EFFECTS OF QUARRY ON THE AIR QUALITY IN MPAPE, BWARI AREA COUNCIL, FCT ABUJA, NIGERIA

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Abstract

Man might survive weeks without food and days without water, but he can only last a few seconds without clean air, It has become clear that air quality in the study area need to be examined, since air pollution in the study area has affected the health of human beings and animals, damaged vegetation, soils and deteriorates materials and generally affects not only the large metropolitan areas but also the medium sized urban areas. This study assessed the effects of Quarry on Air Quality in Mpape, Bwari Area Council, FCT Abuja, Nigeria. A total of 218 Air samples were collected from six points around the quarries sites and recorded insitu for analysis. The samples were collected three times in a day (Morning, Afternoon and Evening) for three days. Absolute Instrument System (AIS) model Aerocet 5315 was used to collect the parameters according to WHO, USEPA and NESREA guideline. The following parameters were investigated; Particulate Matter (PM), Carbon monoxide (Co), Sulphur dioxide ($S0_2$), Nitrogen dioxide (NO_2), Ammonia (NH_3), Chlorine (CL_2) and Hydrogen Cyanide. 2 active and 2 dormant quarries were considered by the study, land was measured to determine the impact of quarry in the study area. The statistical test employed was Analysis of Variance and student t-test. Based on the data collected and the analysis made, it was observed that the mean values of the parameters varied from points to points and at different time of the day. Also, the mean values of the parameters were compared with the NESREA recommended limits, and it was observed that Julius Berger have used about 50% of the area granted to her by Nigerian Mining Cadastre Office, while Galaxy quarry have used 33.33% of the area granted, it was observed that Sulphur dioxide has a concentration of 0.45ppm, NO_2, 0.17ppm and NH_3 0.38ppm, were above the NESREA recommended limit. While C0, 6.11ppm,

HCN, 0.16ppm, SPM mg/m^3 and Cl_2, 0.03ppm are still below the standard limit. Air quality Index shows that Sulphur dioxide, and Nitrogen dioxide has a very poor quality index. The study therefore recommends that, all activities that lead to the release of air pollutants should be liable to environmental tax law; the quarries companies should upgrade their plants to more efficient technologies and by switching to lower carbon content fuels which will reduce emission of pollutants in the study area.

Keywords: *Effect, air, quarry, quality, minerals*

Introduction

Exploitation of mineral resources has assumed prime importance in several developing countries including Nigeria. Nigeria as a country is endowed with abundant mineral resources which have contributed immensely to the national wealth with associated socio-economic benefits. Mineral resources are important source of wealth for a nation but before they are harnessed, they must pass through the stages of exploration, mining, and processing (Adekoya 1995, and Adekoya 2003). According to Aigbebion (2005) different types of environmental damage and hazards inevitably accompany the three stages of mineral development. The complex mixture of gases that make up the earth atmosphere has been altered much more in recent time. Human activities that range from domestic energy utilization to large scale industrial operations are largely responsible for this undesirable status of the atmospheric constituents due to addition of pollutants. Air pollution is a major environmental problem affecting both the developing and developed countries of the world. Its effects on human health are extraordinarily complex as there are different sources; thereby providing varying effects (Peter, Alozie and Azubuine, *2019).*

Environmental changes caused by mankind's exploitation, and development of natural water and soil resources have long been a severe problem in the world (Wang, Shi, Chen, and Xue, 2012). Quarrying activities which are part of the mankind's exploration of the earth have an important influence on ecological environment (Xue, Teng, Li and Su, 2010). Stone quarrying is a form of land use method concerned with the extraction of non-fuel and non-metal minerals from rocks (Peter *et al,* 2018). It is usually done by open-cast method using rock drills, explosion of dynamite and use of other methods. Quarrying has

environmental and health effects. (Ming'ate and Mohammed 2016) for instance reports that mining has a number of common stages or activities, each of which has potentially adverse impacts on the natural environment, society and cultural heritage, the health and safety of mine workers, and communities based in close proximity to operations. Further the operations in stone quarrying, whether small or large-scale, are inherently disruptive to the environment, producing enormous quantities of waste that can have deleterious impacts for decades and that the environmental deterioration caused by stone quarrying occurs mainly as a result of inappropriate and wasteful working practices and rehabilitation measures. For instance, some studies in the Northern Region of Ghana and East Gonja District found that commercial extraction of sand and gravel cause land degradation and desertification through destruction of economically important trees mostly indigenous in nature (Nartey, Nanor and Klake, *2012*). This degradation of environment due to stone quarrying activities has put forth questions as to whether the mining activities should be continued (Olusegun, Adeniyi and Adeola, *2009*). Additionally, some 4 million people have been reported also to die yearly from acute respiratory problems in developing countries, for the most part being aggravated by environmental pollution emanating from quarrying, sandblasting and emission of dangerous chemicals (Sati 2015 and Wells 2016).

However, it has been found on the other hand that in Africa, East Asia, Southeast Asia and Latin America, accessibility to natural resources such as building stones plays a critical role in the provision of livelihood (Asante *et al*, 2014). A livelihood comprises the capabilities, assets (including both material and social resources and activities required for a means of living: a livelihood is sustainable when it can cope with and recover from stress and shocks and maintain or enhance its capabilities and assets both now and in the future (Lameed and Adebayo, 2010).

The Study Area

Location and size

Federal Capital Territory (FCT) is the home of Abuja, the capital of Nigeria. The territory was created in 1976 from parts of former Nasarawa, Niger, and Kogi States and it is in the central region of Nigeria, bordered to the north by Kaduna State, to the east by Nassarawa State, to the south-west by Kogi State

and to the west by Niger State. It lies between longitudes 6^0 20'E and 7^0 33'E of the Greenwich Meridian and with latitudes 8^0 30'N and 9^0 20'N of the equator. It occupies an area of about 8000km^2. The FCT is in the centre of the country. Mabogunje (1977) describes the FCT as being in the middle belt of Nigeria with a size equivalent to 0.87% of Nigeria.

The FCT has six area councils namely, Kuje, Gwagwalada, Abaji, AMAC, Kwali and Bwari where the Lower Usuma Dam is located. The federal Capital Territory is central to Nigeria in administrative, geographical, and lying just above the hot and humid lowlands of the Niger/Benue trough but below the drier parts of the country lying to the north. It lies north of the wide alluvial plains formed by the confluence of the Niger and the Benue rivers. The Jema'a platform, a continuation of the Jos plateau extends well into the middle of the territory. The city is in a scenic valley of rolling grasslands.

The area Mpape which means "rock" in the local Gwari language, supplies much of the stone used to transform Abuja from a small village in the 1980s into the fasters growing capital in the world. Mpape is located about 2kms away from Maitama district and has about 10 active quarry industries and 4 inactive quarry.

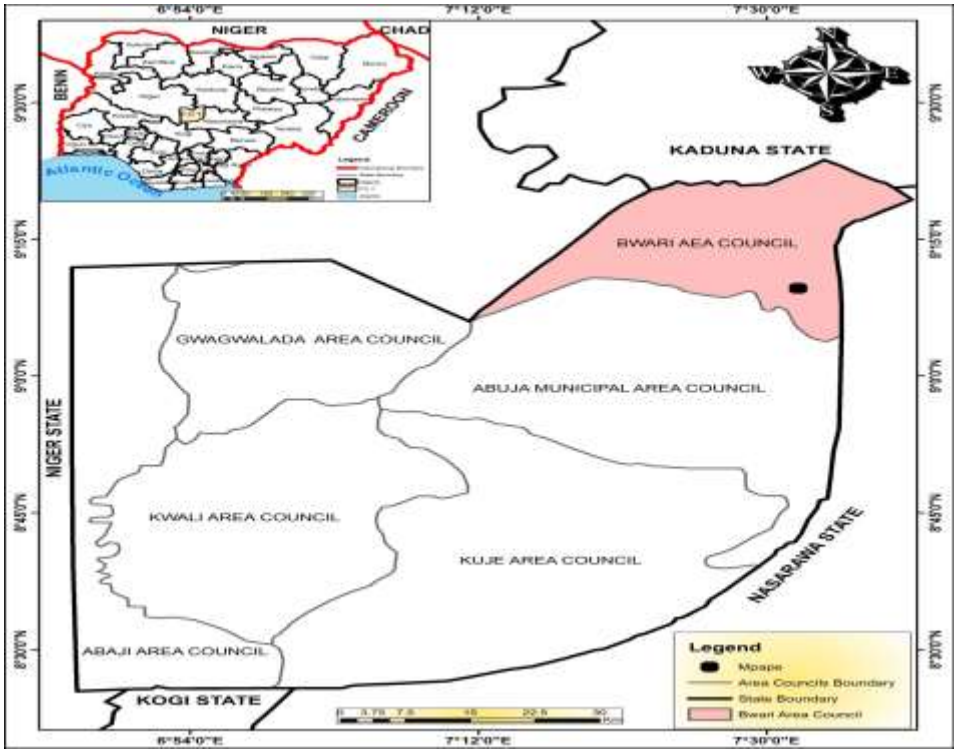

Figure 1: Abuja showing Bwari Area Council.
Source: Department Geography, NSUK, 2018

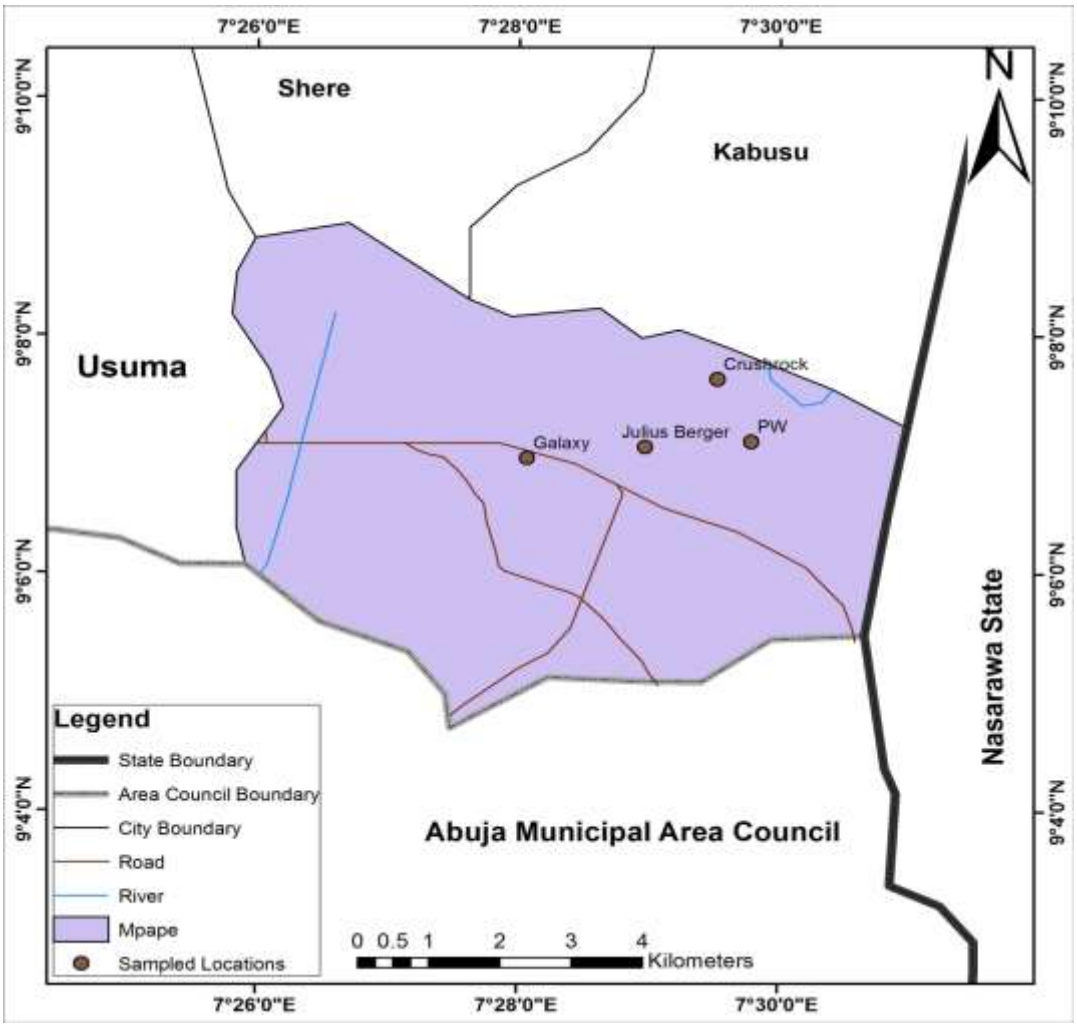

Figure 2: Mpape Showing quarries sites in the Study Area
Source: Department Geography, NSUK, 2018

Materials and Methods

Analysis

A major part of the air analysis was carried out at the sample site. A standard laboratory procedure was followed in the analysis of the selected air quality parameters that was considered in the study were recorded in situ.

Statistical Analysis

The statistical analysis employed were descriptive statistics such as mean, standard deviation and coefficient of variation. The data were subjected to

analysis of variance (ANOVA) and student t test for the comparison of the mean differences between the survey values and the NESREA limit.

Result and Discussion

The areas affected by quarrying in Mpape

The result in table 1: revealed the areas affected by quarrying the study area, crushrock quarry recorded the least land degradation measuring about 1 cadastre unit approximately about 20 hectares of arable land being used for quarry activities in the study, which is about 25% of the land granted to the company by Nigeria Mining Cadastre Office (MCO), PW quarry recorded 0.3km^2 land lost approximately 60 hectares of land and used about 75% of the land granted to her for her quarry development, Galaxy quarry used about 3 cadastre unit granted to her for her quarry activities and degrade 33.33% of the land due to her quarry development, Julius Berger quarry used 4 Cadastre Units (CU) of the 8 cadastre unit granted to her, losing about 50% of the land due to her quarry activities.

Table 1: Areas affected by quarrying in the study area.

S/N	Quarry	Area granted CU	No of Quarry face/pits	Used area. CU	Unused area CU	% of quarrying area	Status
1	Julius Berger	8 (3.2km^2)	4	4 (1.6 km^2)	4 (1.6km^2)	50	**active**
2	Galaxy	9 (3.6km^2)	2	3 (1.2km^2)	6 (2.4 km^2)	33.33	**Active**
3	PW	2 (0.4km^2)	1	1.5 (0.3km^2)	0.5 (0.1km^2)	75	**Abandon**
4	**Crush Rocks**	**4**	**2**	**1 (0.2km^2)**	**3 (0.6km^2)**	**25**	**Abandon**

Source: Field survey, 2020

The study shows that only Julius Berger and Galaxy quarry are the active quarry sites from the selected 4 quarry sites, Julius Berger quarry is also the biggest quarry site in terms of equipment and quarrying activities, this is due to their construction works in the FCT, while Crushrock quarry abandon her quarry activities due to encroachment and changing land use within the vicinity of her quarry site.

The study agrees with the work of Solomon et al, (2018). Their study mapped and analyzed spatial-temporal variability of quarry sites in Mpape District, Bwari Area Council of Abuja. The study used high-resolution IKONOS satellite

image, ASTERDEM and Hi-Target Differential GNSS receivers. The result showed that nine quarry sites exist in Mpape with three abandoned and six are active while three are in the center of Mpape with one active and two abandoned. The depth analysis revealed that the deepest site is 25 m at Julius Berger quarry site and the lowest depth was 6 m at PW quarry site. The study also reveals that the rocky surfaces have the highest elevation and are in the upper and lower region of Mpape. The quarry sites and settlement are located on a high elevation ground. Importantly, the study revealed that the derelict ponds were formed because of rigorous quarry activities, since there are no tributaries connecting each of the derelict ponds. The buffer analysis carried out at 100 and 150 m distances revealed that settlements are already engulfing the three quarry sites located at the core center of Mpape. Also, Crushrock quarry site has been encroached, while the other 2 do not have settlement contiguous to them at 100 and 150 m buffer distances.

This result agrees with the study of Angela et al, (2018). Their study examined the open cast quarrying technique and the spatial pattern of the quarrying activities and their locations in the study area. The result of the study obtained from the principal component analysis showed that there is a significant pattern in the quarrying activities and their locations with explained variance of (82.91 %). The spatial pattern and locations of the quarrying activities in the study area showed: Ohaukwu (11), Ivo (2), Ishielu (1), Ezza North (5), Afikpo North (4) and Izzi (4).

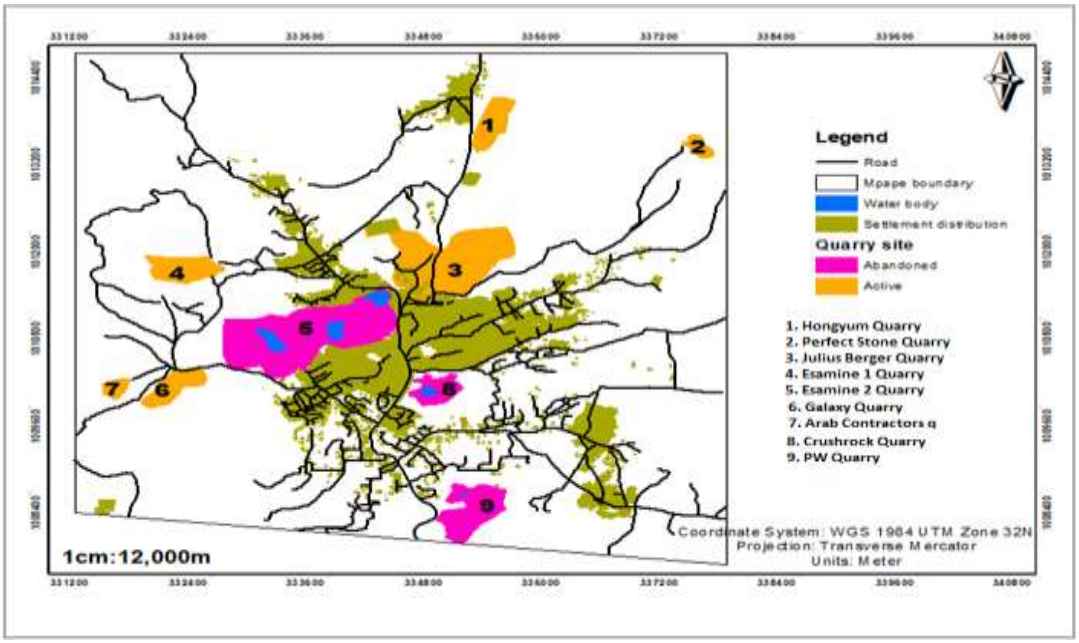

Figure 2: Showing Quarry sites in the Study Area.
Source: NAGIS, 2018

The quarrying activity map of the study area in figure 4.1 shows the locations of active and dormant quarry sites. It showed the areas with large and small concentration of pits. It also showed the extent, distribution of each quarry lease. Obviously, open cast method has had serious effect on all landscape and vegetative components and functions in the study area. This had led to significant alteration of the original landscape, biodiversity loss and land degradation in the area. Blasting of rocks must take place for quarrying operations to commence. The process disturbs the landscape as the original ecosystems are removed and the topography is significantly altered. The basic ecological relations are unchangeably disrupted, and biodiversity is decreased.

The existing condition of the area showed a high level of land deformation in the study area. The results from this study are of great importance in the management of the environment, precisely on land use/ land cover planning and conservation. This is because land resources must be safeguarded from the menace of quarrying activities emanating from unscientific extraction of rocks. Sustainable practices and precautionary measures should be taken into consideration prior and after quarrying operations.

The result also agrees with the study of Angela et al (2016), The study examined the open cast quarrying technique and the spatial pattern of the quarrying activities and their locations in Ebonyi state. George *et al (2008)*. Their study discovered that extraction of marble in Greece takes place by open cast quarries in hill slopes. They identified that original landform is permanently altered and the original vegetation cover is destroyed. These findings could also be linked to the study by Cement Corporation of India Limited (2008). They maintained that open cast quarrying technique employed during the limestone processes resulted in huge environmental effects. These are evident in the removal of large soil mass, change in landscape and displacement of flora and fauna including human from their natural habitats. Again, the study carried out by Osinbajo (2003) also confirmed that activities like blasting and drilling operations are accompanied by significant noise and vibration which can disrupt terrestrial and wildlife habitats. These studies consent to the fact that open cast method contributes immensely to loss of vegetation cover. The quarrying operations by foreign and private companies make use of sophisticated machines and equipment. These are used for drilling, crushing, and grinding to explore the rock buried underneath the earth.

Concentration of gases at different time of the day in the study area

A careful observation of Table 2 A: shows that the mean of Sulphur dioxide (SO_2) is lowest (0.40ppm) in the evening and slightly higher in the afternoon and morning (0.53ppm) and (0.41ppm) respectively, the different value of SO_2 in the study area can be attributed to the low activities in the study area in the late hours of the day and high activities during the afternoon hour of the day. Magaji and Hassan, (2015) collaborated the findings that SO_2 concentration is generally low in the morning and high as the day goes by, because during the early hours of the day most of the SO_2 concentration most have settled down. The mean value of Nitrogen dioxide (NO_2) is observed in the morning (0.33ppm) and increases lightly in the afternoon (0.40ppm), with an increase in the evening (0.78ppm). Chlorine (Cl_2) has its lowest mean value (0.26ppm) in the morning with its highest mean value (0.44ppm) being in the afternoon and decrease in the evening (0.28ppm). That of Carbon monoxide (CO) too is lowest in the evening (5.10ppm), slightly highest in the afternoon (7.80ppm) and moderate in the morning (5.10ppm).

Table 1 A: Concentration of gases at different time of the day during raining season in the study area.

Parameter's time	SO_2 Ppm	NO2 ppm	Cl_2 Ppm	H_2S Ppm	VOC Ppm	CO Ppm	NH_3 Ppm	SPM mg/m3	HCN ppm	Noise dB(A)
Morning 6am	0.41	0.09	0.03	0.02	0.17	5.10	0.06	17.13	0.16	33.50
Afternoon 12:00pm	0.53	0.27	0.05	0.27	0.27	7.80	0.63	26.20	0.43	40.05
Evening 6:00pm	0.40	0.11	0.03	0.06	0.17	5.10	0.05	19.20	0.17	33.00

Source: Field survey, 2020

Sulphur dioxide (SO_2) has its lowest mean value (0.43ppm) in the morning and increases as the day go by, having its highest mean value in the evening (0.88ppm). The study observed also that the lowest mean value (0.24ppm) of Hydrogen Sulfide (H_2S) is in the afternoon and highest in the evening (0.27ppm) and (0.25ppm) respectively. Ammonia (NH_3) has its lowest mean value (0.04ppm) in the evening unlike the other parameters considered under

study and slightly higher in the morning and highest in the afternoon (0.06ppm) and (0.63ppm) respectively. Hydrogen cyanide (HCN) has its lowest mean value (0.16ppm) in the morning, (0.43ppm) and (0.17ppm) in the evening and afternoon, respectively. Volatile Organic Compound (VOC) has its lowest recorded mean value of (0.16ppm) in the evening, its highest mean value of (0.63ppm) and (0.17ppm) in the morning. Suspended Particulate Matter (SPM ug m_3) has its lowest mean in the morning with a value of (17.12ug m_3), highest mean value of (26.20 ug m_3) in afternoon and (19.20 ug m_3) in evening. Noise dB(A) has its lowest mean value of (33.00) in the evening, followed by (33.50) in morning and its highest mean value of (40.05) in afternoon.

The concentration of the parameters at different time of the day is highly influenced by the variation in the temperature of Abuja where the study area is located. The temperature at the time (August) when the field survey was carried out was between 28^0C – 31^0C.Usually the mornings are characterized by low temperatures, which increases sharply as noon approaches and decreases slowly towards evening. As a result of this, mean values of parameters are all in their lowest in the morning (except Sulphur dioxide, Noise and Hydrogen cyanide which have their lowest mean values in the evening as 0.40ppm, 33.00 and 0.33ppm respectively) and highest mean values in the afternoon and evening. Magaji and Hassan, 2015 collaborated the findings that temperature at different hours of the day affects the concentration of air quality of the area, Adelagun *et al, (*2012) also collaborated the findings that concentration of gases in quarry areas is typically low in the morning and increase slightly as production activities kick off in the afternoon and evening.

Table 2 B: Concentration of gases at different time of the day during dry season in the study area.

Parameter's time	SO_2 Ppm	NO_2 Ppm	Cl2 Ppm	H_2S Ppm	VOC Ppm	CO Ppm	NH_3 Ppm	SPM mg/m3	HCN ppm	Noise dB(A)
Morning 6am	0.42	0.18	0.03	0.15	0.20	5.09	0.49	17.15	0.17	34.50
Afternoon 12:00pm	0.53	0.27	0.05	0.27	0.27	7.90	0.63	26.40	0.43	44.05
Evening 6:00pm	0.40	0.11	0.03	0.12	0.19	5.20	0.53	19.50	0.18	35.00

Source: Field survey, 2020

A careful observation of Table 2 B: shows that the mean of Sulphur dioxide (SO_2) is lowest (0.40ppm) in the evening and slightly higher in the morning and afternoon (0.42ppm) and (0.53ppm) respectively, the different value of SO_2 in

the study area can be attributed to the low activities in the study area in the late hours of the day and high activities during the afternoon hour of the day. Magaji and Hassan, (2015) collaborated the findings that SO_2 concentration is generally low in the morning and high as the day goes by, because during the early hours of the day most of the SO_2 concentration most have settled down. The mean value of Nitrogen dioxide (NO_2) is observed the lowest in the evening, with a mean concentration of (0.11ppm) and increases lightly in the morning (0.18ppm), with the highest mean concentration in the evening (0.27ppm), high concentration of nitrogen dioxide in the study area can be attributed to the usage of heavy-duty equipment such as crushing plant, trucks, generators amongst other. Chlorine (Cl_2) has its lowest mean concentration of (0.03ppm) in the morning and evening respectively with its highest mean concentration of (0.05ppm) being in the afternoon. The high concentration of chlorine in the afternoon can be attributed to explosive and drilling activities that takes place around the time and unvented gas leaks from air compressors and other sources within the quarry area. Carbon monoxide (CO) has the lowest concentration of (5.09ppm) in the morning, slightly highest in the afternoon with a concentration of (7.90ppm) and moderate in the morning with a concentration of (5.20ppm), the high concentration of Carbon Monoxide in the study area can be attributed to the use and combustion of fuel, residue of blasting materials, clearing of overburden and interburden. The study observed also that Hydrogen Sulfide has the lowest concentration of (0.12ppm) in the evening and highest in the evening (0.27ppm) and moderate concentration in the morning (0.15ppm) respectively, Hydrogen Sulfide can be attributed to combustion of oil, diesel, fuel amongst others. Ammonia (NH_2) has its lowest mean value of (0.49ppm) in the morning unlike the other parameters considered under study and slightly higher in the evening and highest in the afternoon (0.53ppm) and (0.63ppm) respectively, the high concentration of Ammonia can be attributed to drilling activities and gas leaks from air compressors during mining activities. Hydrogen cyanide (HCN) has its lowest mean value of (0.17ppm) in the morning, (0.43ppm) and (0.18ppm) in the evening and afternoon, respectively. Volatile Organic Compound (VOC) has its lowest recorded mean value of (0.19ppm) in the evening, its highest mean value of (0.20ppm) and (0.20ppm) in the morning. Suspended Particulate Matter (SPM ug m_3) has its lowest mean in the morning with a value of (17.15ug m_3), highest mean value of (26.40 ug m_3) in afternoon and (19.50 ug m_3) in evening. Noise dB(A) has its lowest mean value of (34.50) in the evening, followed by (35.00) in evening and its highest mean value of (45.05) in afternoon.

The concentration of the parameters at different time of the day is highly influenced by the variation in the temperature of Abuja where the study area is

located. The temperature at the time (February) when the field survey was carried out was between 29^0C – 32^0C.Usually the mornings and evenings are characterized by low temperatures, which increases sharply as noon approaches and decreases slowly towards evening. As a result of this, mean values of parameters are all in their lowest in the morning and evening. Magaji and Hassan, 2015 collaborated the findings that temperature at different hours of the day affects the concentration of air quality of the area, Adelagun *et al, (*2012) also collaborated the findings that concentration of gases in quarry areas is typically low in the morning and increase slightly as production activities kick off in the afternoon and evening.

Peter et al. (2018) also reported that a particle in the air does not travel as there is less wind during this period. Furthermore, most quarries reduce their activities during this rainy season because construction work also reduce most construction work involving the use of quarried stoneslike road construction, bridge construction and even other operations requiring stones in large quantities decreases during the rainy season. Since the companies reduce their activities in the rainy season, the implication of air also reduces. This assertion agrees also with Nweke and Okpokwesili who reported reduced activities at a quarry company in Abakaliki Ebonyi State.

Plate 1: During Blasting of rock in the study area.

Conclusion

The result of the analysis shows that about 30% of the mining land allotted to the quarry companies in the study area have been degraded in one form or the other, result of the analysis of the gaseous pollutants, CO, NOx, and SO2 which were released into the atmosphere from the activities of quarrying revealed that the environment has been greatly polluted and the fact that the values obtained are much higher than the limits stipulated by the NESREA, implies that the lives of people living and working in this environment are seriously threatened. Moreover, the smoke emanating from the chiming causes impairment of respiratory organs, reduction in visibility for both pedestrians and motorists along the factory and the settlement, which could lead to accident. Emission of the stone dust also causes discoloration and weakening of the pillars of the houses around the settlement due to acid rain. It is therefore recommended that the mining of granite should be discontinued while alternative method of blasting and crushing processing should be enacted. All activities that lead to the release air pollutants should be liable to an Environmental Tax Law. Moreover, the Federal Government and all stakeholders as well as other relevant bodies should as a matter of urgency curtail the activities of the sawmill industries to abate the magnitude of environmental pollution in the area. Despite the low level of contamination, it can be concluded that all things being equal, if this situation is not checked, it will lead to environmental disaster as nobody selects the air, he/she breaths.

References

Abubakar, G.S., Yagana, B.A., & Zarah, M. (2015) Environmental and health hazards associated with exploration of barite from Bukkuyum (Zamfara State), Nigeria. Journal of Health and Environmental Sciences, 2(3), 11-15.

Abumere, S.I. (1993). A Quantitative Assessment of the Magnitude of Urban Slu Parameters in Nigeria. University of Ibadan Staff Postgraduate Seminar, January 13.9-10

Adakayi P.E. (2000). Climate Change in Dawan P.D. *Geography of Federal Capital Territory*. Asanlu Publication, Minna.

Adamczyk, A.F., Motyka, J., Wilk, Z., and Witczak, S, (1988), Mine drainage of a karstic aquifer and the related protection problems – Olkusz Mining District, Poland: Proceedings if the IAH 21st Congress, Guilin, China, Geologic Publishing House, Bejing, China, pp. 1097-1104.

Adekoya JA (1995) Negative environmental impact of mineral exploitation in Nigeria, J Phys Sch 12: 613-619.

Adekoya JA (2003) Environmental effects of solid minerals mining. J Phys 8: 625-640. 3.

Ademola, J. A. (2008) Exposure to High Background Radiation Level in the Tin Mining Area of Jos, Plateau, Nigeria. Nigeria Journal of Rediology, Vol. 2, No. 2, 2008, pp. 10-20.

Adie D.B, Otunb J.A, Okuofuc C.A, Nasiru A. (2012) Assessment Of Noise Generated By Operations Within The Gunduwawa Quarry In Kano State, Nigeria. Nigerian Journal of Technology (NIJOTECH) Vol. 31, No. 3, November, 2012, pp. 314–320. Copyright ©2012 Faculty of Engineering, University of Nigeria.ISSN 1115-8443.

Afgan, N.H. and Carvalho, M.G. (2001), "Multi-Criteria Assessment of New and Renewable Energy Power Plants". Energy, 27, pp. 739-755.

Agunleti, Y.S. and Arikawe, E.A. (2014) Groundwater Targeting Within The Basement Complex Rocks of Federal Capital Territory Abuja Using Remotely Sensed and Vertical Electrical Sounding Data. International Journal of Technology Enhancements and Emerging Engineering Research, 2, 38-47.

Agunwamba, J. C. (2001) Waste Engineering and Management Tools. Immaculate Business Support Services, Enugu, 2001, pp. 403.

Aigbebion I.W. (2005) Environmental pollution in Nigeria. Habit Internat 3: 205210.

Aigbebion, I., and Iyayi, S.E. (2007).Environmental effect of mineral exploitation in Nigeria. International Journal of Physical Science, 2(1) 33–38.

Ajakaiye, D.E. (1985) another Possible Earthquake Near Gombe Nigeria, Bulletin of the Seismological Society of America. 78 (2): 1006-1010

Ajibade, A.C. (1976) Proterozoic Crustal Development in the Pan-African Regime of Nigeria. In: Kogbe, C.A., Ed., Geology of Nigeria, Rock View Ltd., Nigeria, 57-63.

Ajibade, A.C. and Woakes, M. (1983) Proterozoic Crustal Development in the Pan-African Regime of Nigeria. In: Kogbe, C.A., Ed., Geology of Nigeria, Rock View Ltd., Nigeria, 57-63.

Alaba, OC; Adebayo, B; Adesida, PA (2018). Assessment of Environmental Effects of Post Blasted Explosive on the Ecosystem of Old Netim Village in Akamkpa Local Government Area of Cross River State, Nigeria. J. Appl. Sci. Environ. Manage. Vol. 22 (5) 719 – 724 May 2018.

Anand, P.B. (2006). "Waste Management in Madras Revisited"; Environ-urbanisation.

Angela U., Veronica O., Joy, C.N., and Samuel, W. (2017), the Effects of Open Cast Quarrying Technique on Vegetation Cover and the Environment in South-Eastern Nigeria. In: Kogbe, C.A., Ed., Geology of Nigeria, Rock View Ltd., Nigeria, 57-63.

Asante F, Abass K, Afriyie K. Stone quarrying and livelihood transformation in Peri-Urban Kumasi. Research on Humanities and Social Science. 2014;4: 13. 10.

Assad, F.A., and Jordan, H., (1994), Karst terranes and environmental aspects: Environmental Geology, v. 23, pp. 228 – 237

Arbogast, B.F., Knepper, D.H., Jr., and Langer, W.H., (2000), The human factor in mining reclamation: U.S. Geological Survey Circular 1191, 28 p.

Arimoro, A.O; Fagbeja, M.A, and Eedy, W, (2002); "The Need and Use of Geographic Information Systems for environmental Impact Assessment in Africa: with Example from Ten Years Experience in Nigeria. AJEAM/RAGEE, Vol. 4, No. 2.Pp 16-27.

Azad S.A and Dr. Ashish Mittal (2006). The Stone quarrying industry around Delhi impact on Worker and the Environment.

Balogun, (2001). The Federal Capital Territory of Nigeria. A Geography of its Development, University of Abuja.

Banez, J., Ajon, S. M., *et al* (2010). Report on Quarrying and its environmental effects. U.N. Journal, Vol 10.

Baraldi, F., Castaldini, D. and Marchetti, M. (2001). Geomorphological impact assessment in the River Mincio plain (Province of Mantova, Northern Italy). In: Marchetti, M. and Pinas, V. (eds) Gomorphology and environmental impact assessments. Balkema, Rotterdam, pp 7–30.

Barksdale, R.D., ed., (1991), The aggregate handbook: National Stone Association, 717 p.

Barrow, C.J. (1985), Land Degradation: Development and Breakdown of Terrestrial Environments. Cambridge University Press, Cambridge.

Beaumont, P, (1989). Environmental Management and Development in Dry Lands. Routledge Publishers Ltd., UK.

Bell, F.G., (1992), Open excavation in rock masses, in, Bell, F.G., ed., Engineering in rock masses: Buterworth, Heinemann, Oxford, England, p. 400-422.

Benjamin M. and Bohdan K, (2012). Environmental and Health Impacts of Mining in Africa Proceedings of the Annual Workshop IGCP/SIDA, No. 594, Windhoek, Namibia, July 5th – 6th, 2012.Czech Geological Survey, Prague 2012.

Berglund, B, Berglund, U, and Induall, T. (1974) Scaling of annoyance in epidemiological studies. International symposium In proceedings of the CEC, WHO, NESREA International on recent advances in the assessment of the health effects of environmental pollution. Paris, 24-28 June 1974, Pp.1-16

Berger, P.R., Ford, W.C., Graham, E.K., Long, J.F., Jr., Rohrs, D.M., West, J.R., and Willard, R.B., (1991), Environmental and community concerns, in Barksdale, R.D., The Aggregate Handbook: National Stone Association, p. 5-1 – 5-59.

Blaikie, P.M. and Brookfield, H>C. (1987), Land Degradation and Society. London; Mctheun.

Bobrowsky, P.T., ed., (1998), Aggregate resources - A global perspective: A.A. Balkema, Rotterdam, Netherlands, 470 p.

Busayi, A.T.; Fredrick, C. and Fatai, I.A. (2008) "Assessment of the Socio-

Economic Impacts of Quarrying and Processing of Limestone at Obajana. Nigeria". European Journal of Social Sciences, Vol. 6, No. 4.Pp.56-71.

Carney D. (1998) Sustainable rural livelihoods. What contribution canwe make? Papers presented at the DFID Natural Resources Advisers' Conference, July 1998. DFID, London; 1998

Cavallaro, F. (2005), "An Integrated Multi-Critiria System to Assess Sustainable Energy Options: An Application of the Promethee Method" International Energy

Markets,http://www.feem.it/NR/rdonlyres/9E940C73-A958-4D9C-B5CC48E940D89829/1448/2205.pdf, accessed 8 November 2005.