Asian Review of Environmental and Earth Sciences
Vol. 7, No. 1, 79-86, 2020
ISSN(E) 2313-8173 / ISSN(P) 2518-0134
DOI: 10.20448/journal.506.2020.71.79.86

Assessment of Environmental Impacts of Limestone Exploitation in Igarra, Nigeria

Ogundele J.O.[1]
Olotu .Y.[2]
Parker-Ikharo F.[3]
Sanni E.B.[4]
Yusuf I.[5]
Eremiokhale, J.I[6]


(Corresponding Author)

[1,4,5]*Department of Mineral & Petroleum Engineering Technology, Auchi Polytechnic, Auchi, Nigeria.*
[2]*Department of Agricultural Engineering, Auchi Polytechnic, Auchi, Nigeria.*
Email: realyahaya@yahoo.com
[3]*Department of Civil Engineering, Auchi Polytechnic, Auchi, Nigeria.*
[6]*Department of Architectural Technology, Auchi Polytechnic, Auchi, Nigeria.*

Abstract

The exploration of limestone is the nerve of socio-economic integration of the Igarra community. However, the exploration activities have been linked with several adverse effects on human health and the deterioration of the surrounding environment. This research work investigates the quality of air in the study area. Dust emission was measured using a digital air quality monitor of model HP 5800D PM2.5-10 with an accuracy of ±5% or ±4ug/m^3 and measuring and detection ranges of 0.3 ug/m^3 and 0-999.9 ug/m^3. The dust level readings using PM2.5 and PM10 at 1 km apart from the three selected exploration sites in Igarra at a 60-minute interval was taken. Quarry one (Q1) recorded the lowest dust level of 20.6 µg//m^3 for PM2.5 and 72.5 µg//m^3 for PM_{10} in the early hours before exploration. The general outputs show that exploration sites (Q_2) and (Q_3) produced a high degree of polluted air than site Q_1. A higher dust level of 966.0µg/m^3 was recorded for PM10. The overall dust level measurements for PM2.5 and PM10 are higher than the recommended 70.0-80.0 µg/m^3 by the World Health Organization (WHO) and the Environmental Protection Agency (EPA). It is projected that continuous emission of dust at Igarra could lead to an increasing number of diseases such as asthma, catarrh, and breathing problems. In conclusion, an integrated exploration mechanism is essential to improve air quality and substantially reduce air related pollution.

Keywords: Limestone, Dust emission, PM2.5-10, Environment, Igarra.

Citation | Ogundele J.O.; Olotu .Y.; Parker-Ikharo F.; Sanni E.B.; Yusuf I.; Eremiokhale, J.I (2020). Assessment of Environmental Impacts of Limestone Exploitation in Igarra, Nigeria. Asian Review of Environmental and Earth Sciences, 7(1): 79-86.
History:
Received: 29 October 2020
Revised: 17 November 2020
Accepted: 7 December 2020
Published: 22 December 2020

Publisher: Asian Online Journal Publishing Group

Acknowledgement: All authors contributed to the conception and design of the study.
Funding: This study received no specific financial support.
Competing Interests: The authors declare that they have no conflict of interests.
Transparency: The authors confirm that the manuscript is an honest, accurate, and transparent account of the study was reported; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained.
Ethical: This study follows all ethical practices during writing.

Contents

Contribution of this paper to the literature
This study contributes to existing literature by investigating the quality of air in the study area. Dust emission was measured using a digital air quality monitor of model HP 5800D PM2.5-10 with an accuracy of ±5% or ±4ug/m^3 and measuring and detection ranges of 0.3 ug/m^3 and 0-999.9 ug/m^3.

1. Introduction

The exploitation of mineral resources has assumed prime importance in several developing countries, including Nigeria. Nigeria is endowed with abundant mineral resources, contributing immensely to the national wealth with associated socio-economic benefits. Mineral resources are an essential source of wealth for a nation, but before they are harnessed, they have to pass through the stages of exploration, mining, and processing [1] Natural resources can be classified into two groups: renewable and non-renewable resources. Renewable natural resources are replenished on short time scales of a few months or years—for example, wind, hydraulic and solar energies. Non-renewable resources are contained in the earth in fixed quantities and are not replenished by natural processes operating on short time scales [2, 3]. Examples are oil, natural gas, coal, metals, and mineral products produced from the earth. The formation period of oil, gas, metals, and minerals is very long (i.e., over tens of millions of years), vastly slower than the rates at which we mine these materials. The resources we obtain from the earth's crust today are products accumulated over the last billions of years. Most non-renewable natural resources are also mineral resources, both organic and inorganic in origin. Resources can also be classified into three major use groups: metallic, energy, and non-metallic mineral resources [1].

Nigeria's environment (at urban and rural levels) has suffered an accelerated decline in air quality, soils, biodiversity, and water resources [4]. It is clear that sound natural resources management and planning are essential to tackling the problems above and to promote sustainable development [4, 5]. Mining activities represent human actions that cut through the landscape, scarring, and interfering with the natural habitat conditions as well as micro-climatic conditions. Specifically, the environmental effects of limestone mining and cement production are known to impoverish flora and fauna of host environment, result in sediments deposition in riverine systems, create mining spoil mounds and deep mining lakes mainly, result in loss of timber resources and another vegetal cover, toxification, and pollution due to chemical wastes or weathering of mining spoils, cause changes in micro-climate, and several others [2, 6]. These effects on the ecosystem are not only on-site but also occur off-site as well. These, in turn, significantly alter the environmental spheres of the affected areas.

Quarrying is obtaining quarry resources; usually, rocks are found on or below the land surface. Quarrying generates a lot of particulate matter (dust) with a diameter of 1-75 μm (micron) [7, 8]. Particles with aerodynamic diameters of less than 50 μm (termed Total Suspended Particulate matter, or TSP) can become suspended in the atmosphere, and those with aerodynamic diameters of less than ten μm termed PM10 (inhalable particles) can be transported over long distances and enter the human respiratory system [9, 10]. Many researchers have reported these processes to have responsibility for several health problems.

2. Methodology

2.1. Study Area

The study area is located at Igarra in Akoko Edo local Government of Edo-State, Nigeria. Figure 1 shows the map of Nigeria, Edo state and the study area (Igarra). Table 1 shows the codes used in describing the sampling sites. Igarra is located between Latitudes 07° 08 16 and 07° 31 58, and Longitudes 08° 37 46 and 09° 10 31. The study area is located within a sub-humid tropical region with mean annual temperature ranging from 29°C to 30°C, and is characterized by two distinct seasons: the dry season and rainy season. The mean annua1 precipitation is about 1,370mm, with an average wind speed of 1.50 m/s.

2.2. Experimental Design

Data on the impact of limestone mining (extraction) activities on the com-munities in the study area (Igarra) were collected using two methods known as primary and secondary data collections.

i. Primary data collection: This involved measurement of air quality/ dust level using digital particulate matter instrument ($PM_{2.5}$).
ii. Secondary data collection: data collected from health records in the clinics/hospital most patronized by the people. Social survey was also conducted by questionnaire administration in the communities sampled.

2.2.1. Descriptions of Particulate Matter ($PM_{2.5}$ and PM_{10})

The instrument is an of high-tech air quality to measure the $PM_{2.5}$ and PM_{10}. It uses a laser $PM_{2.5}$ sensor, single-chip microcomputer technology and high visibility dot matrix LCD. This instrument is of high precision, short measuring time, stable performance, strong function, easy operation, low power consumption, with function of time display, real time measurement very suitable for indoor and outdoor environment monitoring, can also be used in the detection of air purification machine to air purification effect. The instrument is shown in Figure 2 and 3.

2.2.2. Measurement of Particulate Matter ($PM_{2.5}$ and PM_{10})

$PM_{2.5/10}$ was used to monitor air quality (μ/mg) at Igarra near Freedom Quarry for 10-day. $PM_{2.5/10}$ was sampled for a period of 6-hour at 30 minutes intervals per day. Measured dust levels at every interval were recorded. PM_{10} was empirically estimated using Equation 1:

$$PM_{10} = \frac{M_2 - M_1 * 10^6}{FR * T} \quad (1)$$

PM_{10} = Particles with aerodynamic diameter of 10 microns.
M_1 = Weight of filter paper before sampling (g).
M_2 = Weight of filter paper after sampling (g).
FR = Average flow rate (l/min or m^3/min).

T = Sampling duration in minutes [2].

$PM_{2.5}$ and PM_{10} was calibrated using the expression in Equation 2.

$$PM_{10} = 6.2PM_{2.5} \quad (2)$$

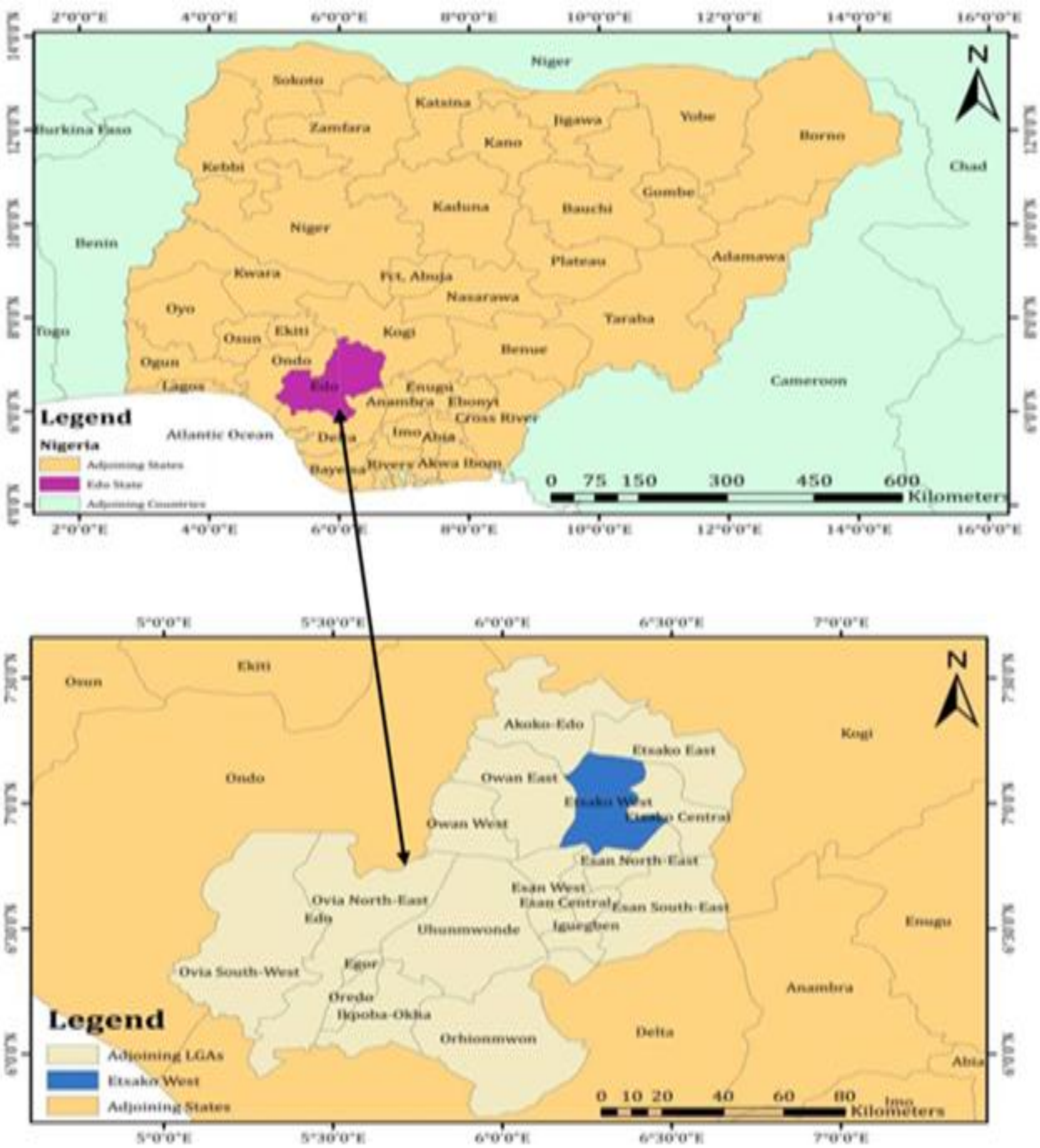

Figure-1. Map of study area.

Source: ESMHW [11].

Figure-2a. Air quality monitor.

Source : Salvi and Holgate [12].

Figure-2b. Dust level measurement.

Source: Field work, 2018.

2.2.3. Climate Variables

Field climatic parameters (minimum and maximum temperature, relative humidity) of the study area were measured with digital thermometer model CX 201A. Current climatic data (1975-1985) and (1990-2005) were obtained from Nigerian Meteorological Agency (NMET). Future projected climatic data (2030-2045) of Igarra was downscaled using Centre of Canadian Climate Modelling & Analysis (CCCMA) under Representative Concentration Pathways (RCP 4.5).

2.2.4. Health and Agricultural Data Collection

Structural questionnaires were used to obtained health and agricultural information in the study area. These data were collected to establish the relationship between exploration activities and the health of the dwellers and also to determine the link between quarrying activities and crop yield as indicated in Table 1.

Table-1. Code for the sampling of study area.

Area Code	Sampling Sites
Q_1	Exploration site 1
Q_2	Exploration site 2
Q_3	Exploration site 3

3. Results and Discussion

3.1. Dust Level Measurement

Digital air quality monitor was used to measure and evaluate particle concentration variations within a pre-set time interval. Tables 2-4 show the results of dust level measurement using PM2.5 and PM10 from three limestone exploration sites at Igarra. The measurement was carried at a 30-minute interval for 6-hour daily. It is observed that Q_1 recorded lowest dust level of 19.6 μg/m³ for PM2.5, 59.6 μg/m³ and 62.5 μg/m³ for the PM_{10}. This indicates that the air quality is good and healthy around this period. The result is in agreement of Najime, et al. [9]; Musa and Jiya [10]; Yoon and Brimblecombe [13].

The concentration dust particle starts to rise between 10.00 am to 10.30 am and reduced to 56.6 μg/m³ which corresponds to 365μg/m³ for PM_{10}. The highest concentration of 529.1 μg/m³ and 864.3 for $PM_{2.5}$ and these values correspond to 0.0μg/m³, 3280.0μg/m³ and PM_{10} and estimated PME_{10} respectively (Table 2 and Figures 3-4). The maximum dust level measurement for digital dust monitor HP 5800D PM_{-10} is 9990μg/m³, based empirical equation was applied to compute the values that could not be easily monitored from the digital equipment. 0.0μg/m³ indicates out of measurement range for PM_{10}. The overall results show that exploration site two and three produced a high degree of dust. Dust level of 5917.2μg/m³ was generated from PME10 which corresponds to 0.0μg/m3 and 906.0μg/m3 of PM_{10} and $PM_{2.5}$ (Figures 2-5; Table 3). The results are similar to previous studies [1, 4, 9].

Table-2. Dust level reading in exploration one (Q_1).

Time (Mins)	Duration	$PM_{2.5}$ (ug/m³)	PM_{10} (ug/m³)
9.30	0.00-30.0	19.6	59.5
10.00	30.0-60.0	126.0	739.3
10.30	60.0-90.0	143.9	892.2
11.00	90.0-120.0	56.6	365.5
11.30	120.0-150.0	529.1	0.0
12.00	150.0-180.0	19.8	119.8
12.30	180.0-210.0	10.8	61.3
1.00	210.0-240.0	143.9	892.2
1.30	240.0-270.0	99.6	685.6
2.00	270.0-300.0	92.2	513.4
2.30	300.0-330.0	24.1	178.8
3.00	330.0-360.0	864.3	0.0

Table-3. Dust level reading in exploration site two.

Time (Min)	Duration	$PM_{2.5}$ (ug/m³)	PM_{10} (ug/m³)	PME_{10} (ug/m³)
8.00	0.00-30.0	75.4	529.2	696.2
8.30	30.0-60.0	99.6	685.6	785.6
9.00	60.0-90.0	139.5	828.5	988.5
9.30	90.0-120.0	92.2	513.4	767.4
10.00	120.0-150.0	24.1	178.8	199.8
10.30	150.0-180.0	906.0	0.0	5617.2
11.00	180.0-210.0	864.3	0.0	5358.7
11.30	210.0-240.0	674.7	0.0	4183.1
12.00	240.0-270.0	99.6	685.6	889.6
12.30	270.0-300.0	126.0	59.5	70.5
1.00	300.0-330.0	143.9	0.0	892.2
1.30	330.0-360.0	19.8	169.8	199.8

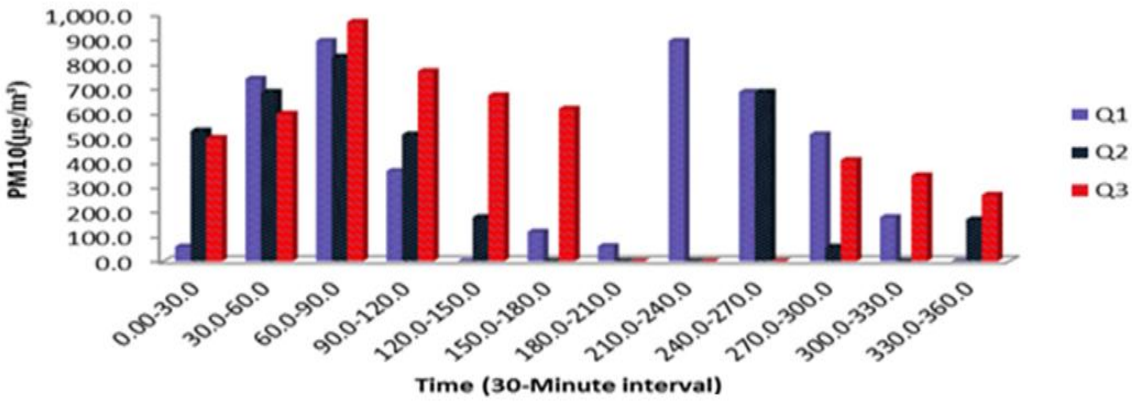

Figure-3. Comparison of PM 10 results measured from three quarry sites (Q1-Q2-

However, Quarry (3) shown the similar increasing trend of dust level as in Quarry (2). Q_3 recorded higher values both at 11.00 am (180.0-210.0) and 11.30 am (210.0-240.0) and least unhealthy air of 80.6 μg/m³,499.7 μg/m³ and 599.7 μg/m³ for $PM_{2.5}$, PM_{10} and PME_{10} respectively. The higher particulate matter (PM) shows the peak of limestone exploration activities during the day Figure 5.

3.2. The Impact of Climate on Dust Concentration

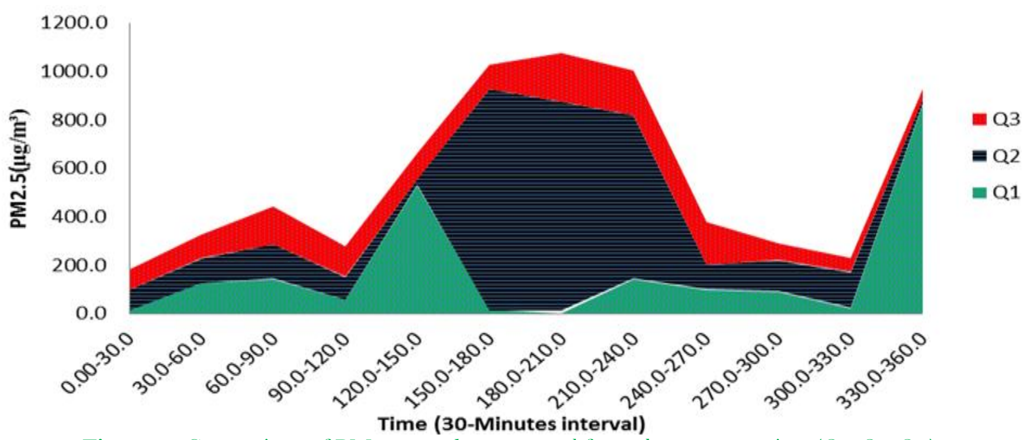

Figure-4. Comparison of PM 2.5 results measured from three quarry sites (Q1-Q2-Q3).

The weather data was taken in-situ along with dust level. The results show that the climate is very warm in all the quarry sites with the minimum temperature from 26.4⁰C to 27.7°C and maximum temperature from 37.8°C to 40.1°C for Q_3, Q_2 and Q_1 respectively. However, Q_3 has a higher relatively relative density of 57.0% over Q_2 and Q_1(Table 4). During the dry season (warmer climate) the air moisture content is very low and this allows dust to be accumulated and easily dispersed, whereas dust particles are being trapped during the wet season. Tables 5-6 show the baseline climate of the study area for before and during the limestone exploration. The result of the future projected climate of Igarra using Centre of Canadian Climate Model & Analysis under the climate change scenario (RCP 4.5).

Table-4. Annual average climate data of Ikpeshi during pre-limestone exploration(1970-1985).

Year	Tmin(°C)	Tmax(°C)	Prec(mm)
1970	19.0	31.0	1111.3
1971	19.9	31.5	1228.0
1972	20.3	31.7	1367.2
1973	20.0	31.9	1306.6
1974	19.1	32.3	1091.8
1975	18.5	30.8	1393.0
1976	20.1	31.0	1172.9
1977	19.7	31.6	1352.2
1978	19.1	31.5	1053.4
1979	20.1	31.3	1309.8
1980	20.1	31.7	1278.8
1981	19.0	31.3	1091.0
1982	20.2	31.9	1254.3
1983	20.5	31.9	1394.4
1984	20.6	31.8	1222.4
1985	19.0	31.2	1230.8

Source: Yoon and Brimblecombe [13].

Table-5. Annual average climate data of ikpeshi during limestone expliotation (1990-2005)

Year	Tmin(°C)	Tmax(°C)	Prec(mm)
1990	19.8	32.8	1435.1
1991	26.1	32.1	1508
1992	20.5	32.2	1138
1993	18.7	31.4	1258.8
1994	19.5	31.6	1393.6
1995	19.8	32.3	1269.7
1996	21.3	33	1001.2
1997	20	33.1	1071.2
1998	19.2	32.1	1115.4
1999	18.6	31.8	1250.3
2000	20.2	32.5	1216.6
2001	20.7	32.6	1464.1
2002	20.9	33	1005.5
2003	19.8	32.5	1326.2
2004	20.2	32.7	1417.3
2005	19.8	32.6	1321.9

Source: Yoon and Brimblecombe [13].

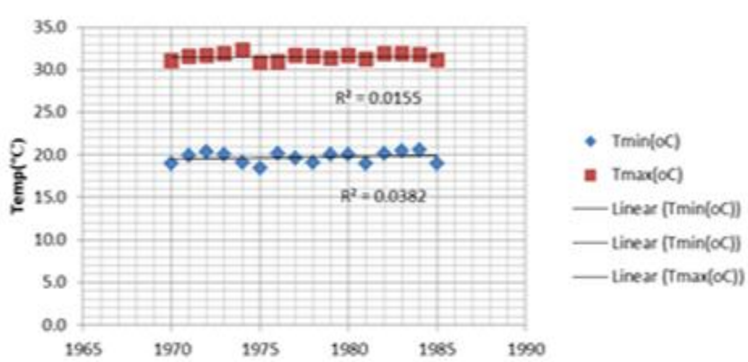

Figure-5. Climatic (Temp) analysis of study area during pre-limestone exploration.

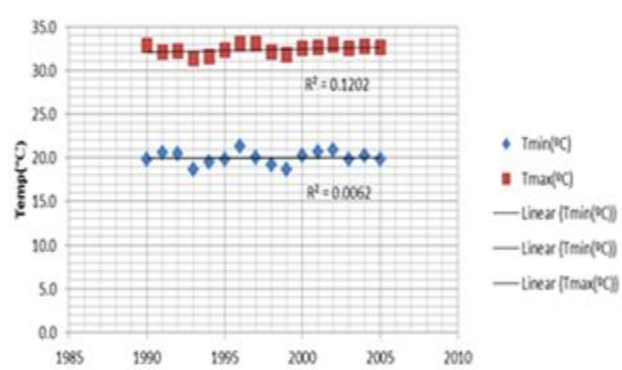

Figure-6. Climatic (Temp) analysis of study area during pre-limestone exploration.

Source: Sensitivity analysis, 2018

Table-6. Annual average climate data of ikpeshi during limestone expliotation (2030-2045)

Year	Tmin(oC)	Tmax(oC)	Prec(mm)
2030	20.1	30.3	1387.8
2031	25.7	31.1	573
2032	25.5	30.7	2105.8
2033	26.1	31	1920.7
2034	25.9	31.6	151.4
2035	25.5	30.9	1641.9
2036	26.7	28.7	1595.9
2037	26	291.9	1609.2
2038	26.2	31.3	1606.2
2039	25.7	31	1636.9
2040	26.1	31.3	2007
2041	26.7	31.6	1547.2
2042	26.5	31.3	1705.1
2043	25.8	30.2	1531
2044	26.2	31	1743.6
2045	26.1	31.7	1764.4

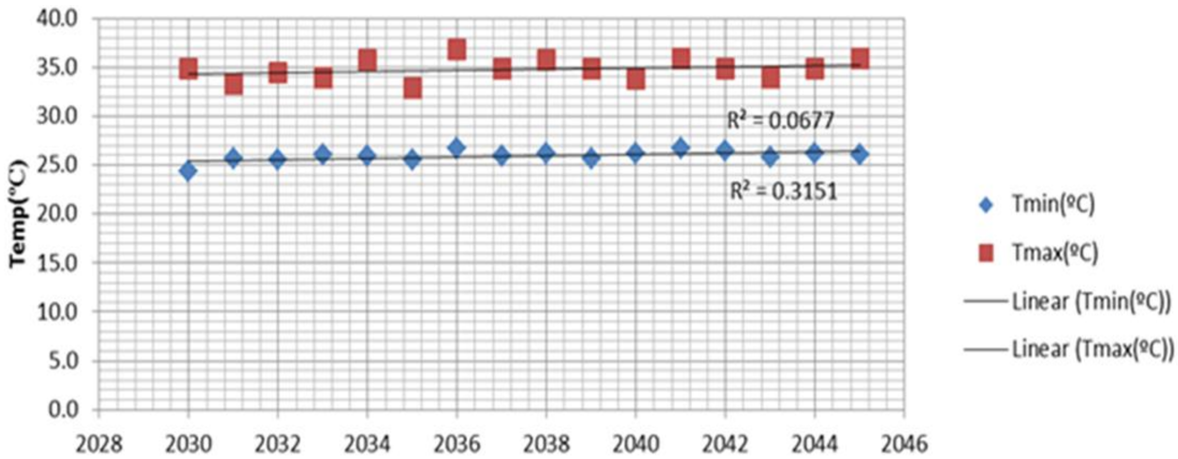

Figure-7. Climatic (Temp) analysis for projected (temp) from CCCMA-RCP 4.5 for the study area.

It is clear that T_{max} increased with 0.12^{0}C per year from 1985 to 2010 and this trend is projected with marginal increase of 0.0677^{0}C annually for the period 2028 to 2046, while increase of 0.32^{o}C was projected for the minimum temperature Figures 6-8. Any large-scale impacts of dust on atmospheric temperatures in these periods would have potentially important implications for atmospheric stability and ultimately for the ability of the atmosphere to foster conditions conducive to rainfall generation. Dust is a major natural source of atmospheric aerosols that can potentially affect clouds. The effect of dust concentration on precipitation was not known before the TRMM satellite was launched and applied to clouds forming in dust-laden air [6, 7]. The large sizes of some of these dust particles had led to the assumption that dust would enhance precipitation rather than decrease it. The result of rainfall analysis in Figures 8-9 indicate variation of rainfall distribution before, during and projected future climate in the study area.

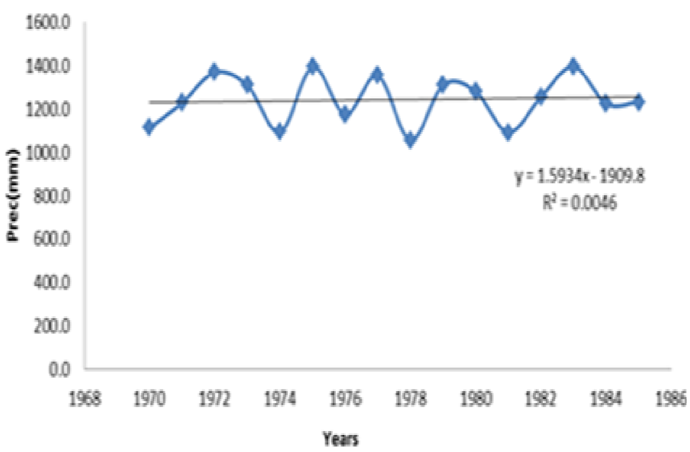

Figure-8. Precipitation analysis during pre-limestone exploration era

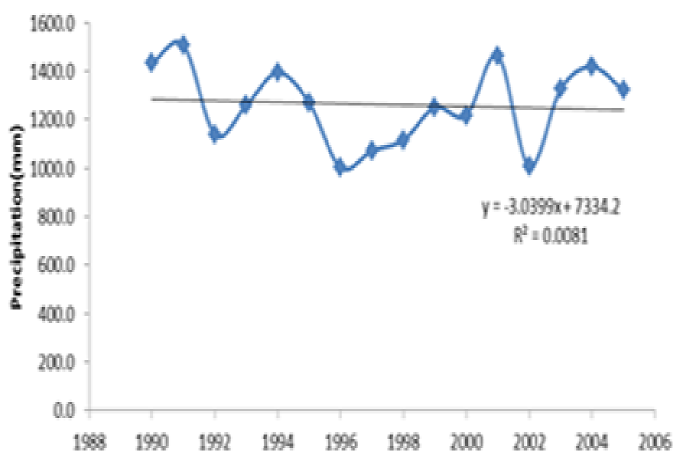

Figure-9. Precipitation analysis during limestone exploration era

3.3. Dust Concentration and Human Health

Dust is a common air pollutant. Dust particles vary in size from coarse (non-inhalable), to fine (inhalable), to very fine (respirable). Coarse dust particles generally only reach as far as the inside of the nose, mouth or throat. Smaller or fine particles, however, can get much deeper into the sensitive regions of the respiratory tract and lungs. These smaller dust particles have a greater potential to cause serious harm to your health. The potential health effects of some common dusts in mines and quarries are analysed as shown in Figure 10.

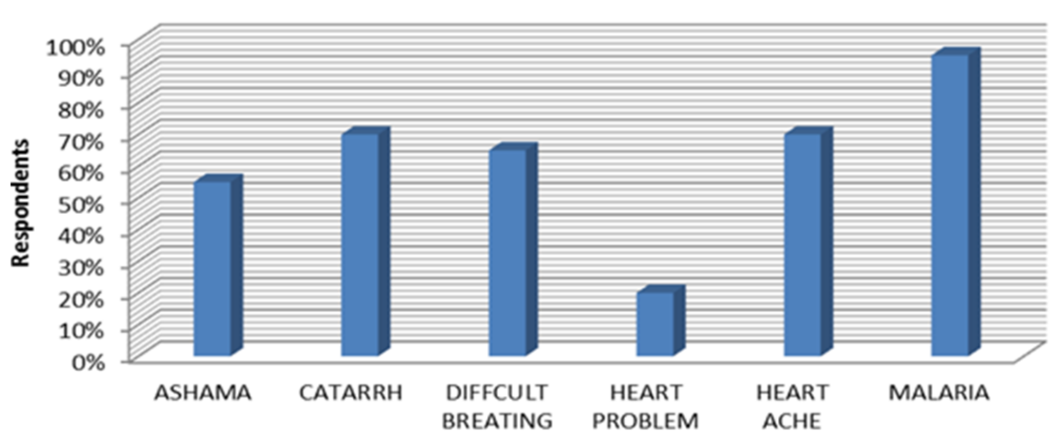

Figure-10. Health conditions of the dwellers of study area.

The results of the analysis indicate that four out of six most commonly reported diseases in Igarra are dust-pollution related diseases. Above 50% of the respondents claimed to have suffered asthmatic attacks, while over 60% and above have suffered catarrh, difficult breathing and headache respectively. However, 28% of heart attack cases had been reported. In most cases each of the diseases goes along with malaria parasites. In addition, the most common symptoms experienced during a dust storm are irritation to the eyes and upper airways infants, young children and the elderly are most vulnerable.

4. Conclusion

The study of limestone exploration on the prevailing climate of Igarra was carried out by measuring the air pollution of the study area with $PM_{2.5}$ and PM_{10} at 30 minutes interval respectively. Empirically-based model was also used to compute PM_{10} in order to create robust dataset since the digital air monitor was not calibrated to measure above 999.0($\mu g/m^3$). Results from annual $PM_{2.5-10}$ and PME_{10} data confirm the air quality in the study zones is highly hazardous to human health and this may probable the result of high cases of illness in the region. The implication is that the observed daily average values of both $PM_{2.5}$ and PM_{10} are higher than the WHO and 70 $\mu g/m^3$ set by EPA, permissible limits for all stability classes. Additionally, results confirm the interdependent importance of relative humidity, minimum and maximum temperature in $PM_{2.5-10}$ concentration from Igarra. Effects of variability of precipitation (distribution and intensity) should also be considered. The output of the health analysis shows deadly effects of limestone exploration activities on the dwellers in Igarra. There has been a sharp rise in dust and water related or borne diseases since the advent of limestone mining commenced in Igarra and its environs. Water resources (surface and underground) have been polluted and this has made safe drinking water unavailable and inaccessible. Moreso, the settling of dust particle on the roof surface of most homes further complicate rain harvesting system.

References

[1] I. Aigbedion, "Environmental pollution in the niger-delta, Nigeria," *Inter-Discplinary J. Enugu-Nigeria*, vol. 3, pp. 205–210, 2005.

[2] E. Acheampong, "Impact assessment of mining activities by ashanti goldfields, Bibiani Limited on the Environment and socio-economic development of bibiani," Undergraduate Dissertation, Faculty of Social Sciences, Kwame Nkrumah University of Science and Technology, 2004.

[3] J. I. D. Adekeye, *The impact of artisanal and illegal mining on the environment in Nigeria*: Elizabethan Publishing Co, 1976, 2001.

[4] J. A. Adekoya, "Environmental effect of solid minerals mining," *Journal of Physical Science*, vol. 45, pp. 625–640, 2003.

[5] D. Cameron, E. L. Bartlett, J. S. Coats, D. E. Highly, G. K. Lott, D. Flight, J. Hillier, and Harrison, *Directory of mines and quarries 2002*, 6th ed. Nottingham: British Geological Survey, 2002.

[6] D. Ajakaiye, "Environmental problems associated with mineral exploitation in Nigeria," presented at the A Paper Presented at the 21st Annual Conference of the Nigeria Mining and Geosciences Society held at Jos, 1985.

[7] T. Najime, "Cretaceous stratography, sequence and techno-sedimentary evolution of gboko area, Lower Benue Trough Nigeria," Unpublished Ph.D Thesis, Department of Geology, Ahmadu Bello University Zaria, Nigeria, 2010.

[8] O. A. Kogbe CA, *Statistics of mineral production in Nigeria (1916 - 1974) and contribution of the mineral industry to the Nigeria economy. In C.A. Kogbe (ed.) Geology of Nigeria*. Lagos Nigeria: Elizabethan Publishing Co, 1976.

[9] T. Najime, P. M. Zaborski, and S. I. Abaa, "Allocyclic control on the depositional sequence of the gboko formation, Lower Benue Trough," *Borno Journal of Geology*, vol. 4, pp. 56-69, 2006.

[10] H. D. Musa and S. N. Jiya, "An assessment of mining activities impact on vegetation in bukuru Jos Plateau state Nigeria using normalized differential vegetation Index (NDVI)," *Journal of Sustainable Development*, vol. 4, pp. 150-159, 2011.Available at: https://doi.org/10.5539/jsd.v4n6p150.

[11] ESMHW, "Categorization of agro-ecological zones in Edo State," *Bulletin*, vol. 6, p. 71, 2007.

[12] S. Salvi and S. T. Holgate, "Mechanisms of particulate matter toxicity," *Clinical and Experimental Allergy*, vol. 29, pp. 1187-1194, 1999.Available at: 10.146/j.1365-2222.1999-00576.x.

[13] Y. H. Yoon and P. Brimblecombe, "The distribution of soiling by coarse particulate matter in the museum environment," *Indoor Air*, vol. 11, pp. 232-240, 2001.