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ENVIRONMENTAL IMPACT OF AGGREGATE MINING BY CRUSH ROCK INDUSTRIES IN AKAMKPA LOCAL GOVERNMENT AREA OF CROSS RIVER STATE

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Abstract

The impact of aggregate mining operation such as noise, dust, air quality, suspended particulate matter and gaseous emission poses serious environmental problem to both the inhabitant and the workers at Crush Rock Industries Limited at Old Netim in Akamkpa Local Government Area of Cross River State. Eight geo-referenced sampling points were chosen for the study which were SP1, SP2, SP3, SP4, SP5, SP6, SP7 and SP8. Results obtained shows that the noise level at the sampling stations varied slightly. The highest noise level was 101.8d(B) A at sampling point SP7 inside the premises of the company followed by 96.1d(B) A at station SP6 recorded at the plant during wet season. Other results were 78.7, 67.2, 46.0, 49.2, 71.0, 40.5d(B) A, while the FMENVs was above the threshold value at sampling point SP7, while carbon monoxide (CO) and nitrogen dioxide (NO_2) levels were also above the threshold values at sampling point SP7 in Table 3 during wet season.

Keywords: noise, dust, gaseous emission, suspended particulate matter (SPM), volatile organic compounds (VOC), carbon monoxide

1. Introduction

Environmental impact is any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization activities, products or services. Quarrying is a form of land use method concerned with the extraction of non-fuel and non-metal minerals from rock. Sand, gravels and limestone are obtained from the earth through quarrying for building houses and other civil construction are obtained from quarrying or rocks of the earths crust Keeperman [1], defined quarrying as an act of exploring and exploiting stone from rocks. Metal ores are extracted by mining which involves removal of rock from the ground. According to Cassidy [2] there is now a great demand for stone especially as limestone in form of crushed rock and it is also an essential constituent of many building and contraction materials.

A wide variety of product from mining and crushing of rocks form primary raw materials in many industrial applications [3]. Crushed rocks are used as aggregate in highways or concrete construction; in bituminous mixture and railroad ballast [4].

Quarrying could be done in diverse methods such as hard rock mining, using rock drills, explosion of dynamite and other sophisticated methods. The process could also be open pit or surface method, underground and solution mining. The mining method used depends on the particular mineral, the nature of the deposit and the location of the deposit. Each mining method has its own impact on the environment.

However, several wastes are generated when rocks are extracted from the earth. Environmental disturbances as a result of mining and processing activities constitute a major threat to public health and environmental quality [5].

Severity of the environmental problem depends on the characteristics of the mineral being extracted, the methods of mining, waste materials generated and the site characteristics. The effect is manifest in air, land, plants and water associated with mining process.

Environmental degradation accompanies mining operations and remains after they cease, with air pollution, scars on the landscape and threatened surface and underground waters. Quarrying activities dates back to the beginning of the 20th century, and are conducted not in isolated areas but near water bodies, farmland and human settlement [6], [7]. As a result of this quarrying waste generated alongside could constitute serious environmental problems either at point of production; processing or during extraction. Since prehistoric time, quarrying has been integral and essential to mans existence Backer [8], reported that mineral discovery and development in Nigeria dated back to the pre-historic era. The colonial administration embarked on quarrying in Nigeria for limestone in 1920 in Akamkpa and its subsequent exploitation led to the establishment of Calabar Cement Company (CALCEMCO) as reported by [9]. Although limestone was discovered in 1920 in Nigeria. Chrysanthus [7] reported that quarrying started in 1800 at Old Netim Akamkpa Local Government Area.

1.1. Types of mining

Mineral extraction is broadly divided into 3 basic methods; open-pit surface, undergone and solution mining.

1.1.1. Open-pit or surface mining

According to Cassidy [2], surface mining or open-pit mining require extensive blasting and removal of rock, soil and vegetation in order to reach mineral deposit. Waste rock or over burden is pilled away from mine. Benches are cut into the walls of the mine to provide access to progressively deeper ore, as upper-level ore is depleted. Open-pit mining produce large amount of over burden and accounts for 90% of the ore mined in U.S.A [2].

1.1.2. Underground mining

Underground- mining involves extraction from beneath the surface from depths as deep as 5,000 meters. It entails sinking a shaft to reach the ore. The passages are cut the shaft at various depths to access the ore.

Mobile rigs are used for drilling holes in the rock, which are ten filled with explosives for blasting waste rock and ore. Drill system could be rock, diamond, water-jet flame. Rock and diamond drills involve the rotation of a pipe or rod tipped with a rolling gear-like bit while water jet drills use a powerful jet to blast mineral lose. Jet flame drills use a high velocity flame to create holes in hard rock. Blasting is a method of mineral extraction involving the displacement and breaking of solid rock through the use of explosives to sizes that require a minimum of secondary breakage and can be handled by loading and hauling equipment.

According to Wills [4], quarrying for crushed stones is a form of underground mining that uses high explosives to dislodge great quantities of rock, which are latter crushed or screen to specific small sizes.

1.1.3. Solution mining

Ademola [10] stated that alluvial or placer mining is an aqueous extraction method of recovery of heavy minerals from alluvial deposit, it uses water to excavate, transport and concentrates the mineral. According to Adepoju [5], alluvial mines usually involves relatively high volume and low cost excavation. Solution mining is the method of mining extraction and uses an aqueous extraction method in the recovery of heavy minerals.

1.2. Classification of aggregate mining impacts

1.2.1. Engineering impact

Some of the environmental disturbance created by quarrying is caused directly by engineering activities during aggregate extraction and processing the most obvious engineering impact of quarrying is a change in geomorphology and conversion of land use, with association change in visual scene. This major impact may be accomplished by loss of habitat, noise, dust, vibrations, chemical spills, erosion, sedimentation and dereliction of the mined site.

Some of the impacts are short-lived and most are easy to predict and easy to observe. Barksdale [9] said that most engineering impacts can be controlled, mitigated, kept at tolerable levels and restricted to the immediate vicinity of the aggregate operation by employing responsible operational practices that use available engineering techniques and technology. Engineering impacts causes other impacts as sub classified below:

1.2.2. Cascading impacts

In Karst environments, aggregate mining may alter sensitive parts of a natural system at or near the site thus creating cascading environmental impacts as suggested by [11]. Cascading impacts are initiated by engineering activity such as the removal of rock, which alters the natural system [12].

1.2.3. Geomorphic impact

Quarrying has an associated, often dramatic, visual impact. Karst terrain is commonly considered to be of high scenic value, thus compounding the effects of visual impact of quarrying. The principle geomorphic impact of quarrying is the removal of stone, which results in the destruction of habitat including relict and active caves and natural sinkholes. The extent of the geomorphic impact is a function of the size of the quarry, the number of quarries and the location of the quarry, especially with respect to the overall landscape and land forms. The influence of quarry size on environmental impact is obvious: all things being equal, the larger the quarry, the larger the geomorphic impacts. The size of quarries has increased over time, and so has their impact. Great numbers of quarries in a Karst and Region amplifies the geomorphic impact [5] suggested that the disturbance created by numerous smaller quarries is greater than that created by one large quarry and recommend that geomorphic disturbance be minimized by maximizing reserves through deep quarrying.

1.3. Noise

Noise is an unwanted sound-produced by a source causing vibrations in the medium around it [13]. According to the International Programme on Chemical Safety WHO [14], an adverse effect of noise is defined as change in the morphology and physiology of an organism that results in impairment of functional, capacity, or an impairment of capacity to compensate for additional stress, or increases the susceptibility of an organism to the harmful effects of other environmental influences. According to Prodec-Fugro Consultant Ltd [15], drilling or shotholes, deposition of rock pieces into the jaw crushes by pail-loaders, grinding action of crushers, power generating sets, vehicular motion and rock blasting with explosives are major source of noise within and around the quarry site. Langer [12] reported that the impacts of noise and highly dependent on sound source, the topography, land use, ground cover of the surrounding site and climatic conditions. The beat, rhythm, pitch of noise and distance from the noise source affect the impact of noise on the receiver. Exposure to noise pollution arising from industrial machines can induce hearing loss and other pathological changes in the affected worker.

1.3.1. Effect of noise

a) Noise induced hearing impairment

Worldwide, noise-induced impairment is the most prevalent irreversible occupational hazard. Wills [4] reported that in 1995 at the World Health Assembly, it was estimated that there were 120 million persons with disabling hearing difficulties worldwide. It has been shown that men and women are equally at risk of noise-induced impairments [16]. Another sensory effect that results from exposure is tinnitus (ringing in the ears). Commonly, tinnitus is referred to as sounds that are emitted by the inner ear itself (physiological tinnitus).

b) Interference with speech communication

Noise interference with speech communication results in a large number of personal disabilities, handicaps and behavioural changes. Problem with concentration, fatigue, uncertainty and lack of self-confidence; irritation, misunderstandings, decreased working capacity, problems in human relations, and a number of stress reactions have all been identified [17].

Environmental noise may also mask many other acoustical signals important for daily life, such as door bells, telephone signals, alarm clocks, fire alarms and other warning signals and music [18].

As the sound pressure level of an interfering noise increases, people automatically raise their voice to overcome the masking effect upon speech (increase of vocal effort). This imposes an additional strain on the speaker (*16).

c) Sleep disturbance

Uninterrupted sleep is known to be a prerequisite for good physiological and mental function of healthy persons [19], sleep disturbance on the other hand is considered to be a major environmental noise effect.

According to William [20], from study findings the general conclusion can be drawn to ensure undisturbed sleep, the maximum sound pressure level should note exceed 45db(A). The primary physiological effects that can be induced by noise during sleep include increased blood pressure, increased hear beat, increased finger pulse amplitude, vaso constriction, changes in respiration, cardiac arrhythmia and an increase in body movement [16].

d) Cardiovascular and physiological effects

Epidemiological studies involving workers exposed to occupational noise, and general populations (including children) living in noisy areas around airports, industries and noisy streets, indicate that noise may have both permanent and temporary impacts on physiological functions in humans.

e) Mental health effects

FEPA [21] defined mental health as the absence of identifiable psychiatric disorders. According to current norms studies on the diverse effect of environmental noise on mental health cover a variety of symptoms, including anxiety, emotional stress, nervous complaints, nausea, headache, instability, argumentativeness, sexually impotency, change in mood, increase in social conflicts as well as general psychiatric disorders such as neurosis, psychosis and hysteria.

1.4. Dust

Agunwamba [13] defined dust as solid particles dispersed in a gaseous medium as the result of the mechanical disintegration of matter. According to Ademola [22], dust is one of the most visible, invasive and potentially irritating impacts associated with quarrying, and its visibility often raises concerns that are not directly proportional to its impact on human health and the environment. Dust may occur as fugitive dust from excavation, from haul roads, and from blasting, or from point sources, such as crushing and screening [12].

1.4.1. Effect of dust

a) Effects of plants

Dust deposits can have significant effect on plant life, though, mainly at high dust loadings. This includes:

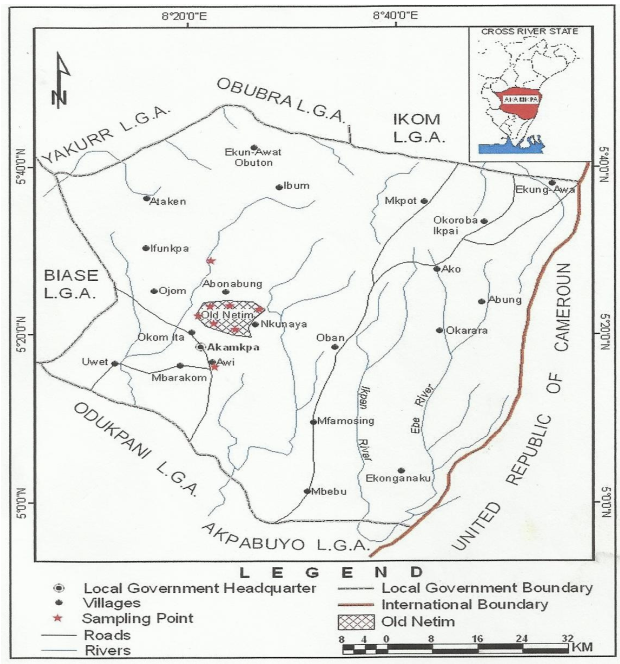

Figure 1: Map of the study area showing sampling point

(1) Reduced photosynthesis due to reduced light penetration through the leaves.
(2) Increased incidence of plant pet 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.
(3) Reduced effectiveness of pesticides spray due to reduced penetration.

b) Effect on human beings and health

The harmful effect of dust contamination can be found in numerous locations that people choose to spend their leisure time, unknown to the fact that they are breathing in dangerous dust particles that are linked to a barrage of serious respiratory illnesses. 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. For instance, some mineral dusts contains quantities of quartz, which can cause the lung disease known as silicosis when persistent at high concentrations.

Exposure of workers to high dust level causes irritation of the respiratory tracts as well as the eyes. According to Prodec-Fugro Consultant Ltd [15], these particulate matters penetrate into the respiratory system and induce respiratory diseases such as silicosis.

c) Soiling and amenity value effect

This leads to aesthetic degradation caused by both active and abandoned aggregated. The most common areas of concern include the visual soiling of clean surfaces such as cars, window ledges, and household washing. Dust deposits on flowers, fruits and vegetable.

Table 1: Methods used in determining the Gaseous Emissions.

Parameters	Equipment	Range	Alarm levels
Sulphur dioxide (SO_2)	SO_2 Gas monitor Gasman model 19648H	0-10ppm	2.0ppm
Carbon Monoxide (CO)	CO monitor Gasman model 1925H	0-50ppm	50ppm
Volatile organic carbon (VOC)	A multi RAE plus	0-200ppm	
Nitrogen dioxide	NO_2 Gas monitor Gasman model 1983N	0-10ppm	3.0ppm
Hydrogen Sulphide (H_2S)	H_2S gas monitor Gasman model 1983N	0-50ppm	10ppm
Radiation	Radiation alert monitor 4 Se international, USA	0.5-5mR/hr	
Ammonia (NH_3)	NH_3 gas monitor Gasman model 19730H	0-50ppm	25ppm
Chloride (Cl_2)	Cl_2 gas monitor Gasman model 19812H	0-5ppm	0.5ppm
Suspended particulate matter (SPM)	Haz-Dust TM particulate monitor	0.1-200	+1.0
Hydrogen Cyanide (HCN)	HCN gas monitor Gasman model 19773	0-25ppm	500m

The aim of the study is to assess the impact of aggregate mining in Crushed Rock Industry Limited on the environment of Old Netim Community in Akamkpa Local Government Area. Under this, the following specific objectives would be achieved:

(1) To identify the sources of noise, assess the noise levels and ascertain the impact of the elevated noise levels in the immediate environment.
(2) To identify, characterize and compare the air quality parameters with well known standards.
(3) To assess the effects of industrial effluents from the quarry on the sources of domestic water supply.
(4) To determine the seasoned variations in the surface water quality in the study area.

1.5. Study area

The study area is at Akamkpa Local Government Area of Cross River State, Nigeria. The area lies between latitude 06° 50 N and 07° 30 S. The maximum annual mean daily temperature of the area is 29°C to 34°C. The area receives abundant insulation during the day. The population of the people in this area is about 230,568; and their main occupation is farming. The farmlands are owned by individuals according to the traditional tenure system, and the major crops grown include cassava, maize, yam, okro, cocoyam etc.

Table 3: Air quality parameters results at study area during the wet season.

Sampling Point	SO_2 (ppm)	CO (ppm)	VOC (ppm)	H_2S (ppm)	NH3 (ppm)	Cl_2 (ppm)	SPM ($\mu g/)m^3$	HCN (ppm)	RAD (ppm)	NO_2
AQ1	0.02	10	0.02	0.03	< 0.01	0.02	11.3	< 0.01	0.06	0.13
AQ2	0.03	5.4	0.03	0.01	0.01	0.01	13.2	0.02	0.02	0.04
AQ3	0.05	5	0.01	< 0.01	< 0.01	0.01	10.1	0.01	0.02	0.08
AQ4	0.01	2.4	0.01	< 0.01	< 0.01	< 0.01	11.2	0.02	0.01	0.21
AQ5	0.04	4.7	0.04	0.02	0.01	0.01	19.5	< 0.01	0.04	0.14
AQ6	0.07	24	0.04	0.03	0.03	0.02	22.6	0.02	0.06	0.32
AQ7	0.07	32	0.03	0.01	0.02	0.02	19.4	0.02	0.10	0.23
AQ8	0.05	22	0.04	0.02	0.02	< 0.01	15.2	0.01	0.04	0.21

Table 2: Equipment used in Measuring Meteorology/Noise Level.

Parameter	Equipment
Temperature	Thermometer 10 – 50°C
Atmospheric Pressure	Multi purpose Baro model Baro (740-777mmHG)
Relative Humidity	Multi purpose Hydro. (20-100% model)
Wind speed	Portable wind vane Model-Deuta Anemo wind speed indicator (0-3.5m/s)
Wind direction	GPS and magnetic compass
Solar radiation	Photometer (Luxmeter) model = Lutron LX 101 Lux meter
Noise Level	TES sound level meter model TES 13504

Table 4: Comparison of air quality parameters in wet season with FMEN'v's 1995 limits.

Parameters	Range	Mean	FMENv (1995) limits
SO_2 (ppm)	0.01-0.07	0.043	0.1ppm
NO_2 (ppm)	0.11-30	0.171	0.04-0.06ppm
CO (ppm)	2.4-32	13.18	10ppm
VOC (ppm)	0.01-0.04	0.027	-
H_2S (ppm)	< 0.01-0.03	0.017	8
NH_3 (ppm)	< 0.01-0.03	0.026	200ppm
Cl_2 (ppm)	0.01-0.02	0.016	-
SPM ($\mu g/)m^3$	10.1-22.6	15.31	250-600
HCN (ppm)	< 0.01-0.02	0.015	-
RAD (usv) yr^{-1}	0.01-0.10	0.043	-

2. Materials/Methods of Study

The impact of aggregate mining on environment (CRI Akamkpa quarry site and its vicinity) assessment are made possible through the following methods and procedures.

2.1. Seasonal sample collection

For this study, two season sampling was employed (wet and dry season), taking into consideration seasonal changes which occur in certain parameters. Wet season sampling took place by October of 2008 while dry season sampling took place in February 2009.

2.2. Collection of suspended particulate matter (SPM) data measured in and around the CRI facilities

The equipment used was the haz-dust TM particulate monitor with exchangeable filters in connection with the following instrument: weighing balance, air pump and containers with filters.

An air pump draws ambient air at a constant flow rate into a specially shaped inlet where particulate matter is separated into size fractions as sample. Particulate matter is then collected on a filter. Each filter is weighed before and after use, to determine the net mass gain due to collected matter. The total volume of air filtered is known from the constant air flow, and the difference in filter weights is used to calculate the particulate matter concentration in micrograms per cubic meter ($\mu g/m^3$) of air according to NARSTO [23] and APHA-AWWA-WPCF [24]. The data are presented in Table 3 and 5 for wet and dry season respectively.

2.3. Meteorology and noise level data

The meteorology and noise level data were also measured at the predetermined sample points using dosimeter/sound level meter (TES sound level meter model TES 1350a). Eight measurements were taken for both the meteorology and noise level.

The meter response can be set to either slow or fast, corresponding to the integration periods 1 and 0.125 second, respectively. The indicator reflects the average sound pressure level measured by the meter during the period selected. The noise dosimeter may be thought of as a sound level meter with an additional storage and computational function. It measures and stores the sound levels during an exposure period and computes the readout as the % dose or TWA. The noise level can be converted to dB (A) according to Stanton [25]. The data are presented in Table 7 and 8 for wet and dry season.

2.4. Gaseous emission data

The level of gaseous emissions were also determined at the predetermined sample points. Eight measurements were carried out for each parameter at an

Table 5: Air quality parameters results at study area during the dry season [7].

Sampling Point	SO_2 (ppm)	CO (ppm)	VOC (ppm)	H_2S (ppm)	NH_3 (ppm)	Cl_2 (ppm)	SPM (μg/)m^3	HCN (ppm)	RAD (usv yr^{-1})	NO_2
AQ1	0.03	11	0.03	0.01	0.02	0.03	12.3	0.01	0.03	0.15
AQ2	0.04	5.4	0.02	0.02	0.01	0.01	14.2	0.02	0.02	0.06
AQ3	0.02	4.5	0.02	$<$ 0.01	$<$ 0.01	0.01	11.1	0.01	0.02	0.08
AQ4	0.02	22	0.01	$<$ 0.01	$<$ 0.01	0.01	10.2	$<$ 0.01	0.01	0.11
AQ5	0.05	4.2	0.05	0.02	0.01	0.01	18.5	$<$ 0.01	0.02	0.10
AQ6	0.08	24	0.04	0.01	0.02	0.02	22.4	0.01	0.05	0.14
AQ7	0.07	12.5	0.04	0.02	0.02	0.02	19.4	0.02	0.11	0.30
AQ8	0.04	12	0.03	.01	0.03	0.01	14.2	0.01	0.03	0.24

Table 6: Comparison of Air Quality Parameters in Wet Season with FMEN'v's 1995 Limits

Parameters	Range	Mean	FMENv (1995) limits
SO_2	0.02-0.08	0.046	0.1ppm
NO_2	0.11-30	0.147	0.04-0.06ppm
CO	4.52-24	11.95	10ppm
VOC	0.01-0.04	10.87	-
H_2S	$<$ 0.01-0.02	0.013	8
NH_3	$<$ 0.01-0.03	0.016	200ppm
Cl_2	0.01-0.03	0.015	-
SPM	11.1-24.6	15.56	250-600
HCN	$<$ 0.01-0.02	0.012	-
RAD	0.01-0.11	0.036	-

hourly interval for 6 hours at a distance of 1.5m above ground level.

The equipments, which was a highly sensitive digital meter was held at arms length from the body. A hand-held Magellan GPS model sporrak was configured in Universal Transverse Mercator (UTM) and used in establishing coordinates.

The sample points are in appendix 1 while the methods used during in-situ measurements are presented in Table 1.

3. Results

The results of the several parameters measured are presented in this section of the paper. They include analysis of the air quality data, gaseous emission as well as meteorology and noise level data.

Table 3, 4, 5, 6, 7, 8 and 9 shows the results of all the surface environmental parameters investigated during the wet and dry seasons, respectively.

Table 7 and 8 shows the meteorology and noise level at study area during the wet and dry season respectively.

3.1. Radiation

Radiation was 0.01-0.11USV year-1 in dry season to 0.01-0.10USV year -1 is wet season in the study area. This is consistent with a recent study in Radiation Exposure to Workers and Villages in an Around Some quarry sites in Ogun State of Nigeria [20].

3.2. Volatile organic compounds (VOC)

The VOC in the study area ranged between 0.01ppm 0.04ppm in both dry and wet seasons. These values are below the maximum permissible discharged limits and surprisingly are indicative of insignificant emission of hydrocarbon in the study area.

3.3. Sulphur dioxide and hydrogen sulphide

The concentration of SO2, and H2S in the study area were 0.02-0.08ppm and $<$ 0.01-0.02ppm respectively in dry season and 0.01-0.07 and $<$ 0.01-0.03ppm in wet season. The recorded values for SO_2 were lower than the Federal Ministry of Environment limit of 0.01 to 0.1ppm.

3.4. Nitrogen dioxide (NO_2)

The concentrations of NO_2 at all the sampling stations were 0.21-0.32ppm (for both dry and wet seasons) much higher than the Federal Ministry of Environment limit of 0.04-0.06ppm.

3.5. Meteorology and noise level

The results of meteorology and noise level measurements are shown in table 7 and 8 for wet and dry seasons respectively.

The main sources of noise in the study area included noise from rock blasting site, crush rock processing plants, haulage trucks, diesel power generating plant, heavy duty trucks, welding machines, heavy traffic on the highway traffic hooting, human activities in the neighbourhood etc. The noise level at the sampling stations (including control) varied slightly. The highest noise level was recorded at SP7 inside the premises of the company followed by SP6 recorded at the plant. Other sampling points recorded noise level consistent with what is to be expected from such environment. However, only sampling points inside the plant exhibited noise levels that exceed the Federal Ministry of Environment permissible exposure limits.

Table 7: Meteorology and Noise Level Results at Study Area – Wet Season.

Sampling Point	Coordinates	Pressure (mmHg)	Wind Speed (m/s)	Wind Direction	Relative Humidity (%)	Noise d(B)A
SP1	5° 21' 22" N 8° 2' 53"E	747	2.5	SW	86.0	78.7
SP2	5° 21' 22" N 8° 21' 54"E	747.1	1.8	SW	74.7	67.2
SP3	5° 12' 31" N 8° 21' 38"E	747.2	2.5	SW	91.3	46.0
SP4	5° 2' 06" N 8° 17' 02"E	747	2.7	SW	84.1	49.2
SP5	5° 2' 07" N 8° 21' 36"E	747	2.0	SE	82.8	71.0
SP6	5° 21' 51" N 8° 21' 43"E	747.2	2.6	SW	74.1	96.1
SP7	5° 21' 24" N 8° 21' 53"E	747	3.5	SW	78.0	101.8
SP8	5° 21' 43" N 8° 21' 42"E	747.1	3.1	SW	82.0	70.5
FMENv's 1995 limits	-	-	-	-	-	90d(B)A

4. Analysis and Discussion of Results

4.1. Air quality

The results of air quality measurement are shown in table 3 and 5 for both wet and dry seasons. It is clear that some parameters were within the Federal Ministry of Environment permissible limits, while others were above the permissible limits indicating some degree of pollution, probably as a result of emission from the plant and vehicular movement, generator and other machines.

4.2. Suspended particle matter (SPM)

The concentration of SPM recorded between 11-24l/g/m^3 in dry season and 10.1-22.6cl/g/m^3 for daily average of 1 hour values [21]. 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 fine 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.

4.3. Carbon monoxide

Carbon monoxide concentration levels measured in the study area ranged from 4.52-24ppm in dry season to 2.4-32ppm in wet season. This level is above the maximum discharge range of 10.0-20.0ppm for daily average of 8 hourly values in Nigeria [21]. Carbon monoxide (CO) is generated from the incomplete oxidation of fossils fuels (hydrocarbon). Sources of CO in the study area are giant diesel powered generating plant, processing plant, vehicular emissions, diesel and petrol engines such as heavy-duty equipment, welding machines, trucks etc. Prolonged and excessive exposure to ambient accumulation of CO values greater than 877ppm could bring about formation of carboxyhaemoglobin and prevent oxygenation of the blood leading to suffocation and consequent death. Young and elderly persons as well as individuals with cardiovascular diseases and respiratory problems are most at risk from exposure to this gas.

4.4. Sulphur dioxide and hydrogen sulphide

Sulphur dioxide (SO_2) is one major air pollutant. It is usually formed from the oxidation of sulphur containing fuels and biomass. Hydrogen sulphide (H_2S) gas is extremely toxic, odorous and corrosive. It can be present in natural gas in certain areas and can be released by sulphate reducing bacteria in certain marine environments. 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 form cardiac and/or respiratory diseases and increased prevalence of related symptoms. Sustained exposure to H2S gas above 0.06ppm could result in death.

4.5. Nitrogen dioxide (NO_2)

The oxides of nitrogen are usually formed at higher temperature combustions e.g. industrial combustion

Table 8: Meteorology and Noise Level at Study Area – Dry Season.

Sampling Point	Coordinates	Pressure (mmHg)	Wind Speed m/s	Wind Direction	Relative Humidity (%)	Noise d(B)A
SP1	5° 21' 22" N 8° 2' 53"E	747	1.8	NE	67.4	78.7
SP2	5° 21' 22" N 8° 21' 54"E	747.1	1.7	NE	56.9	77.2
SP3	5° 12' 31" N 8° 21' 38"E	747.2	1.5	SW	57.1	48.6
SP4	5° 2' 06" N 8° 17' 02"E	747	2.4	SW	66.6	51.2
SP5	5° 2' 07" N 8° 21' 36"E	747	3.0	NE	72.8	76.5
SP6	5° 21' 51" N 8° 21' 43"E	747.2	2.0	NE	72.9	98.4
SP7	5° 21' 24" N 8° 21' 53"E	747	4.0	SW	68.9	100.5
SP8	5° 21' 43" N 8° 21' 42"E	747.1	3.0	SW	69.0	67.5
FMENvs 1995 limits	-	-	-	-	-	90d(B)A

* Source: Field Work, 2009

and vehicle engines. NO_2 is readily formed 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. NO2 may also be generated by oxidizing nitrogen at high temperatures.

Long term exposure to NO_2 concentrations above 563ppm may cause pulmonary disease and increase susceptibility to bacterial infection in man.

4.6. Ammonia (NH_3)

Ammonia levels were < 0.01ppm-0.03ppm for both dry and wet seasons. This was far below the Federal Ministry of Environment (FMENv) limit of NH3 which is 200ppm.

Ammonia is the most abundant basic chemical substance in the atmosphere and the third most abundant Nitrogen compound. Major sources of ammonia include anaerobic decomposition of organic matter, animals and their wastes, biomass burning, soil humus formation and application of anhydrous NH3 to cropland. Other sources include industrial emissions.

NH3 reacts rapidly with strong acids e.g. H_2SO_4 and HNO_3 to produce ammonium salts. Thus NH3 plays an important role in removing SO_2 and NO_2 from the atmosphere.

4.7. Hydrogen cyanide (HCN) and chlorine (Cl_2)

Hydrogen cyanide occurs in the atmosphere in low background levels. Little is known about its atmospheric chemistry. They limits of these gases are not given by FMENv. The range of 0.01-0.03ppm for Cl_2 and < 0.01-0.02 (both dry and wet seasons) for HCN does not call for concern.

4.8. Meteorology and noise level

The results of meteorology and noise level measurements are shown in table 7 and 8 for wet and dry seasons respectively.

The main sources of noise in the study area included noise from rock blasting site, crush rock processing plants, haulage trucks, diesel power generating plant, heavy duty trucks, welding machines, heavy traffic on the highway traffic hooting, human activities in the neighbourhood etc. The noise level at the sampling stations (including control) varied slightly. The highest noise level was recorded at SP7 inside the premises of the company followed by SP6 recorded at the plant. Other sampling points recorded noise level consistent with what is to be expected from such environment. However, only sampling points inside the plant exhibited noise levels that exceed the Federal Ministry of Environment permissible exposure limits.

It is clear from table 7 and 8 that the noise level is highly variable. It ranges from 48.6d(B)A at the control point at Awi settlement to 100.5d(B)A at the location of power plant (SP7). The values recorded at both the power generating plant and the blasting site exceeds the FMENvs threshold value of 90d(B)A. Similarly, the relative humidity values ranges from 56.7% to 72.95% in dry season. The wind direction in the study area is either NE or SW during the dry season. This is expected as the dominant wind system in Nigeria during the dry season which is usually the dry, dusty and light NE trade winds from the Sahara desert. Fig. 2 shows that the wind speed is mild and do not vary much in dry season. It ranges from 1.5m/s to 4m/s. This is equally true of the atmospheric pressure which ranges from 747 to 747.2 milibars during the dry season.

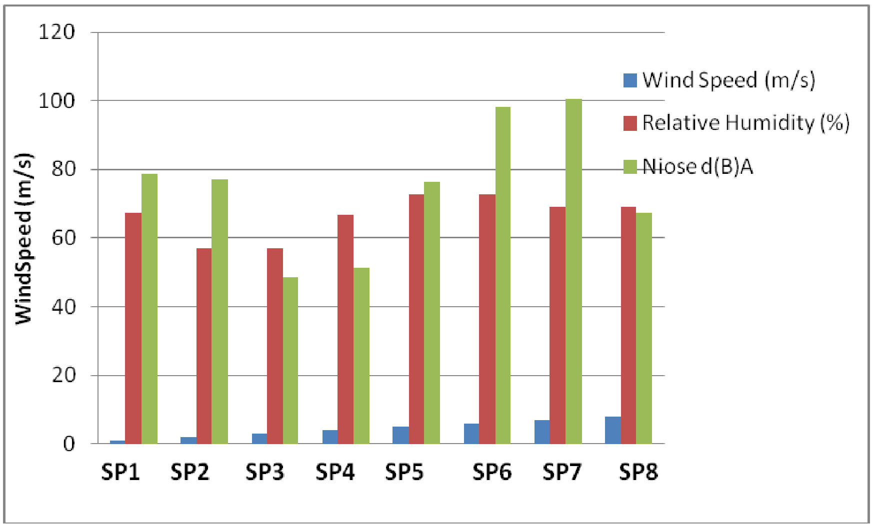

Figure 2: Bar Chart Showing Variation in Relative Humidity, Noise Level and Wind Speed at Study Area in Dry Season.

The spatial variation in meteorological parameters/noise level recorded during the wet season is illustrated in fig 3 below. It reflects the same pattern as was observed during the dry season, notice that elevated noise levels are recorded at sites located inside the quarry plant. However, the noise level ranges from 46.0d(B)A to 100.8d(B)A. The relative humidity values are slightly higher in wet season (74.1% to 91.3%) than in dry season. This seasonal variation in relative humidity values is expected.

5. Conclusion

This research study assessed the environmental impact of aggregate mining activities of Crushed Rock Industry Limited in Akamkpa Local Government Area of Cross River State. Eight geo referenced locations were chosen to carry out the study. These were achieved through in situ measurements of air quality parameters and noise level. The results obtained were compared with allowable limit set by national and international regulatory agencies viz. FMENv and WHO respectively. The comparisons of result with both standards are expressed in tables 4 and 6.

Carbon monoxide (CO) and Nitrogen dioxide (NO_2) levels were also above the permissible limits. The noise level was above the threshold value at sampling point 7.

Quarrying in Akamkpa Local Government of Cross River State has had significant adverse environmental impacts on the host communities. These include elevated noise level, detonated air and water quality. A comparison of these results with the acceptable level standard showed that their concentration at the quarry site is elevated. This poses a potential health risk to the people living within the area. Although the present levels of some of these trace metals, for instance, iron pose no toxicity problem, there is need to regulate and control the waste produced from quarrying activities in order to prevent the introduction of further excessive heavy metals into the surface water. The aggregate mining in Old Netim shows that there are much negative impact on the environment, objects, plants and human beings. From the result, workers are likely to have hearing loss impairment especially those working in crusher area, also the degree of suspended particulate matter levels are high compared to FEPA standard, hence, workers and people living in the quarry vicinity are likely to suffer from silicosis if preventive measures are not considered. Also, a carefully prepared and implemented dust control plan by Federal, state, and local regulations and policies can help in reducing the amount of dust emission, if properly followed.

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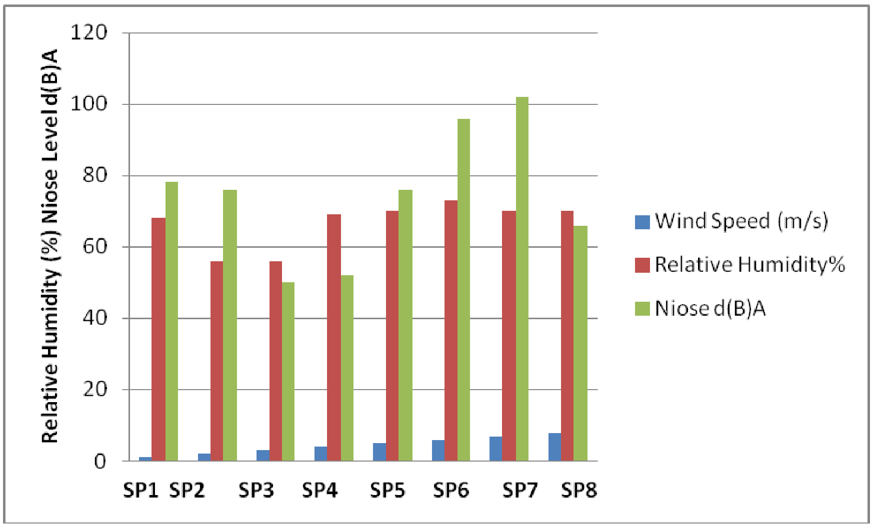

Figure 3: Bar Chart Showing Variation in Relative Humidity, Noise Level and Wind Speed at Study Area in wet Season.

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APPENDIX 1 Co-ordinates of sampling location.

Sample Code	Location	Latitude	Longitude
SP1	Inside the plant premises	N5° 21' 22"	E8° 2' 53"
SP2	By the main gate	N5° 21' 22"	E8° 211 541
SP3	Control point (AWI) 3km away (left)	N5° 12' 31"	E8° 21' 38"
SP4	Control point (Uyanga) 3km away (right)	N5° 2' 06"	E8° 17' 02"
SP5	Prodeco Asphalt plant	N5° 2' 07"	E8° 21' 36"
SP6	Rock blasting site	N5° 21' 51"	E8° 21' 43"
SP7	Generating plant	N5° 21' 24"	E8° 21' 53"
SP8	Stream near blasting site	N5° 21' 243"	E8° 21' 42"