ASSESSMENT OF AIR QUALITY WITHIN A QUARRY SITE: CASE STUDY OF EZIAMA QUARRY SOUTHEASTERN NIGERIA

BY

NWANNAH, CHINENYE COLLETTE (B.TECH FUTO, PGD FUTO)

20124764268

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CERTIFICATION

This is to certify that this thesis "**Assessment of Air Quality within a Quarry Site: Case Study of Eziama Quarry Southeastern Nigeria**" was carried out by **Nwannah Chinenye Collette**, with registration number **20124764268** in partial fulfilment for the award of the degree of Master of Science (M.Sc) in Environmental Geology in Geology Department of Federal University of Technology Owerri, Imo State.

PROF. C.A. AHIARAKWEM Principal Supervisor	…………………… Signature	10/10/2016 Date
ENGR. DR. O.C. OKEKE Co-Supervisor	…………………… Signature	11/10/2016 Date
ENGR. DR. O. C. OKEKE Head of Department	…………………… Signature	11/10/2016 Date
PROF. BEDE ANUSIONWU Dean, SOPS	…………………… Signature	17/10/2016 Date
PROF. (MRS) N. N. OTI Dean, Postgraduate School	…………………… Signature	……………… Date
Prof. H.N. Ezeh External Examiner	…………………… Signature	22/09/16 Date

DEDICATION

This thesis is dedicated to God Almighty and all lovers of good works.

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I acknowledge the effort of my supervisors Professor C.A Ahiarakwem and Engineer Dr O. C Okeke for their patience, motivation and immense knowledge. A big thank you goes to my Head of Department, Engr. Dr. O. C. Okeke who made sure that i was kept on speed to achieve success in my Masters Degree program.

My sincere thanks also goes to the staff of the Eziama Quarry, Abia state who assisted me throughout the monitoring periods for the achievement of this work. My profound gratitude goes to my husband and family members for their financial and moral contributions. The success of this work would not have been possible without you all. Finally to the Almighty God for his protection, infinite mercy and grace.

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ABSTRACT

This study involved an assessment of air quality within the vicinity of Eziama quarry site South-eastern Nigeria with respect to emissions from drilling/blasting, crushing and noise generating sections. Ambient air quality was monitored at five stations for three different periods (Jan, June and Oct) by sampling four gaseous emissions (SOx, CO, CH_4, NH_4), Particulate matter, noise and some meteorological parameters. Measurements of gaseous emissions were carried out with the aid of digital gas analyser, particulate counter for PM10, PM2.5, PM1.0& SPM. Digital sound level meter was used to measure noise level while multi-parameter digital anemometer for ambient temperature, relative humidity & wind speed.The measured parameters were found to be in the following ranges for hourly readings: Carbon II Oxide (CO) (0.6-1.0ppm), Oxides of sulphur (SOx) (0.10-0.226ppm), Methane (CH_4) (0.066-0.08ppm), Ammonium (NH_4) (0.01ppm) and particulates: PM10 (17.80-21**μ**g/ Cm^3), PM 2.5 (34.4-36.4 **μ**g/Cm^3), PM 1.0 (29.8-32.6Cm^3), TPM (100.706-101.106μg/Cm^3). The mean ambient temperature, relative humidity and wind speed for January were 33.38^0C, 54.98% and 2.88m/s; those of June were 32.84^0C, 55.52%, and 2.62m/s; while October had 33.28^0C, 55.74% and 2.92m/s respectively. The recorded mean values of noise for the three monitoring periods were 77.0, 79.16 and 79.72Db. Air Quality Index values for $PM_{2.5}$ and SO_2 in the study varied between a minimum of 49 and maximum of 147 showing that the health of workers who spend long hours around generating areas were at risk especially during monitoring periods.

Keywords: Assessment, quality, quarry site, air, ambient, drilling, blasting, emission

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF STUDY

The complex mixture of gases that make up the earth's atmosphere has been altered much more significantly in the recent times. Human activities ranging from domestic energy utilization to large scale industrial operations are largely responsible for this undesirable status of atmospheric constituents due to addition of pollutants. Industrial activities such as quarrying and mining activities have the potential to alter the status of the environment if not properly managed. Quarrying is usually associated with environmental impacts at all stages of its activities and processing. These include emissions of airborne pollution in the form of dust, gases, noise and vibration when operating machinery, during blasting and crushing, and damage to countryside. Based on air quality assessment, negative impacts of quarrying includes, ground vibration/noise and percussions from rock blasting, generation of dust, smoke and fumes; production of noxious gases. Exploitation of intrusive rocks from quarries like Eziama quarry in this study is associated with the release of fugitive dust, particulate matter and gaseous emission (SO_X, CO_X, NO_X CH4) through the quarry activities like generator houses, engines, dumper trucks on haul routes to the environment. These can affect the environment adversely for example fugitive dust can cause acid rain deposition, global warming, respiratory illness and formation of photochemical smog. The methods and equipment used in quarries depend on the purpose for which the stone is extracted. Different quarrying activities have different impacts on air quality. The process of making holes in rock or overburden with the aid of a drilling machine (drilling process) may be treated as a point source of pollutant emission. Shattering the drilled rock or overburden in a bid to loosen the mass in smaller fragments (blasting process) may be treated as an instantaneous point source for suspended particulate. Also, the loading and movement of dumper trucks on haul routes would generate suspended particulates while the crushing of rock and transferring it to a belt conveyor would be a potential source of dust generation. Loading and movement of vehicles may be treated as point and line sources. Quarrying activities just like mineral exploration, mining and processing have resulted in environmental damages including pollution of air, land and water, ecological disturbance, destruction of natural flora, instability of soil and rock masses, landscape degradation and radiation hazards (Aigbedion & Iyayi,2007). The effects of air pollution on human health are very complex as there are different sources; thereby producing varying effects. Dust is the main source of air pollution in quarry industry; generally, the effects of its emission from quarries have both micro and regional dimension. The extent of pollution by dust depends on the local microclimate conditions, the concentration of dust particles in the ambient air, the size of the dust particles and their chemistry (Hsin-Yi, 2012). Hence, this study examined the level and concentration of air quality parameters within Eziama quarry in Abia State

Southeastern Nigeria. Moreover, it investigated the prevalent health problems and other environmental implications arising from the chemistry/ status of the air quality within the quarry vicinity. Finally, it assessed the awareness of the negative impacts of living in close proximity to quarry sites.

1.2 STATEMENT OF THE PROBLEM

Quarrying activities constitute a threat to the environment due to emission of gaseous pollutants and particulates. Different quarrying activities have different impacts on air quality. The major processes responsible include:

- Drilling and Blasting
- Loading and movement of dumper trucks on haul routes
- Rock processing i.e. Crushing and transferring of rocks to a conveyor belt. All these activities outlined above serve as point sources for the emission of pollutants and particulate matters which can lead to adverse effects to people and it's environs.

1.3 AIM OF STUDY

To investigate on air pollutants associated with quarrying activities and providing relevant data for sustainable air quality management within and around the site. This will involve an assessment of the ambient air quality within the facility over a period of time.

1.4 OBJECTIVES OF STUDY

The objectives of this investigation are as follows;

i. To determine gaseous emissions and level of ambient air quality in the quarry site during the monitoring period.
ii. To determine the Total Particulate Matter (TPM)
iii. To identify noise sources, determine and assess the noise level within the quarry vicinity and ascertain the impact of elevated noise levels on the immediate environment.
iv. To identify, characterize and compare the air quality parameters with well known standards.

1.5 SIGNIFICANCE OF STUDY

i. It will aid in identification of areas with it's reference to assessment of air quality within the quarry site.
ii. It will serve as reference source to potential readers of this work on assessment of air quality.
iii. It will assist in identifying the extent of gaseous emissions within the study area.
iv. It will provide direction for future policy in improving local air quality.

1.6 SCOPE OF STUDY

Measurement of some gaseous emissions, wind speed, wind direction, relative humidity, ambient air temperature, and total particulate matter within the study area

1.7 LIMITATIONS OF STUDY

This study is restricted to the ambient air quality and toxic substances monitoring within the Eziama quarry site.

CHAPTER TWO

LITERATURE REVIEW

2.1 GENERAL REVIEW

Frequent generation of dust from quarries are usually the most outstanding negative impact of quarrying operations identified. Others include noise and ground vibration. Suspended particulate matter may be affecting more people globally than any other pollutant on a continuous basis (Richard et al., 2002). Similarly, the health problems experienced by quarry workers are identical, and are similar to those identified by Murray ; Lopez (1996), Dockery ; Pope (1994); Pope et al., (1995) and Peters (1996) in their studies of the impacts of dust pollution on exposed subjects. Going by epidemiological studies, a dose-response relationship between exposure to PM10 and respiratory morbidity and mortality are established (Dockery; Pope 1994, Pope, et al., 1995; Qamar et al; 2001). Likewise is the role of PM10 in the causation of asthma, lung cancer, cardiovascular issues, and premature death. Even at relatively low concentration (not exceeding standard guideline of 150ug/m3 for 24 hours), inhalable particulate matter (PM10) have adverse effects on human health. Indeed, an increase of 50mg/m^3 in particulates levels is shown to induce increase death rate from 2 to 8 percent in several countries (HEI,1995). Supporting this particulate level and health relationship, WHO (1994) indicated that daily mortality rates would increase by 20 percent with an increase of particulate level to 200mg/m^3. A report by the Environmental Working Group in California showed that respiratory illnesses caused by particulate matter are responsible for more than 10,000 deaths and 16,000 hospital admissions. The health care cost of these illnesses was put at $132 million, in addition to millions of missed work days and school absences each year (Deborah et al., 1996). Air pollution problem has a local, continental and global ramification (WHO,1994b).The pollution problem is as complicated as it is serious. This is so because much pollution is caused by things that benefit people. Exhaust from automobile or vehicles for haul routes can cause large percentage of all air pollution but the automobile provides transportation either for people or loads (crush rocks). The circumstances surrounding most developing countries, Nigeria inclusive, is more pathetic in view of the utter disregard of pollution limits by most industries, low knowledge of environmental laws, immigration of polluting industries and the general poor living standard which affect people's nutrition status. In most African countries, the risks faced by those who are occupationally exposed and the non-occupationally exposed are poorly researched. Of serious concern is the elderly, children and infirmed people who constitute threat-risk population in the various communities hosting quarries. In any case, there is scarcity of information because much work has not been done on assessment of air quality.

2.2 STUDY AREA LOCATION

The study area Eziama quarry site is located in Abia State within coordinates N05^{0} 54$^{/}$ 56.574$^{//}$ and E007^{0} 26$^{/}$ 116.554$^{//}$ and on an elevation of 105.79m above mean sea level (Figure 1 & 2). The study area may be accessed through the Okigwe-Lokpaukwu road and other minor/track roads through Eluama in Abia state. The quarry company engages in the excavation of dolerite and crushing/processing into various aggregate sizes for sale to construction companies and registered agents.

2.3 GEOLOGY OF THE STUDY AREA

The study area is underlain by Nkporo formation (Figure 1) with an estimated maximum thickness of 1000m and consists of blue or dark grey shale and mudstone with occasional thin bands of sandy shale & sandstone. The formation also contains thin bands of shaly limestone in some places.

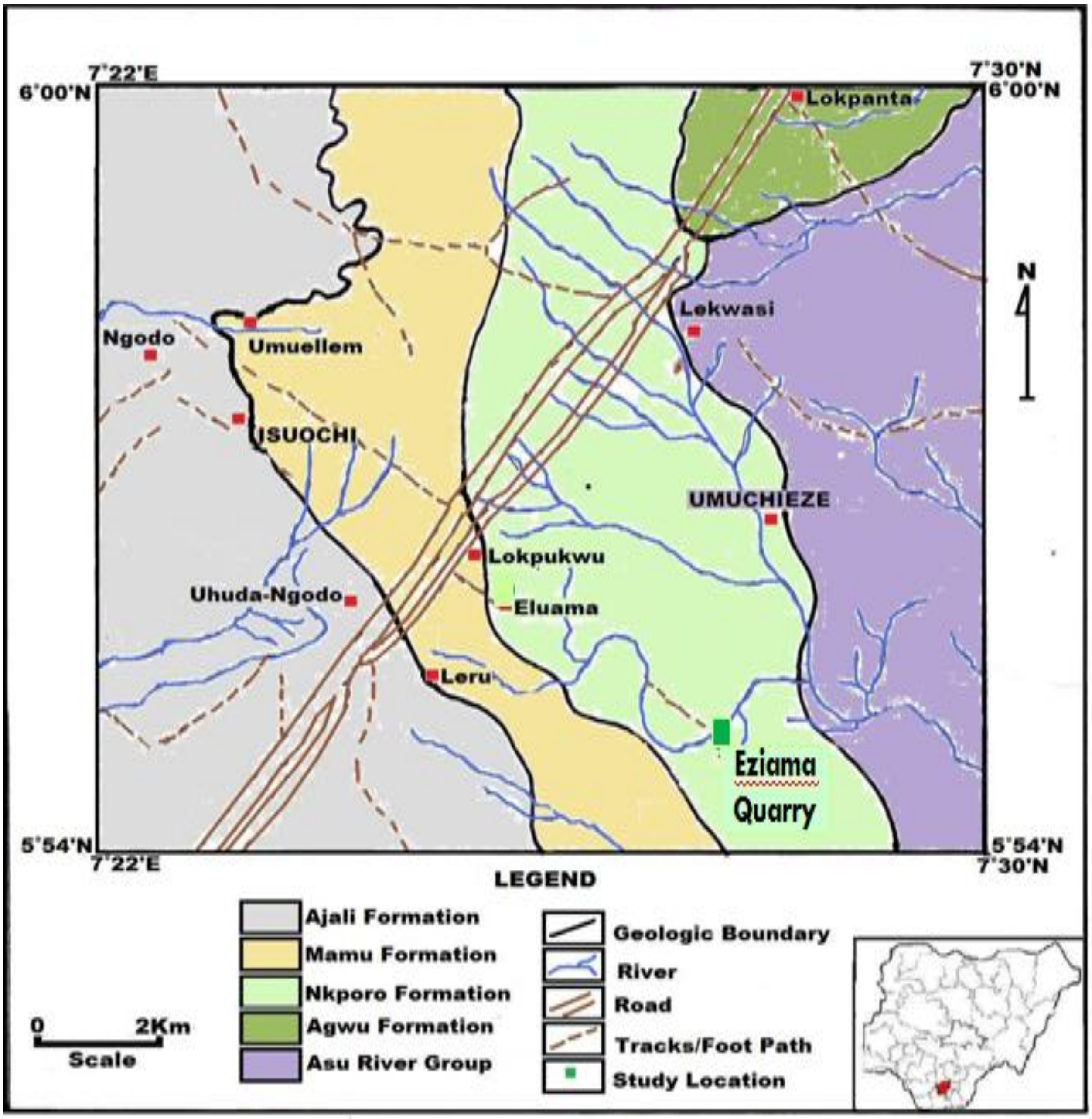


Fig 1: Geological Map of Study Area (Modified from NGS 1984)

The Nkporo Formation passes laterally into Owelli sandstone and attains a maximum thickness of 2000m (Reyment, 1965). The Nkporo Formation is underlain by the Agwu Formation (which consists of fissile shales and thin bands of sandstone) and overlain by the Mamu Formation. Records from the formation indicate a Campanian-Maastrchtian age. Massive Intrusive dolerite rocks also occur in places within the Formation in the study area. The hyperbyssal intrusive rocks are porphyritic in nature and Cretaceous in age as they occur within the fissile Nkporo shale (Reyment, 1965; Simpson, 1956).

2.4 CLIMATE AND VEGETATION

The area experiences basically two seasons; dry and wet season. The dry season takes place from November to April while the rainy Season is from the month of May to October. Average annual temperature is 25°C. Vegetation of the area is characterized by rain forest and as such and therefore consists of shrubs, palm trees, raffia palms and short trees. Other Activities include: Farming, bush burning, construction and mining activities**.** Based on soil and land use, the area is underlain by the Ferralitic red-yellow soil of humid equatorial rain forest. The soil of the area is derived from nearby hard rocks. The soil equally has low dilatancy and exhibits moderate plastic behavior. The land use pattern includes residential, agriculture and forestry. The surrounding local communities practice subsistence agriculture and grow crops like yam, cassava, maize, plantain, etc. The major industrial land use activity in the area is rock quarrying.

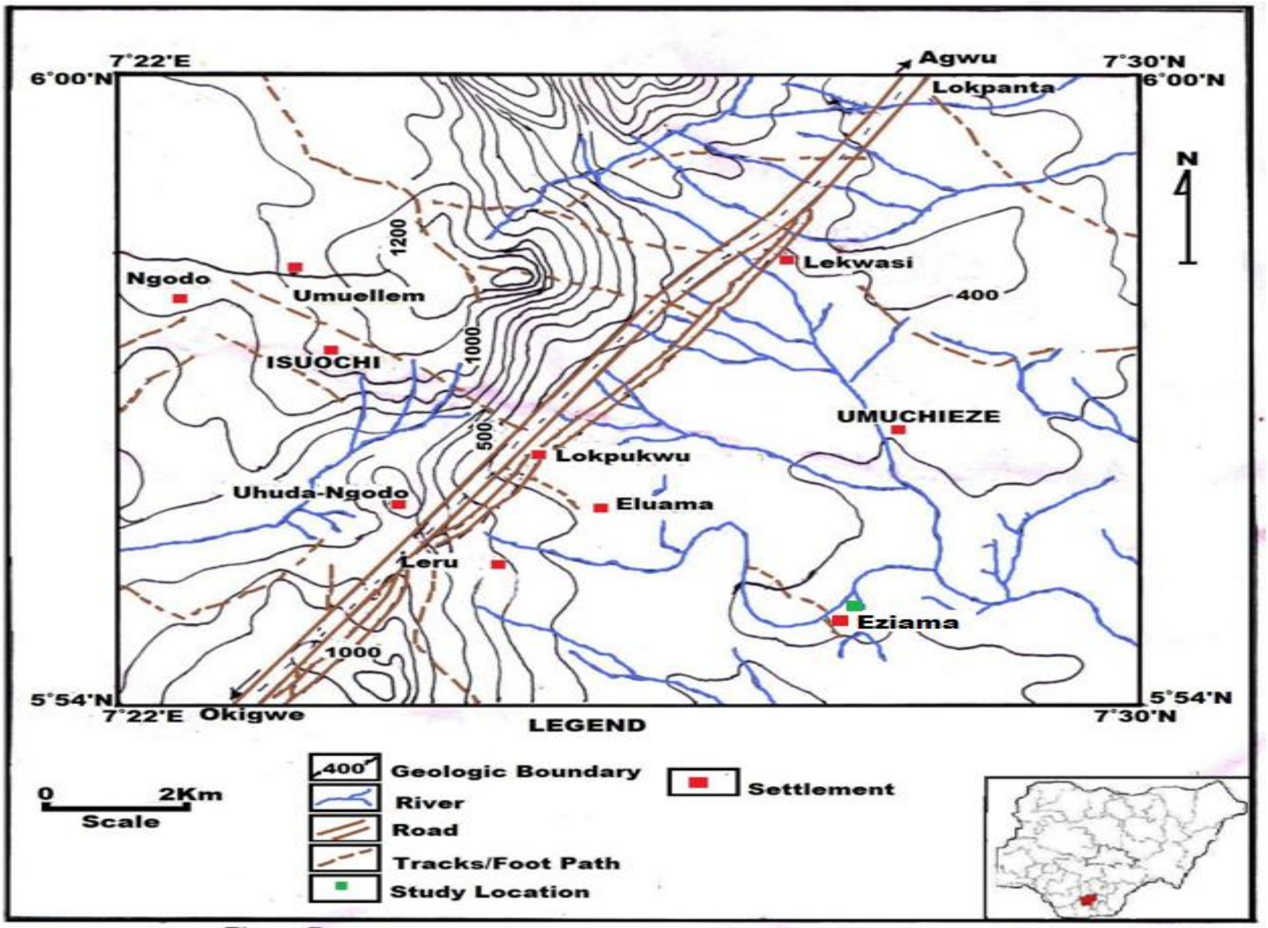


Fig 2: Topographic Map of Study Area (Modified from NGS 1984)

CHAPTER THREE

MATERIALS AND METHODS

3.1 MATERIALS

These include the following**;**

i. Global Positioning System
ii. Location map (Geologic and Topographic maps)
iii. Multi-parameter digital anemometer M45170: To measure mean ambient temperature, relative humidity and wind speed.
iv. Digital gas analyzer
v. Suspended Particulate Matter Meter (PC-GW6AAS-KIT)
vi. Noise meter (Doseometer)
vii. Air Quality Index Calculator

3.2 METHODS

The method of this research initially involved desk studies of various related literatures of similar/previous works carried out on the area. This was followed up by field reconnaissance survey of the study area using a global positioning system, carrying out air sampling, and noise sampling, and measurement of physical parameters such as temperature, relative humidity, wind speed and direction. Detailed studies of the topographical and geologic maps were done to ascertain credible results from the field. The reconnaissance survey involved walking around the site to know the relief of the ground probably undulating. The purpose of this preliminary investigation is to assess the stability of the site and the basis upon which the site exploration is planned for feature study

3.2.1 Air Quality Sampling

The air quality was assessed in the field using the digital Crowcon mobile Gas Analyzer 2012 Model and PC-GW6AAS-KIT particulate counter (SPM-meter). The gas analyzer or air monitor is automatically calibrated in the site and records the concentrations of the gases in parts per million (ppm) with an accuracy of $\pm$0.001ppm. The analyzer is actually used to detect gaseous emission such as SO_2, NO_2, CO, CH_4, NH_3. These were measured at different stations within the quarry site such as; generator house, Weight Bridge, primary crusher, secondary crusher, entrance. Coordinates were determined and recorded with the aid of Global Positioning System (GPS) equipment. The PM10, PM 2.5 and PM 1.0 monitoring was conducted with the aid of a Suspended Particulate Matter (SPM) meter that measures the concentration of particulates present in the air (μ/m^3). The particulate matter kit is initially regulated to the zero mark followed by a second clockwise directional turn to enable readings to be taken once screen value remains constant. The readings were taken as composite at five different points (cardinal directions) so as to arrive at a mean value for a specific sampling location. Particulate concentration at the drilling/blasting and crushing operation areas (primary and secondary crushers) were monitored and also at 5 metres, 10 metres and 25 metres away from these two major operation areas . This is to ascertain how far the dispersion of those pollutants could go . Monitoring measurements also took place at the entrance, weight bridge and generator area within the quarry. The field exercise was carried out in the months of January, June and October 2014.

3.3 BASIC COMPONENTS OF THE CROWCON ANALYZER

The basic components of this digital component instrument consist of;

i. Screen: This displays results
ii. Antenna to improve detection of gases
iii. An in-built error control unit which automatically corrects errors due to weather obstructions such as wind effects.
iv. An automatic in-built processor: this analyzes acquired/generated results and converts them directly into parts per million.
v. Three Knobs which include;
    - The power knob checking knob
    - The knob for battery check on turning of the second knob it displays readings reading on the screen of 120ppm.
    - The third is the knob for taking the actual reading- this is done when it is satisfied that on turning the second knob 120ppm will be displayed on the screen.

3.3.1 Principle of Operation

The Crowcon air analyzer is simple to operate as each gas to be tested for has its own kit switched on while the readings are taken simultaneously. The instrument has an automatic micro-processor which analyzes the air content and displays the results automatically on the screen.

3.4 NOISE SAMPLING

The noise level in the site was determined with the aid of a digital sound level meter, model Casella CEL-231with a resolution of 0.1db and manufactured by Casella CEL Bedford, England. The measurement specifications of the equipment are as follows; Frequency: 20HZ-10.0KHZ 20HZ, measurement Range: 30 – 130Dba, and Accuracy of $\pm$ 1.5dB. The noise meter measures noise level around the quarry site in decibels (Db). The equipment measured noise via the microphone probe that generates signals approximately proportional to sound waves.

3.5 DATA ANALYSIS

Mean values for concentration of each of the parameters were calculated using the Microsoft Excel Spreadsheet computer program for repeated measurements and as well as to obtain a representative discrete value. Bar graphs were generated with the data and used to compare side by side, the concentrations of the different parameters for the five sampling locations on the various sampling days. The Air Quality Index (AQI) was basically calculated for all sampled locations using the AQI Calculator and cross-checked using the daily average concentration of the measured parameters. The AQI is an index for reporting daily air quality. It tells us how clean or polluted the air is, and corresponding health effects. For each of these pollutants, EPA has established national air quality standards to protect public health. The AQI scale is divided into six categories and a specific colour assigned to each to appreciate at first glance whether air pollutants are reaching unhealthy levels in the area or not.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 RESULTS

TABLE 1: AIR QUALITY DATA OF EZIAMA QUARRY SITE (JANUARY, 2014)

STATION	AMB TEMP (C)	REL. Hu (%)	Wind speed (m/s)	Wind dir	Noise (Db A)	NO_x ppm	SO_x (ppm)	CO (ppm)	CH_4 (ppm)	NH_s (ppm)	SPM $\mu g/cm^3$	PM10 $\mu g/cm^3$	PM2.5 $\mu g/cm^3$	PM1.0 $\mu g/cm^3$	Coordinates
Generator House	34.0	53	2.2	NE	74.0	0	0.20	0	0.03	0.01	3.33	2	63	30	E7°26'16.554 N5°54'56.574 104.87m
Weight Bridge	32.5	55.5	2.0	NE	80.0	0	0.15	0	0.04	0.01	12.21	11	35	40	N5°54'55.860 E7°26'19.830 103.66m
Primary Crusher	34.4	54.0	1.2	NE	72.0	0	0.21	1	0.01	0.01	9.99	9	39	30	E7°26'18.912 N5°54'58.998 101.2m
Sec Crusher	32.5	54.4	3.0	NE	84.4	0	0.20	1.20	0.25	0.01	20	40	20	21	E7°26'19.704 N5°55'01.704 105.79m
Entrance	33.5	58.0	6.0	NE	74.6	0	0.24	1	0.00	0.01	24	43	25	28	N5°54'59.088 E7°26'16.080 99.39m
MEAN	33.38	54.98	2.88		77	0.00	0.20	0.64	0.066	0.01	13.906	21	36.4	29.8	
NESREA STD					140	0.06	0.10	20							

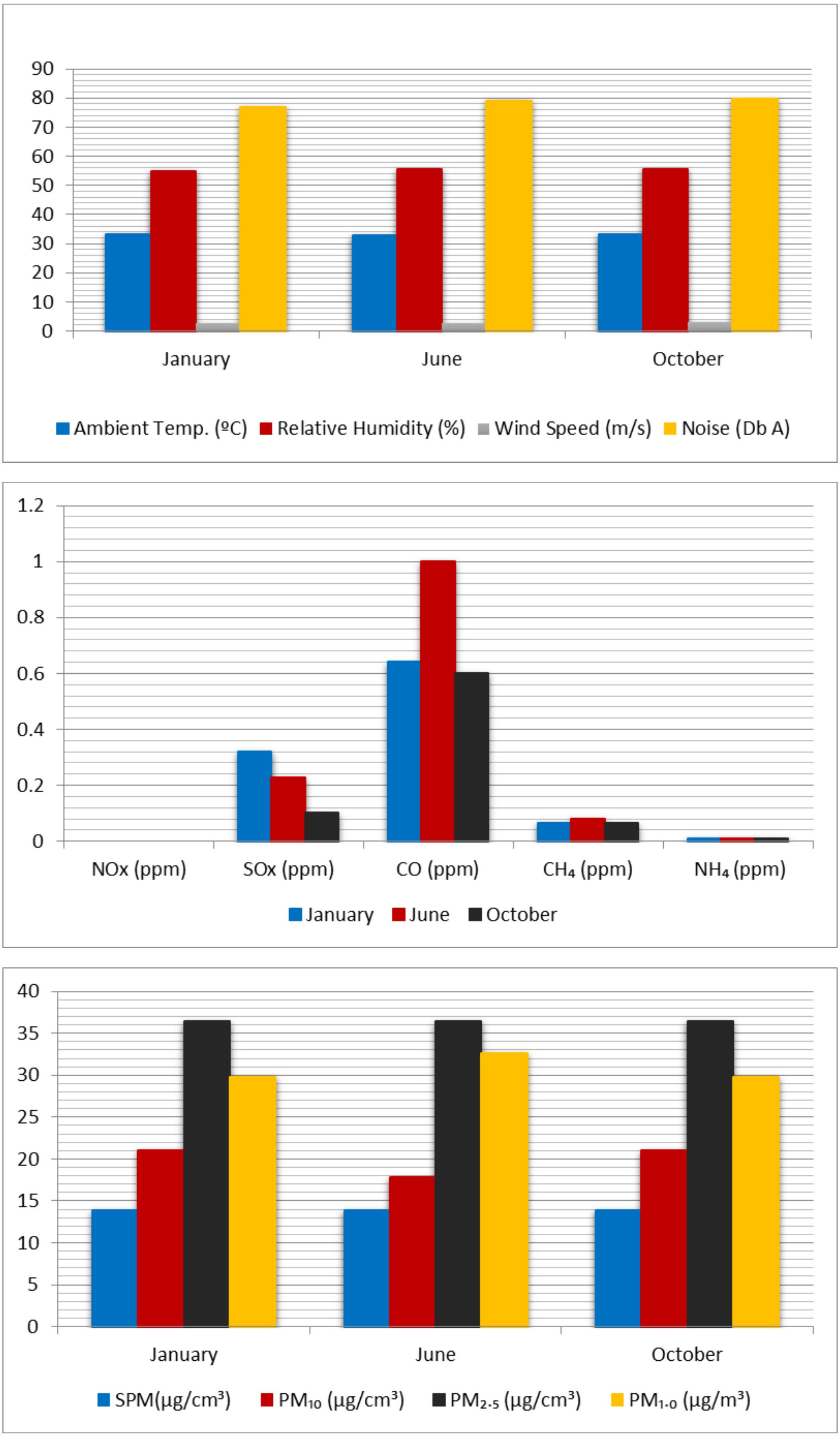
TABLE 2: AIR QUALITY DATA OF EZIAMA QUARRY SITE (JUNE, 2014)

STATION	AMBLE TEMP (C)	REL. Hu (%)	Wind speed (m/s)	Wind direct	Noise (DbA)	NO_x (ppm)	SO_x (ppm)	CO (ppm)	CH_4 (ppm)	NH_s (ppm)	SPM $\mu g/cm^3$	PM10 $\mu g/cm^3$	PM2.5 $\mu g/cm^3$	PM1.0 $\mu g/cm^3$	Coordinates
Generator House	**33.0**	**54**	**2.1**	**NE**	**74.7**	**0**	**0.30**	**0**	**0.04**	**0.01**	**3.33**	**3**	**65**	**26**	**$E7^0 26^1 16.554$ $N5^0 54^1 56.574$ 104.87m**
Wt Bridge	**32.4**	**55.8**	**1.8**	**NE**	**82**	**0**	**0.20**	**0**	**0.04**	**0.01**	**12.21**	**12**	**35**	**42**	**$N5^0 54^1 55.860$ $E7^0 26^1 19.830$ 103.66m**
Pry Crusher	**34.4**	**54.0**	**1.3**	**NE**	**72.9**	**0**	**0.24**	**1**	**0.06**	**0.01**	**9.99**	**15**	**37**	**30**	**$E7^0 26^1 18.912$ $N5^0 54^1 58.998$ 101.2m**
Sec Crusher	**33.0**	**54.8**	**3.9**	**NE**	**91.8**	**0**	**0.18**	**3**	**0.20**	**0.01**	**20**	**30**	**25**	**30**	**$E7^0 26^1 19.704$ $N5^0 55^1 01.704$ 105.79m**
Entrance	**31.4**	**59**	**4.0**	**NE**	**74.4**	**0**	**0.21**	**1**	**0.06**	**0.01**	**24**	**29**	**20**	**35**	**$N5^0 54^1 59.088$ $E7^0 26^1 16.080$ 99.39m**
MEAN	**32.84**	**55.52**	**2.62**		**79.16**	**0.00**	**0.226**	**1**	**0.08**	**0.01**	**13.906**	**17.80**	**36.40**	**32.60**	
NESREA STD					**140**	**0.06**	**0.10**	**20**							

TABLE 3: AIR QUALITY DATA OF EZIAMA QUARRY SITE (OCTOBER, 2014)

STATION	AMBLE TEMP (C)	REL. Hu (%)	Wind speed (m/s)	Wind dir	Noise (Db A)	NO_x ppm	SO_x (ppm	CO (ppm)	CH_4 (ppm)	NH_s (ppm)	SPM $\mu g/cm^3$	PM10 $\mu g/cm^3$	PM2.5 $\mu g/cm^3$	PM1.0 $\mu g/cm^3$	Coordinates
Gen/ Hs	33.6	54.8	2.4	NE	75.4	0	0.10	0	0.02	0.01	3.33	2	63	30	$E7^0 26^1 16.554$ $N5^0 54^1 56.574$ 104.87m
Wt Bridge	31.4	55.5	2.0	NE	81.6	0	0.10	0	0.04	0.01	12.21	11	35	40	$N5^0 54^1 55.860$ $E7^0 26^1 19.830$ 103.66m
Pry Crusher	35.4	55.0	1.6	NE	76.40	0	0.10	1	0.01	0.01	9.99	9	39	30	$E7^0 26^1 18.912$ $N5^0 54^1 58.998$ 101.2m
Sec Crusher	33.7	54.8	3.6	NE	90.40	0	0.10	1	0.25	0.01	20	40	20	21	$E7^0 26^1 19.704$ $N5^0 55^1 01.704$ 105.79m
Entrance	32.3c	58.6	5.0	NE	74.8	0	0.10	1	0.00	0.01	24	43	25	28	$N5^0 54^1 59.088$ $E7^0 26^1 16.080$ 99.39m
MEAN	33.28	55.7 4	2.92		79.72	0.00	0.10	0.6	0.064	0.01	13.906	21	36.4	29.8	
NESREA STD					140	0.06	0.10	20							

The average readings were taking per single reading data at 5 different sample locations like the generator house, weight bridge, primary crusher, secondary crusher and entrance.



FIGs 3a-c: BAR CHARTS SHOWING VARIATION OF PARAMETERS DURING THE MONITORING PERIOD FOR EZIAMA QUARRY (FIELD WORK 2014)

These multivariate diagrams below (fig 4-5) show how the particulate matter and pollutant gases vary with the meteorological parameters.

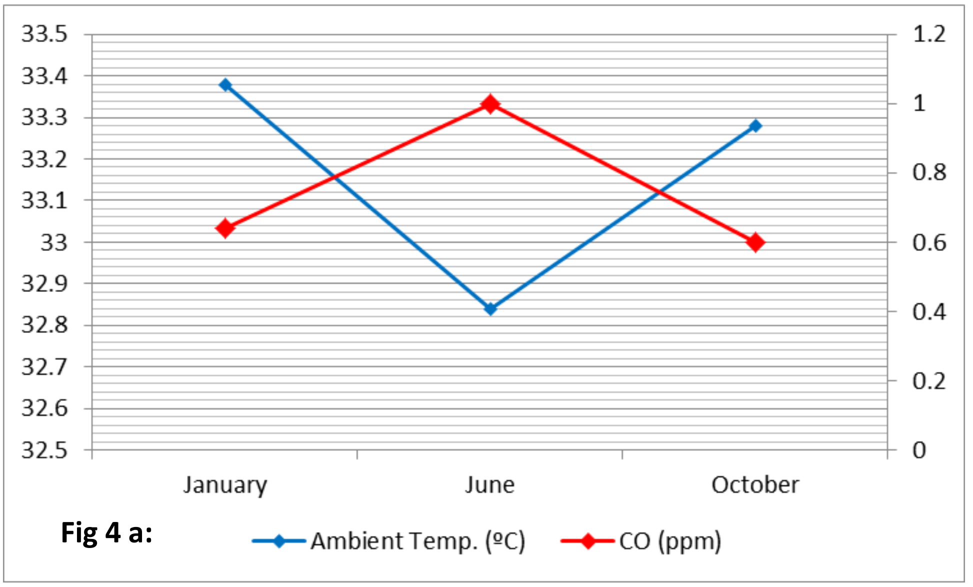


Fig 4 a:

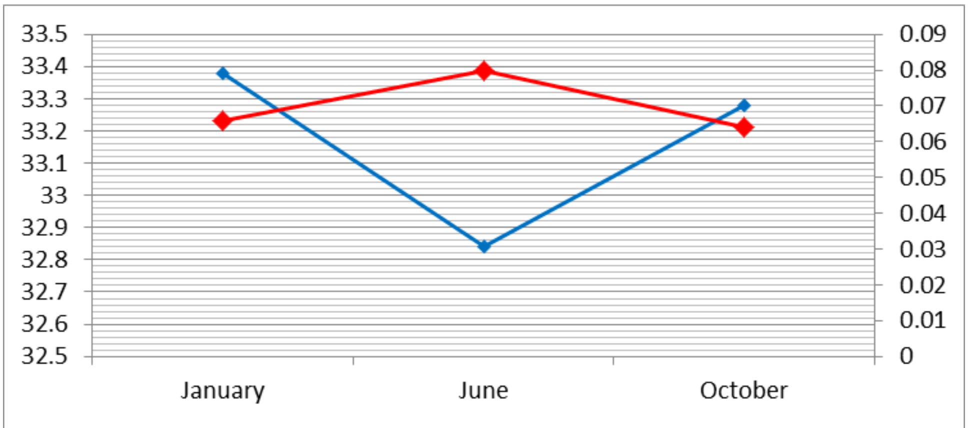


Fig 4 b:

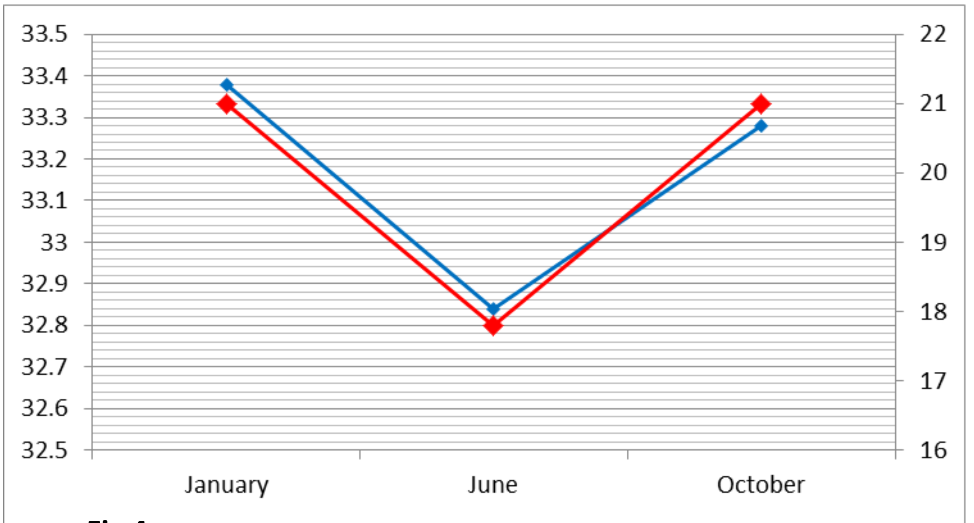


Fig 4c

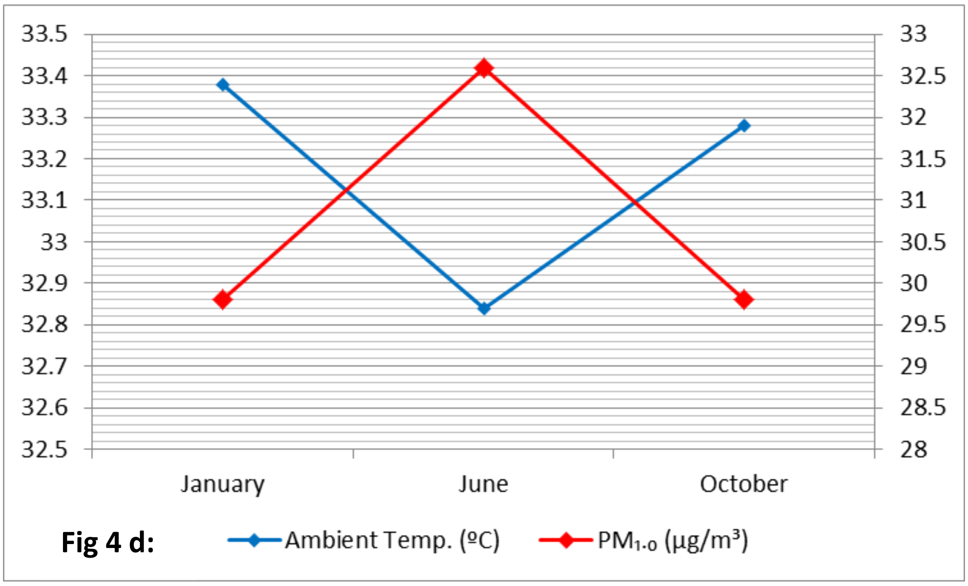


Fig 4 d:

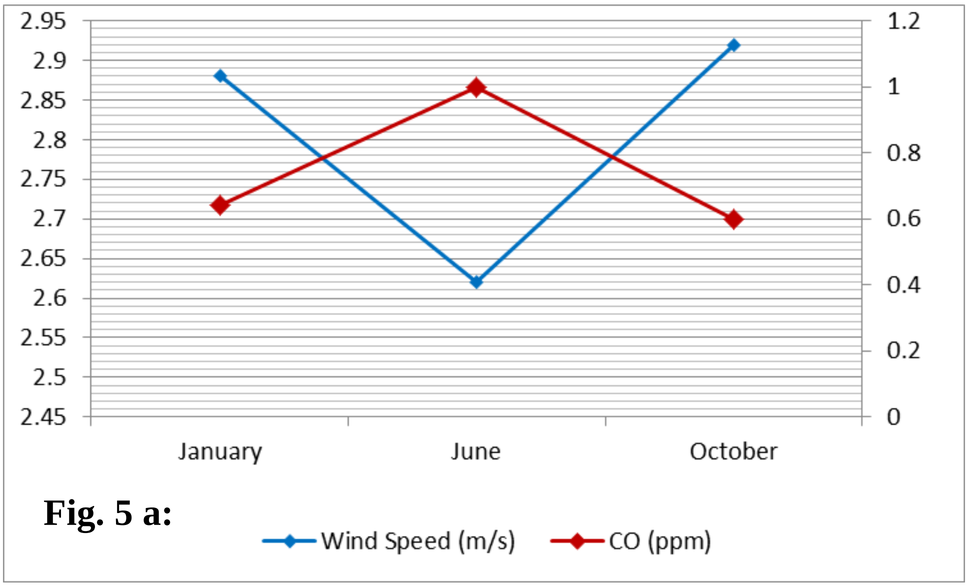


Fig. 5 a:

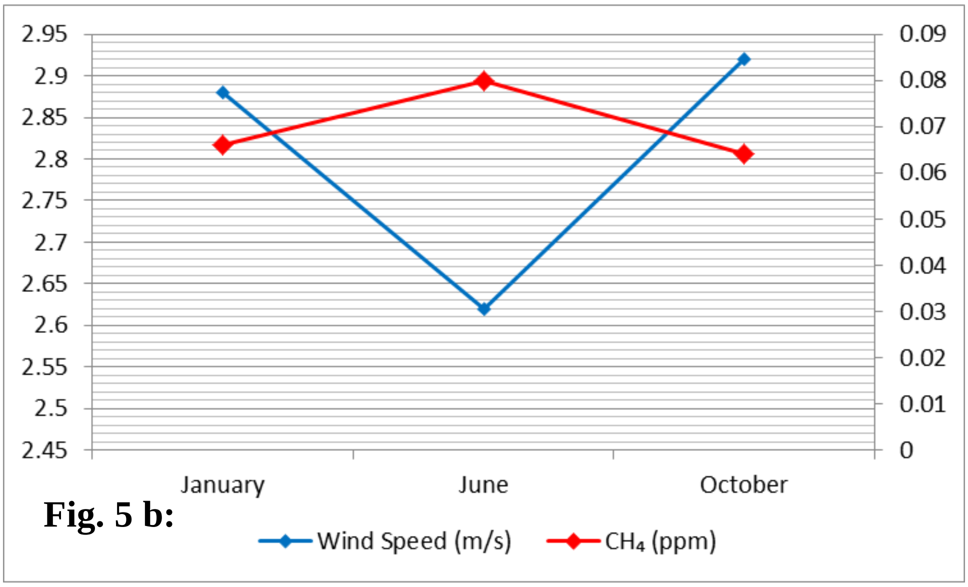


Fig. 5 b:

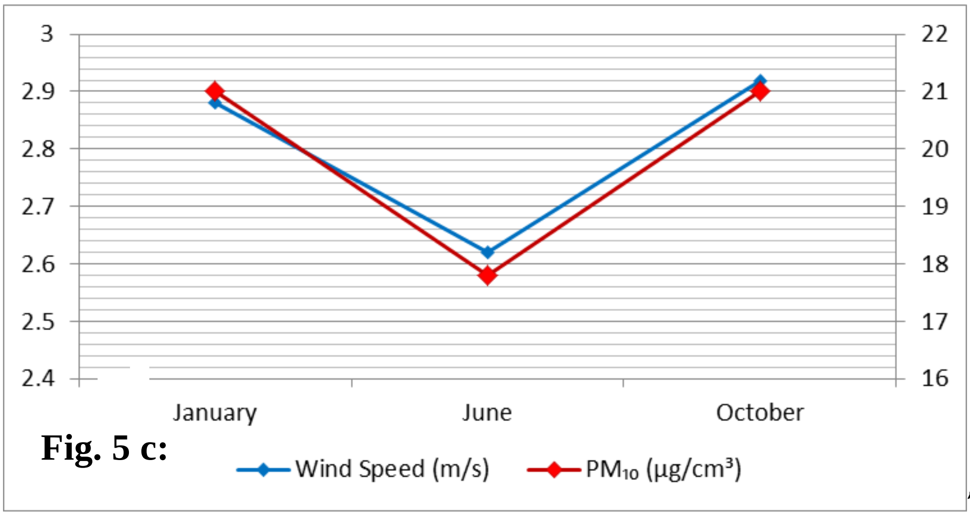


Fig. 5 c:

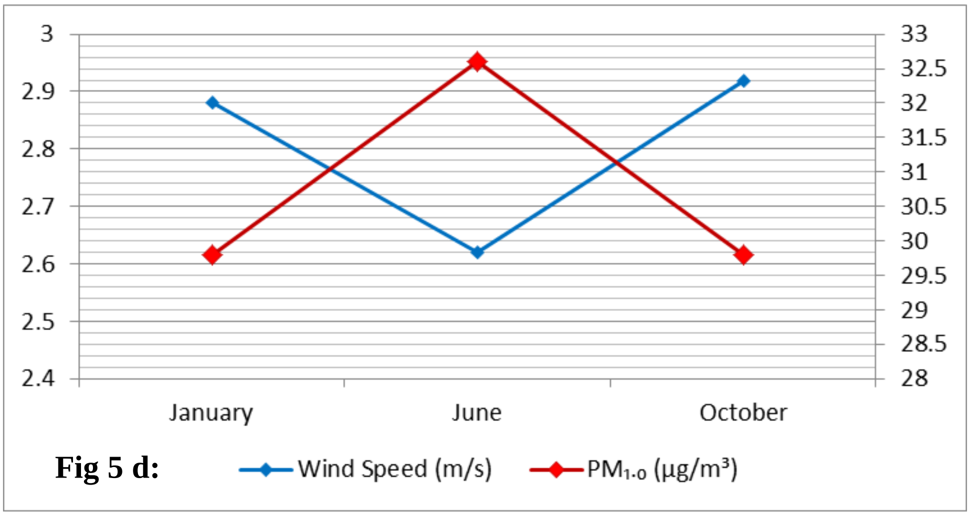


Fig 5 d:

4.2 DISCUSSION

The average readings were taking per single reading data at 5 different sample locations that is the generator house, weight bridge, primary crusher ,secondary crusher and entrance. Results of ambient air quality as shown in Tables 1 to 3 and bar charts, is an analysis of some meteorological parameters, Noise levels and major emissions such as: Particulate matter (Suspended and Respirable), Sulphur oxides, Carbon monoxide, oxides of Nitrogen, VOCs and Methane. .

The multivariate diagrams figure 4-5 above show how the particulate matter and pollutant gases vary with the meteorological parameters .The correlation of these parameters, pollutants and particulate matters show that a relationship existed between them. CO, CH_4 and PM1.0 were inversely proportional to the temperature and windspeed. They equally reached at maximum height or peak during the month of June probably because of the wind speed and wind direction. Therefore this made the dispersion of the pollutants easier during that period while in the case of temperature against PM10, the PM10 was directly proportional to temperature and windspeed. There was a drastic fall of temperature and windspeed during the month of June due to the size of the particulate matter. This is a prove that PM10 is dependent on the surrounding temperature and windspeed for it's dispersion. In conclusion, temperature and windspeed varies proportionately and inversely as the concentration of some of these pollutants and particulate matters are most times being controlled and determined by them. This is to say that they are seasoned while no relationship existed between SO_x ,NH_4 ,SPM and PM2.5 and the meterological parameters. They are equally not seasoned. Therefore temperature and windspeed varies proportionately and inversely to relative humidity because as the temperature increases, relative humidity reduces and vice versa.

4.2.1 Noise Level and Meteorology

The results of noise level and meteorology measurements are shown in table 1-3. The main sources of noise in the study area included noise from rock blasting site, crush rock processing plants (primary & secondary), haulage trucks, diesel power generating plant, heavy duty trucks, welding machines. The noise level at the sampling stations varied slightly. The highest noise levels of 84.4Db, 91.8Db and 90.4Db respectively for the 3 monitoring periods were recorded at the secondary crusher. The recorded mean values of noise for months of January, June and October during operation were 77.0, 79.16 and 79.72Db respectively. These values conformed to NESREA limit of 140Db (Tables 1 to 3). Other sampling points recorded noise level consistent with what is to be expected from such environment. Generally noise levels were in conformity with NESREA STANDARDS. Relative humidity values range from 53% to 59% throughout the monitoring periods, with mean values of 54.98%, 55.52% and 55.74% respectively. Table 1-3 shows that the wind speed is mild and do not vary too widely during the 3 monitoring periods. It ranges from 1.2m/s to 6.0m/s in January, 1.3m/s to 4.0m/s in June and1.6m/s to 5.0m/s in October. Mean wind speed values were 2.88m/s, 2.62m/s and 2.92m/s respectively. The mean ambient temperature, relative humidity and wind speed for January were 33.38^0C, 54.98% and 2.88m/s respectively while that of June were 32.84^0C, 55.52%, and 2.62m/s respectively. Values of these parameters for the month of October were 33.28^0C, 55.74% and 2.92m/s respectively. The wind directions were North-East (NE), Tables 1 to 3. The wind speed within the facility during the monitoring period was mild; this keeps the dispersion of gases and fugitive dust at low ebb.

4.2.2 Major Emissions

Except for Total Particulate Matter (TPM) and SO_2, all the air quality parameters were within the NESREA permissible limits. The mean TPM values for the months of January, June and October were 101.106μg/cm^3, 100.706 μg/cm^3 and 101.106μg/cm^3 respectively. These values very much exceed the NESREA limit of 50μg/cm^3. The difference between the mean TPM values and the NESREA limit is very alarming and calls for safety measures and regular monitoring by the quarry HSE department. It should be noted that elevated TPM values is common with most quarry sites. Tables 1-3 reveal that mean suspended particulate matter levels in the quarry vicinity remained quite stable during the monitoring period at13.906 μg/cm^3. Moreover, SPM levels were higher at the secondary crusher than the primary during the monitoring period. This is probably due to the crusher's production process specification alongside duration of operational hours.

4.3 ENVIRONMENTAL IMPLICATION OF QUARRY EMISSIONS

Generation of dust, smoke/ fumes, production of noxious gases, noise and percussions from rock blasting are some of the major negative impacts of quarrying. Solid materials in the form of smoke, dust and also vapour generated during quarrying operations are usually suspended over a long period in the air. Suspended particulate matter is quite outstanding among all pollutants emanating from quarrying operations (United State Environmental Protection Agency, 2008). Moreover, particulate matter in the air are capable of being transported from the point of generation to areas far removed (UNEP, 1991b). The scale of operation largely influenced the level of dust pollution generated at the quarry monitored in this study. Among the activity areas, drilling and blasting sites constitute dust pollution risk zone within quarries Enger and Smith (2002). These have implications for the planning of mitigation measures within the quarry and the surrounding environment. Dust pollution has detrimental effect on the natural environment.

4.4 AIR QUALITY INDEX

The AQI made it's debut in 1968 when the national air pollution control administration undertook an initiative to develop an air quality index and to apply the methodology to metropolitan statistical areas. The impetus was to draw public attention to the issue of air pollution and indirectly push responsible local public officials to take action to control sources of pollution and enhance air quality within the jurisdictions. Different countries have their own air quality indices, corresponding to different national air quality standards. An air quality index (AQI) is a number used by government agencies to communicate to the public how polluted the air currently is or how polluted it is forecast to become. It is equally an index for reporting daily air quality . it tells you how clean or polluted your air is, and what associated health effects might be a concern for you. The AQI focuses on health effects you may experience within few hours or days after breathing polluted air. Computation of the AQI requires an air pollutant concentration over a specified averaging period, obtained from an air monitor or model. As the AQI increases, an increasingly large percentage of the population is likely to experience increasingly severe adverse health effects. Therefore the lower the index ,the better the air quality.The Air quality index values for Eziama quarry have been grouped into ranges and assigned a descriptor, a colour code, and a standardized public health advisory (Table 4).

TABLE 4: AIR QUALITY INDEX FOR EZIAMA QUARRY

Eziama Quarry Site			AQI
January	Conditional pollutant	SO_2	131
	Average of AQI		62
June	Conditional pollutant	SO_2	147
	Average of AQI		67
October	Conditional pollutant	PM2.5	92
	Average of AQI		49

Descriptor	AQI	Risk Message
Good	0 - 50	No message
Moderate	51 - 100	Unusually sensitive individuals (ozone)
Unhealthy for Sensitive Groups	101 - 150	Identifiable groups at risk – different groups for different pollutants
Unhealthy	151 - 200	General public at risk; groups at greater risk
Very Unhealthy	201 - 300	General public at greater risk; groups at greatest risk

The increase in AQI from January to June implies that the quarry operations generated more SO_2 and also the environments atmosphere experienced little or no dilution of pollutants. Also judging from the low wind speed (Table 2), these might have resulted to Stagnant air within the quarry site in June, resulting to constant air pollution in the local area and significant concentrations of pollutants (e.g. SO_2). AQI computed results show that SO_2 was the major conditional pollutant throughout the monitoring periods of the assessment. Index values rose from 131 in January to 147 in June with respective averages 62 and 67. Air quality is acceptable; however, there may be moderate health concern for a very small number of people who are unusually sensitive to SO_2 pollution. The month of October recorded the best AQI for the quarry environment. AQI for PM2.5 ranked 92 in October and categorized as moderate from descriptor analysis with respect to environmental impact.

4.4.1 Effects of Sulphur IV Oxide

Sulphur dioxide is a major air pollutant usually formed from the oxidation of sulphur containing fuels and biomass. Results show that in January and June higher concentrations of SO_2 (mean values of 0.20ppm & 0.226ppm) were generated at the generator house of the quarry in Eziama. Oxidation of Sulphur in fuel generates So_2 while combination of Oxygen and Nitrogen at high temperature in the burning zone generates Nitrogen oxides. Sulphur dioxide is a noxious/greenhouse gas capable of generally causing respiratory sickness, acid rain and aesthetic damage to buildings as direct impacts. Although the mean

SO_2 values stated above are not critically higher than the NESREA standard of 0.10ppb, such a trend shows gradual increase and should be regularly monitored. Exposure to SO_2, at concentration above 5.00ppm could stimulate broncho-constriction (as in asthma) and mucus secretion as well as irritate the eyes in man. Long term exposure to lower concentration may result in death through cardiac and/or respiratory diseases and increased prevalence of related symptoms. Indirect impacts include contribution to global warming, resulting to sea level rise, flooding, erosion and water pollution (surface and groundwater). Also SO_2 can diffuse into the leaves directly through their stomata causing stomata closures, which protects the leaves against further entry of the pollutant but also curtails photosynthesis. As this occurs, exposed and affected leaves may begin to lose their colour in irregular, blotchy white spots, while others may develop red, brown or black spots. Plants damaged by SO_2 can be as far as 30 miles from its source, but the most severe damage, defoliation and discolouring is typically found within 5miles. Some crop plants that are resistant to SO_2 include; corn, potatoes, cabbage, onion etc

4.5 SUSPENDED PARTICULATES

Potential anthropogenic sources of SPM in the study area include fumes from processing/crushing plant, blasting activities, haulage of crushed rocks, welding activities, exhaust fumes from many sources e.g. heavy duty vehicles, power generating plant etc. High concentration of SPM are known to irritate the mucous membranes and may initiate a variety of respiratory problems e.g.

cough and asthma. Prolonged and excessive inhalation of particulates may cause cancer and aggravate morbidity and mortality from respiratory dysfunctions. SPM can also cause damage to materials by corroding metals (at relative humidity above 75%) and discoloring/destroying painted surfaces. It can also constitute a nuisance by interfering with sunlight and acting as catalytic surface for reaction of absorbed chemicals

4.5.1 Particulate Matter (PM)

Quarries produce dust as a by-product of the quarrying process. If not adequately controlled, the particles can cause excessive wear on machinery and mobile equipment, reduce visibility, contaminate surfaces, and contribute to

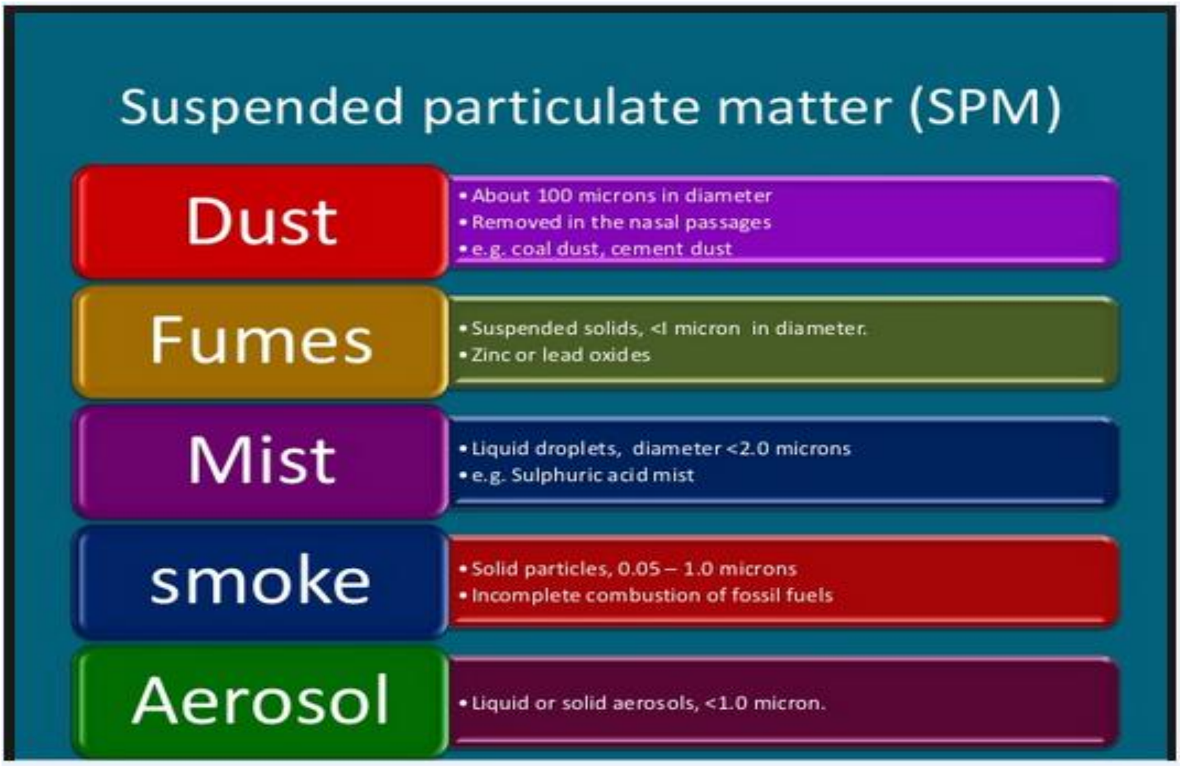


Fig 6: Components of Suspended Particulates from Quarrying

Plate 1: Generation of Particulate matter and Suspended Particulates at the Quarry crushing section Eziama Quarry (Field School 2014)

serious health effects for employees. Drilling, crushing, blasting etc are all quarrying processes that produce a significant amount of dust. The variety of processes and type of rock that is mined contribute to a range of particulate sizes varying from less than 1 µm to greater than 100 µm (MinEx Health & Safety Council, 2008). Dust can be defined as solid particles dispersed in a gaseous medium as the result of the mechanical disintegration of matter. Dust may occur as fugitive dust from excavation, from haul roads, and from blasting, or from point sources, such as crushing and screening. Throughout the monitoring period, highest levels of PM 1.0 were detected at the weight bridge; PM2.5 at the generator house, PM10 at the entrance (in Jan & Oct) & secondary crushing section (in June) while for SPM, highest concentrations were detected at the entrance. The exhaust gases and particulate matters of the dust exhausted from crushing plants are released to air and degrading air quality and thus create considerable environmental pollution (Adak et al., 2007). Dust deposits on towers, fruits and vegetable and even surface waters within and around the quarry environment.

4.5.2 Health Impacts

Air pollution and ground vibration arising from blasting, crushing and emission of noxious gases have negative impacts on human health and well-being. The health effects of particulate matter can increase dramatically as the particulate matter decreases in size. Particles are separated into three categoriesbased on their size distribution; inhalable, thoracic, and respirable." (Shomody,2013). Inhalable particles are the largest of the three categories ranging from 10 to100 micrometers (µm). These particles are easily filtered out by cilia in the nose and throat; therefore, their risk to human health is relatively low. Thoracic particles range from 5 to 10 µm in size. Thoracic particles are small enough to pass through the nose and throat and enter the lungs becoming lodged in the brochial region. Respirable particulates are less than 4 µm in diameter and are known to cause the most severe health effects because the particles travel to the deepest portion of the lungs affecting the aveoli (TSI Inc, 2013). Once particles of varying chemical compositions (PM2.5 & PM1.0) are inhaled, they lodge in human lungs (Figure 6); thereby causing lung damages and respiratory problems (Last, 1998).

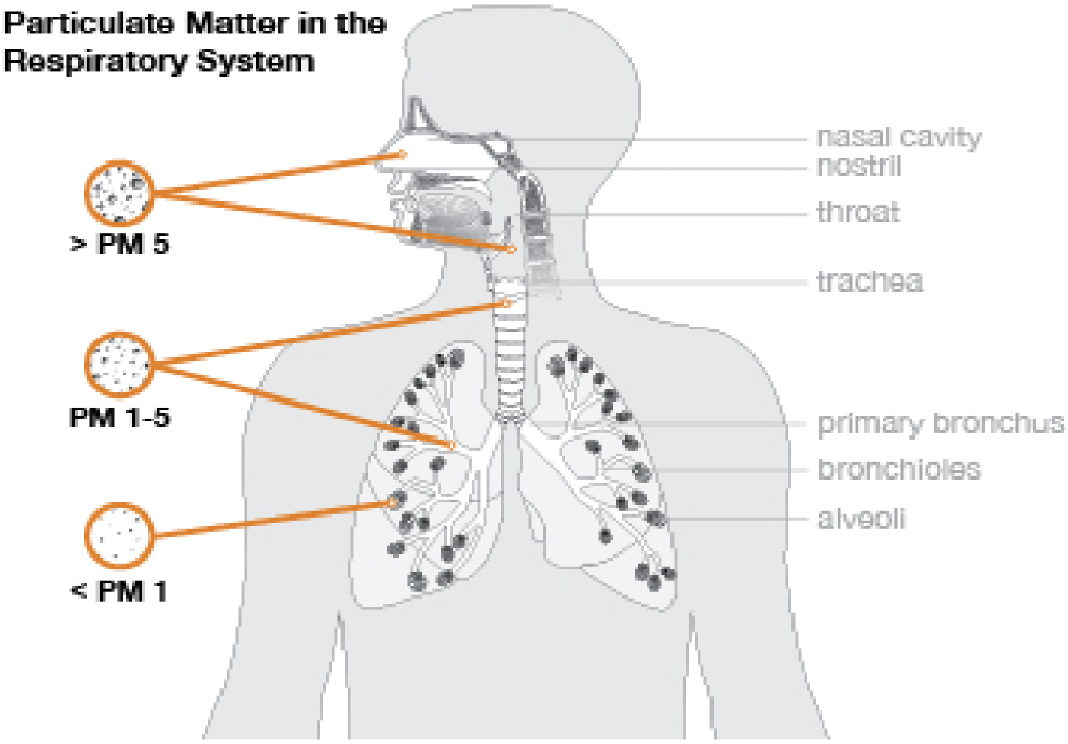


Fig 7: Illustration of Health impacts of Particulate matter

Dust pollution from quarry operations in the study area can lead to chronic health issues such as decreased lung capacity and lung cancer resulting from long-term exposure to toxic air pollutants (Sunyer, 2001). PM10 and PM2.5 are the two categories of particles capable of causing a variety of respiratory and cardiovascular problems including asthma and shortness of breath. These symptoms may be acute or long-term based on exposure. Cardiovascular effects are more strongly associated with PM2.5 and PM1.0, as the particulates are small enough to enter the gas exchange system of the lungs. Also PM2.5 demonstrated a correlation with additional plaque buildup in the arteries. Plaque in the arteries of the heart is known to lead to atheriotsclerosis of the heart, hardening the arteries, and increasing the chances of a person having a myocardial infaraction (Pope et al., 2002). It is important to note that PM2.5 is more strongly associated with acute respiratory effects Schwartz and Neas (2000). Also the relative risk of adverse health effects resulting from particulate matter exposure are significantly increased for the young, old, and pre-disposed populations (Schwartz et al., 2002).

Generally, health problems suffered by quarry workers are mostly those associated with inhalation of dust in the air. Examples of most prevalent problems diagnosed include nasal infections such as cough, followed by catarrh and sinusitis and in some critical cases silicosis especially in granite and dolerite quarries. These findings agree with the report of authors such Murray and Lopez (1996), Natural Resources Defence Council (NRDC, 1996) and Enger and Smith (2002). Apart from silicosis, quarry workers and sandblasters are vulnerable to suffer from pneumoconiosis (www.gulflink.osd.ml). There can also be minor health effects such as eye irritation when the dust is airborne. Indirect stress-related health effects could also arise, especially if dust problems are allowed to persist for an unreasonable length to time.

4.5.3 Effect on Plants

According to Hsin-Yi, 2012, particulate matter such as dust blocks and damages the internal structure and abrasion of leaves and cuticles. Dust deposits can have significant effect on plant life, though, mainly at high dust loadings. This includes:

(i) Reduced photosynthesis due to reduced light penetration through the leaves.

(ii) Increased incidence of plant pest and diseases.

Dust deposits can act as a medium for the growth of fungal disease. In addition, it appears that sucking and dust deposits to any great extent do not affect chewing insects, whereas their natural predators are affected. This could affect the food chain.

4.6 Oxides of Nitrogen (NO_X) and VOCs

The oxides of nitrogen are usually formed at higher temperature combustions e.g. industrial combustion and vehicle engines. Nitrogen dioxide which is also a contributor to air pollution, readily forms by partial oxidation of nitrogen and is usually emitted in exhaust pipe or motor vehicles and the manifold of power generating equipment where rapid oxidation to NO_2 takes place. Some effects of nitrogen dioxide inclde abnormalities in airways resistance, nose irritation and major contributors to acid rain which leads to ozone layer depletion. NO_2 produce ground level ozone or photochemical smog by reacting with volatile organic compounds (VOCs) in the presence of heat and sunlight. The smog can cause damage to lungs tissue alongside its function. NO_2 can also cause pulmonary oedema. Both Nitrogen dioxide and VOCs concentration in the study area (Eziama quarry) were found to fall below detection limit. This equally implies that Nitrogen dioxide is in conformity with NESREA STANDARD of 0.06ppm.

4.7 CARBON II OXIDE (CO)

Carbon II Oxide is a product of incomplete combustion of carbon containing compounds. Stationary combustion sources and coal mining operations also produce carbon II Oxide especially through oxidation of methane. CO can cause suffocation in man, and is also a contributor to acid rain formation although not directly. CO concentrations detected at Eziama quarry site were very low and conformable to the NESREA limit (20ppm). Concentrations are therefore permissible for the quarry workers. This implies that the facility employed good management operational practices and measures to tackle the problem. The mean concentration of CO (0.64ppm) at the site may be correlated with the surrounding vegetation cover and soil micro organisms which remove CO from the atmosphere. Also the mean concentration of methane (0.066ppm) at the site is too low to produce significantly harmful concentrations of carbon II oxide on oxidation. CO concentration in the study area correlates indirectly in proportion with ambient temperature and wind speed (Figures 4B & 5B). June period records the highest mean concentration of Carbon II Oxide (Fig 3b).

4.8 EFFECT OF NOISE

Noise is an unwanted sound produced by a source causing vibrations in the medium around it. Drilling or shot holes, deposition of rock pieces into the jaw crushes by pail-loaders, grinding action of crushers, power generating sets, vehicular motion and rocks blasting with explosives are major source of noise within and around the quarry site. The impacts of noise are highly dependent on sound source, the topography, land use, ground cover of the surrounding site and climatic conditions. Exposure to noise pollution arising from blasting, quarry machines such as crushers and generators can induce hearing loss and other pathological changes in the affected worker. However for Eziama Quarry site, the noise levels fall below the NESREA limits and remain at permissible levels that are not detrimental to the health of workers. Generally, quarry workers stand a risk of experiencing shock due to sudden noise from the use of explosives and ground vibrations that result from rock blasting especially when noise levels exceed standard limits. According to reports, the detonation of explosives in quarrying operation causes ground vibration, which produces effects such as stress, anxiety and increased pulse rate, loss of sleep, fatigue and excessive contraction of pupil among residents living near quarry site Alloyway and Ayres (1997).

CHAPTER FIVE:

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

Quality of air in Eziama quarry SE Nigeria was monitored by sampling various gaseous emissions, particulate matter, noise, wind speed, wind direction, relative humidity and temperature; with the aid of digital gas analyser, particulate counter, digital sound level meter, multi-parameter digital anemometer. Results obtained showed that Quarry activities constantly release air pollutants into the environment within the site. Furthermore, pollutants such as Suspended Particulates (SP), particulate matter (PM1.0, PM2.5 and PM10) and greenhouse gases such as SO_2 and CO were detected while CH_3 and NH_4 fell below the detection limit. Throughout the monitoring period, highest levels of PM 1.0 were detected at the weight bridge; PM2.5 at the generator house, PM10 at the entrance (in Jan & Oct) and secondary crushing section (in June) while for SPM, highest concentrations were detected at the entrance. Apart from Total Particulate Matter (TPM) and SO_2, all other emitted pollutants conformed to NESREA standard showing that air quality within the site is not alarming & that the quarry facility employed good measures to control air quality degradation. To ensure sustainable air quality management within & around the site, constant air quality monitoring and segmented operation is strongly recommended in order to reduce the effects of particulate matter and SO_2 on the environment. For sustainable quarry activities, quarry sites should be located at interior areas surrounded by adequate vegetation which would act as sinks and block for various emissions emanating from the quarry.

Results obtained from the investigation reveal that Quarry activities constantly release air pollutants into the environment within Eziama Quarry site SE Nigeria. The fact that most of the emitted gases conformed to NESREA standards shows that air quality within the site is not alarming and that the quarry facility employed good measures/practices to control air quality degradation. There is also a great need to pay more attention to total particulate matter mitigation so as to ensure a more sustainable air quality within the quarry environment.

5.2 RECOMMENDATIONS

1. Constant monitoring of air quality should be carried out in the quarry using gas monitors/analyzers.
2. Equipment to reduce dust emissions during quarrying & manufacture of aggregates should be widely used, & equipment to trap & separate exhaust gases should also be much more used.
3. Introduction of Scrubbers to absorb some of those harmful gases.
4. Introduction of filters to filter harmful gases as well as wetting of the quarry environment.
5. The use of ear mufflers is strongly recommended for workers especially during blasting and crushing operations. Masks may also be recommended to prevent inhalable particles (PM) from entering the lungs.
6. Segmented Operation: Reduction of duration of machinery operation (reducing operational hours) such as generators and crushers. Intervals can also be created between blasting periods and crushing so as to reduce the

effects of noise pollution and also create space (Lacunae) for the natural environment to dilute and recover from gaseous emissions. This is summarized as reduction/sharing of operational hours.

7. Constant monitoring of wind direction will help regulate and decide how to place /position gas outlets or direction of stacks.
8. Introduction of sound proof generators to minimize noise pollution.
9. Government policy should be put in place to regulate polluting industries.
10. However, where accepted, engineering control measures have not been developed or when necessary due to the nature of work involved, employees may work for reasonable periods of time in concentrations of airborne contaminants exceeding permissible levels if they are protected by appropriate respiratory protective equipment" (Mine Safety and Health Administration, 2013).
11. Adequate controls such as control rooms, enclosed cabs on mobile equipment, watering of roads, and ventilation should be provided by the quarry management to reduce the employee's exposure to contaminants such as particulate matter.
12. Still on the part of Government Proper planning for location of Industries so as to control pollution frequency of industries in same line of production and liberating same pollutants. The atmosphere needs some space and time for recovery from such gases. (Recovery of the natural environment).
13. Generally similar industries should not be sighted close to each other to minimize effect of pollution. For example; quarries already close to each other should not operate crushing at the same time especially for long hours so as minimize the emission of fugitive dust and particulate matter, and also to allow quick /effective recovery of the natural environment from air pollution.

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