842 ppm
ppm↔mg/mL	1 mg/mL = 1000 ppm	Ppm↔ton/yd3	1 ton/yd3 = 1307873.3978551 ppm
ppm↔mg/tsp	1 mg/tsp = 5000 ppm	Ppm↔lbs/in3	1 lbs/in3 = 27679904.70291 ppm
ppm↔ug/uL	1 ug/uL = 1000000 ppm	ppm↔per	1 per = 10000 ppm
ppm↔pg/uL	1 ppm = 1000 pg/uL	Ppm↔ppb	1 ppm = 1000 ppb
ppm↔ng/uL	1 ppm = 1 ng/uL	Ppm↔ppt	1 ppm = 1000000000 ppt
ppm↔pg/mL	1 ppm = 1000000 pg/mL	Ppm↔slug/ft3	1 slug/ft3 = 515378.81852553 ppm
ppm↔pg/dL	1 ppm = 100000 pg/dL	Ppm↔mg/dL	1 mg/dL = 10 ppm
ppm↔ug/mL	1 ppm = 1 ug/mL	Ppm↔g/dL	1 g/dL = 10000 ppm
ppm↔ug/dL	1 ppm = 100 ug/dL	Ppm↔ng/ml	1 ppm = 1000 ng/ml
ppm↔ug/L	1 ppm = 1000 ug/L	Ppm↔ng/dL	1 ppm = 100000 ng/dL
ppm↔ng/L	1 ppm = 1000000 ng/L		

Appendix K

Table 2.7 WHO Ambient Air Quality Guidelines

	Averaging Period	IFC Guideline Value [μg/m^3]	Guideline Value Host country	Project Value (baseline status) [μg/m^3]	Project Value (after implementation) [μg/m^3]
Sulfur dioxide (SO_2)	24-hour	125 (Interim target-1) 50 (Interim target-2) 20 (guideline)			
	10 minute	500 (guideline)			
Nitrogen Dioxide (NO_2)	1-year	40 (guideline)			
	1-hour	200 (guideline)			
Particulate Matter (PM_{10})	1-year	70 (Interim target-1) 50 (Interim target-2) 30 (Interim target-3) 20 (guideline)			
	24-hour	150 (Interim target-1) 100 (Interim target-2) 75 (Interim target-3) 50 (guideline)			
Particulate Matter ($PM_{2.5}$)	1-year	35 (Interim target-1) 25 (Interim target-2) 15 (Interim target-3) 10 (guideline)			
	24-hour	75 (Interim target-1) 50 (Interim target-2) 37.5 (Interim target-3) 25 (guideline)			
Ozone	8-hour daily maximum	160 (Interim target-1) 100 (guideline)			

Appendix L

Table 2.7 Impact Indexes for Dust Concentrations

Impact index (y)	Dust concentration due to quarrying works($\mu g/m^3$)	Presumed total concentration ($\mu g/m^3$)
0	0	50
5	50	100
10	≥90	≥140

The impact scores assigned to relevant points are:
Concentration =0 ug/mc: impact score= 0
Concentration =50 ug/mc: impact score=5
Concentration ≥90 ug/mc: impact score= 10

Source: Berry. P and Pistochi. A, (2015)