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Impact of quarry activities on the air quality around neighbouring localities in Ogun State, Nigeria

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ABSTRACT

Quarry industry and its products play an important role in any economy in the world. This study examined the impact of quarry activities on air quality around the neighbouring localities in Ogun State. Eight locations were selected; Isara, Idode, Iwaye, Ogbere, Ilagbe, Adelokun, Baaki Ake, and Igodo. Air quality was assessed for the concentration of CO_2, $PM_{2.5}$ and PM_{10} using standard procedures. Samplings were carried out in dry and wet seasons. Data were subjected to descriptive and inferential statistics using SAS package (9.4 version), compared with World Health Organisation (WHO) and the probability of particulate matters causing health hazard was also calculated using Air Quality Index (AQI). $PM_{2.5}$ and PM_{10} (dry season) of the surrounding locations were higher than the WHO Limits of 15 and 45 µg/m^3 respectively; except the PM_{10} at Iwaye (32.20±4.18 µg/m^3), Isara (35.60±4.38 µg/m^3) and Adelokun (42.58±2.74). In wet season, the $PM_{2.5}$ (all locations) and only PM_{10} of Ilagbe ((45.99±3.15), Baaki Ake (50.97±3.13) and Igodo (49.68±2.17) were higher than their corresponding WHO Limits. The AQI of $PM_{2.5}$ (both seasons) at various locations were in the range of 51 – 100 (moderate). AQI of PM_{10} dry and wet seasons across locations range 0 – 50 (good); except the $PM_{2.5}$ of Baaki Ake (51.16) hence, moderate. CO_2 concentration at Adelokun (421.73±2.75), Baaki Ake (415.62±5.82) and Igodo (411.85±1.95) (dry season) and Adelokun (405.98±2.60) and Baaki Ake (403.26±1.63) (wet season) surpassed WHO limit (400 µg/m^3). The surrounding localities were polluted with CO_2 and particulate matters ($PM_{2.5}$ and PM_{10}) with no health hazard.

Contribution/Originality: In this study, seasonal variation of the pollution arising from quarries and Air Quality Index were carried out and calculated so as to quantify the level of the pollution respectively. However, sampling size of eight quarries at a time is unprecedented in any investigation on quarry.

1. INTRODUCTION

Quarries have supplied stone for great buildings and civil engineering projects, and for the constructions of roads and railways. It is important because it provides income to State authorities through taxation and creates jobs in areas where there are limited opportunities [1]. Quarries are forms of open mining that produce minerals. The way quarrying is carried out depends on the type of rock and what the rock will be used for, after it is mined. The difference between mining and quarrying is that quarrying is the extraction of the non-metallic mineral (rocks) and aggregates, while mining is the excavation of the metallic mineral deposits. Some of the stones extracted are soilstone, limestone, partite, marble, ironstone, slate, granite, rock salt and phosphate rock [2]. Dust is a major source of air pollution in quarry industry. The extent of pollution by dust depends on the local microclimate conditions, the concentration of dust particles in the ambient air, the size of the dust particles and their chemistry [3]. Dust has effect on both human health and the natural environment by causing a killer disease called 'silicosis', through inhalation of minute dust particles that are high in silica [4]. Suspended particulate matter is quite outstanding among all pollutants emanating from quarrying operations [5]. Quarry activities involve blasting and crushing of rock materials and utilization of explosive and heat (fire) for the production of granite chip that may lead to the release of particulate matters and dust. Also, the loading and movement of heavy load trucks on haul routes generate suspended particulates while the crushing of ore and transferring it to a belt conveyor (ore processing) would be a potential source of dust generation. Oguntoke, et al. [6] reported that the highest means of Suspended Particulate Matter (SPM) levels among the selected quarries vary between 26.03±1.36 and 11.03±1.52 mg/m^3. SPM levels declined significantly ($p>0.05$) with distance from the drilling and crushing locations at each of the quarry sites. Oguntoke, et al. [6] and Akanwa, et al. [7] reported that the concentrations of the particulate matter in all sampling sites were higher at distance close to quarrying sites and that these concentrations were normally decreased with distance as they dispersed, but still they had an impact on human and environment in general. Potential health impacts are almost exclusively linked to the presence of airborne dusts, in particular respirable particles, i.e. those that are less than 10 μm in diameter (also known as PM_{10}). The air pollution is not only a nuisance (in terms of deposition on surfaces) it portends possible effects on health, in particular for those with respiratory problems. Concerning the environmental impact, quarries and stone cutting industries cause ecological disturbance, destruction of natural flora, pollution of air, landscape degradation [8]. It is generally accepted that dust up to 10 μm can be inhaled beyond the larynx and dust up to 4 μm can get into the lungs and cause possible ailment of respiratory and cardio-vascular systems [9-11]. In wet season, the rain helps in sinking these air pollutants and dusts are wetted and mixed with soil, and some were transported with runoff, thereby reducing its negative impact on the soil Sayara [11] and Akanwa, et al. [7]. Rikhtegar, et al. [12] averred that dry season was the strongest season with respect to dust deposition. The gaseous pollutants emission tendency has been observed by several authors including; Li, et al. [13] they reported that the concentration of pollutants decreases with increases in the altitude. The concentration of pollutants decreases as distance from the quarry increases; sulphur dioxide (SO_2), oxides of nitrogen (NO_X) and ozone (O_3) concentrations in the ambient air were below detection limit. Concentration of carbon monoxide (CO) was highest in the drilling point followed by the crushing section, loading section and workshop place. Generator house had the least concentration of CO Bada, et al. [14]. Peter, et al. [15] investigated the effect of quarrying activities on air quality parameter such as volatile organic compound (VOC), CO, NOx, SOx, at various distances away to the quarrying site and found that the effect of these air pollutants reduce as the distance far away from quarry sites at Ishiagu and Akpoha in Ebonyi State, Nigeria during dry and wet seasons. However, these foregoing prompted to carry out a study to assess the impact of quarries on the air quality in the surrounding villages in Ogun State.

2. MATERIALS AND METHODS

2.1. Study Area

Ogun State lies between latitude 7.9031 and 6.3142 °N to longitude 2.7073 and 4.5750 °E. Ogun State covers a geographical area of 16,980.55 square kilometres with a population of about 3,751,140 [16].The state is within the Rain forest zone of Nigeria and enjoys a tropical climate with distinct wet and dry seasons. Wet season in Ogun State lasts between seven and eight months; (April to October) and the dry season running through November to February [2]. Furthermore, there is widespre ad distribution of quarry materials; particularly granite in this part of Southwestern Nigeria. It spreads across eight Local Government Area (LGA) within three divisions (Egba, Ijebu and Remo) out of four divisions of ethnic and cultural line in the state; namely Egba, Ijebu, Remo and Yewa. Figure 1 shows location of selected quarry sites in different Local Government Areas in Ogun State.

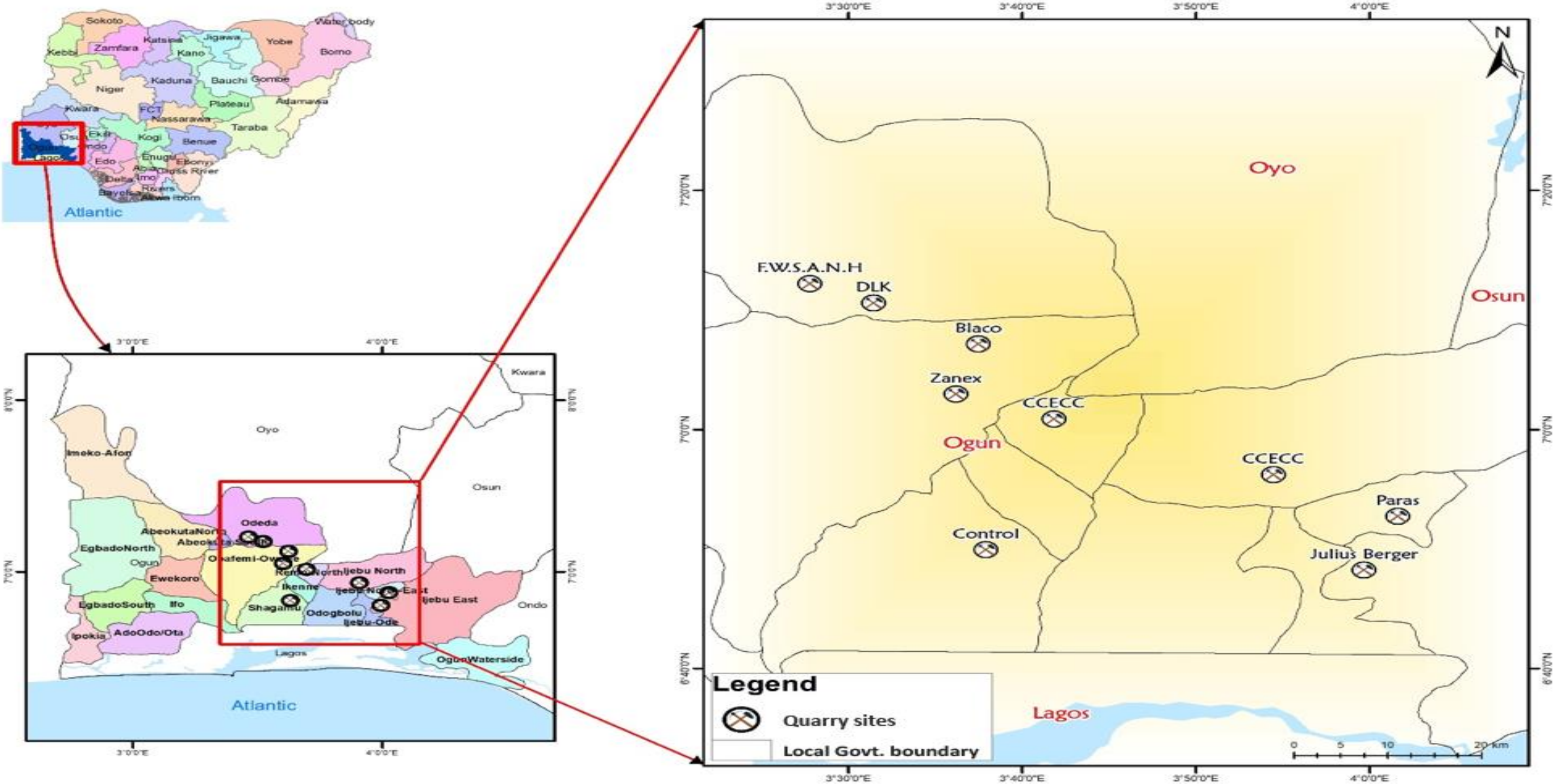

Figure 1. Location of selected quarry sites in different local government areas in Ogun state.

2.2. Sampling Techniques

Purposive sampling method was used to select eight (8) quarry locations in the study area. Sampling was carried out in eight (8) selected locations communities due to their closeness (500 – 1000 m) to the quarry sites in all six local government areas. Two (2) locations were selected from each of Odeda and Obafemi/Owode Local Government Areas due to the presence of higher number of quarry sites in them. One location was sampled from each of the remaining four (4) Local Government Areas. The air (gaseous pollutants and particulate matter samples) were taken twice; covering both dry and wet seasons during production hours between 8am – 4 pm. Sample locations in each Local Government Area are presented in Table 1.

Table 1. Selected quarry sites in Ogun state.

Local government area	Locality or village	Industry
Remo North	Isara	CCECC
Obafemi/Owode	Adelokun	Zanex
Obafemi/Owode	Baaki ake	Blaco
Ijebu East	Ogbere	Julius Berger
Ijebu North	Idode	CCECC
Odeda	Igodo	F.W.S.AN.H.Concept 2
Ijebu North East	Iwaye	Paras
Odeda	Ilagbe	DLK
Shagamu	Shagamu	Control

Note: CCECC = China civil engineering construction corporation.

2.3. Air Sampling

2.3.1. Gaseous Pollutant

The gases were sampled in November, 2021(dry season) and July, 2022 (wet season) so as to determine level of following; CO_2 CO, NO_2, SO_2 and O_3 using Aeroqual – gas sensing (Series 300). Each gas monitored has a sensor head that was attached to the instrument and was initialized for 3 minutes before the reading started. The level of the pollutant started reading and displayed on the meter. The process was repeated for various gas parameters determined during production for three days across all locations. However, mean and standard deviation were calculated.

2.3.2. Suspended Particulate Matter (PM_{10} and $PM_{2.5}$) Sampling

The measurement of the particle matter (PM_{10} and $PM_{2.5}$) were carried in November, 2021(dry season) and July, 2022 (wet season) by employing the respirable dust sampler, APM 460DX and Wins Anderson impactor, APM 550, respectively; during operational hours for 3 days.

All the filter papers (cellulose) of 11 μm size were weighed on a Meter analytical weighing balance before the sampling and desiccated for 24 hours and later placed in the filter holder cassette ($PM_{2.5}$) and zip lock polybag (PM_{10}) to the field for sampling. The filter papers were loaded on respective samplers and screwed properly before starting the samplers.

After sampling, the loaded filter of PM_{10} and $PM_{2.5}$ were removed with forceps, placed in cassette and wrapped in aluminium foils that were put in zip lock for weighing in the laboratory. The means and standard deviation of each three samples (PM_{10} and $PM_{2.5}$) per location were calculated.

2.4. Data Analysis

Data generated were subjected to descriptive (mean, standard deviation) and inferential analysis (T-test). The results obtained were compared with [17]. However, the probability of incidence of health hazard by particulate matters was also calculated using Air Quality Index (AQI) [18], as presented in Equation 1.

$$\mathrm{AQI} = \left[\frac{(Pm_{obs}-Pm_{min})\,(AQi_{max}-AQi_{min})}{(Pm_{max}-Pm_{min})}\right] + AQi_{min} \qquad (1)$$

PMobs = Observed PM ($PM_{2.5}$ or PM_{10}) concentration in $\mu g/m^3$.
PMmax = Maximum concentration of PM range values that contain or accommodate PMobs.
PMmin = Minimum concentration of PM range values that contain or accommodate PMobs.
AQImax = Maximum AQI range values that corresponds to PMobs.
AQImin = Minimum AQI range values that corresponds to PMobs.

Table 2. Classification ladder for USEPA $PM_{2.5}$ and PM_{10} air quality index.

AQI category	AQI value	24 Hours average $PM_{2.5}$ concentration ($\mu g/m^3$) in air	24 Hours average PM_{10} concentration ($\mu g/m^3$) in air
Good	0 – 50	0 – 15.4	0 – 54
Moderate	51 - 100	15.5 – 40.4	55 – 154
Unhealthy for sensitive groups	101 – 150	40.5 – 65.4	155 – 254
Unhealthy	151 – 200	65.5 – 150.4	255 – 354
Very unhealthy	201 - 300	150.5 – 250.4	355 – 424
Hazardous	301 – 500	250.4 – 500.4	425 – 604

Note: United States Environmental Protection Agency [18].

3. RESULT AND DISCUSSION

3.1. Discussion

The values of $PM_{2.5}$ and PM_{10} during dry and wet seasons were demonstrated in Table 3. They were also compared with WHO (Limit) 15 $\mu g/m^3$ 24-hour mean and 45 $\mu g/m^3$ 24-hour mean respectively. In dry season, the $PM_{2.5}$ ranges between 17.8±3.21 – 31.7±3.91 $\mu g/m^3$ with Iwaye (lowest) and Igodo (highest) respectively and every values of $PM_{2.5}$ in different locations were higher than the control (12.5±0.31 $\mu g/m^3$). This implies that quarrying increased particulate matter ($PM_{2.5}$) of the surrounding environments. Furthermore, all the values of the $PM_{2.5}$ across locations higher than WHO Limit (15 $\mu g/m^3$) and there were significant differences among the $PM_{2.5}$ values across locations. Potential health impacts were almost exclusively linked to the presence of airborne dusts, in particular respirable particles i.e. $PM_{2.5}$; and have the potential to affect human health, including effects on the respiratory and cardio-vascular systems [1, 10]. In addition the Air Quality Index (AQI) of $PM_{2.5}$ at Iwaye (55.5), Idode (61.0), Isara (56.7), Ogbere (68.9), Ilagbe (72.8), Adelokun (69.2), Baaki Ake (82.4), Igodo (82.8) all are within AQI values of 51 – 100; implies moderate in term of health implication, while the control (40.58) is within the value of 0 -50 (AQI); implies it is good, as illustrated in Table 2.

Furthermore, in Table 3, the PM_{10} had Iwaye (32.2±4.18 $\mu g/m^3$) and Baaki Ake (55.3±4.58 $\mu g/m^3$) as lowest and highest respectively and were higher than the control (28.2±0.21 $\mu g/m^3$). The implication of this is that quarry activities increased the PM_{10} of the environments around the quarries [15]. All these values were higher than the WHO permissible Limit (45 $\mu g/m^3$), except Iwaye (32.2±4.18 $\mu g/m^3$), Isara (35.6±4.38 $\mu g/m^3$) and Adelokun (42.6±2.74). More so, there were significant differences among the PM_{10} values across the locations. Quarry dust has also been found to cause a killer disease called 'silicosis', especially among quarry workers through inhalation of minute dust particles (0.1 to 150 μm) that are high in silica [1]. The AQI for PM_{10} at Iwaye (29.8), Idode (44.3), Isara (33.0), Ogbere (45.8), Ilagbe (46.2), Adelokun (39.4), Igodo (49.7) and control (26. 1) are within AQI values of 0 – 50; indicates good health, while Baaki Ake (51.16) is within AQI values of 51 – 100; indicating moderation in health as shown in Table 2.

Table 3. Comparison of particulate matter (µg/m³) concentration in dry and wet seasons (N = 3).

Location	Dry				Wet			
	$PM_{2.5}$ (µg/m³)	AQI USEPA (2012)	PM_{10} (µg/m³)	AQI USEPA (2012)	$PM_{2.5}$ (µg/m³)	AQI USEPA (2012)	PM_{10} (µg/m³)	AQI USEPA (2012)
Iwaye	17.8±3.21	55.5	32.2±4.18	29.8	16.0±2.50	51.9	28.4±3.15	26.3
Idode	20.6±2.23	61.0	47.8±3.72	44.3	18.2±1.50	56.4	44.2±3.65	40.9
Isara	18.4±1.21	56.7	35.6±4.38	33.0	15.9±2.40	51.8	31.4±2.15	29.0
Ogbere	24.6±3.11	68.9	49.5±3.73	45.8	19.0±2.00	57.8	43.7±2.25	40.4
Ilagbe	26.6±2.21	72.8	49.9±4.48	46.2	24.1±1.50	68.0	46.0±3.15	42.6
Adelokun	24.8±3.51	69.2	42.6±2.74	39.4	22.5±0.80	64.7	38.6±2.45	35.7
Baaki Ake	31.5±2.22	82.4	55.3±4.58	51. 2	29.2±0.59	77.9	51.0±3.13	47. 2
Igodo	31.7±3.91	82.8	53.9±3.75	49.9	28.8±0.90	77.3	49.7±2.17	46
Control	12.5±0.31	40.6	28.2±0.21	26. 1	22.6±0.61	65.0	33.4±0.91	30.9
Overall Mean±SD	23.2±6.42		43.9±9.78		21.8±5.00		40.7±8.15	
World Health Organisation [17]	15		45		15		45	
T-statistic	-106		-63.2		-137		-77.0	
P-value	0.00		0.00		0.00		0.00	
Source of variation	F			P-value				
Locations	14.4			1.84E-07				
Samples	91.1			2.96E-13				

Table 4. Gaseous pollutant in dry and wet seasons (N=3).

Location	CO_2 (µg/m³)		CO (µg/m³)		NO_2 (µg/m³)		SO_2 (µg/m³)		Ozone (µg/m³)	
	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season
Iwaye	393±5.45	380±1.40	0.01±0.00	0.00±0.00	5.15±1.60	4.66±2.10	6.44±1.61	6.01±1.61	18.3±1.60	14.9±2.60
Idode	382±4.15	366±2.60	0.01±0.00	0.01±0.00	6.23±1.61	5.84±1.60	7.06±2.60	7.00±2.60	21.3±1.61	17.9±1.67
Isara	393±5.25	379±1.67	0.01±0.00	0.01±0.00	5.32±2.60	5.11±2.20	6.54±1.64	6.21±1.66	20.4±2.64	16.5±2.40
Ogbere	387±3.55	373±2.60	0.01±0.00	0.01±0.00	6.84±1.64	6.39±1.60	7.12±3.60	6.90±2.60	24.2±1.63	18.6±1.62
Ilagbe	399±5.63	386±1.65	0.02±0.00	0.01±0.00	6.97±0.60	6.48±2.40	8.16±2.66	8.05±1.63	27.4±2.63	22.8±0.40
Adelokun	422±2.75	406±2.60	0.01±0.00	0.01±0.00	8.43±1.63	7.75±1.40	9.57±2.60	9.17±0.60	24.9±1.61	21.3±1.64
Baaki Ake	416±5.82	403±1.63	0.02±0.00	0.01±0.00	7.54±1.60	7.07±2.60	8.29±1.67	8.11±1.65	27.0±2.67	23.3±0.80
Igodo	412±1.95	392±2.60	0.01±0.00	0.01±0.00	7.75±0.67	7.01±1.30	9.63±1.56	8.45±0.60	26.2±1.68	24.5±1.69
Control	402±5.43	380±1.61	0.01±0.00	0.01±0.00	5.12±1.60	3.42±2.60	5.64±1.69	5.52±1.63	17.2±2.60	19.6±0.91
World Health Organisation [17]	400	400	4	4	25	25	40	40	100	100
Overall Mean	400±10.00	385±2.60	0.01±0.00	0.01±0.00	6.59±2.61	5.97±2.67	7.61±2.60	7.27±2.55	23.0±2.60	19.9±2.61
t test	14.4		2.12		4.34		2.94		3.97	
p value	0.00		0.08		0.00		0.02		0.00	

In the wet season, $PM_{2.5}$ had Isara (15.89±2.40 µg/m^3) lowest and Baaki Ake (29.2±0.59 µg/m^3) highest and among the values across locations. Only Iwaye (16.0±2.50 µg/m^3), Idode (18.2±1.50 µg/m^3), Isara (15.9±2.40 µg/m^3) and Ogbere (19.0±2.00 µg/m^3) were lower than the control (22.6 µg/m^3). Those that were lower than the control were as a result of low production during the wet season [5]. Hence this means that quarry activities affected the neighbouring villages with $PM_{2.5}$. When comparing these values with WHO limit (15 µg/m^3), all were higher than the WHO Limit. There were also significant differences among the values across locations. However, the AQI for $PM_{2.5}$ (wet season) at Iwaye (51.9), Idode (56.4), Isara (51.8), Ogbere (57.8), Ilagbe (68.0), Adelokun (64.7), Baaki Ake (77.9), Igodo (77.3) and control (65.0) are within AQI values of 51 – 100; indicating moderate health.

Moreover, PM_{10} during wet season were between 28.4±3.15 and 51.0±3.13 µg/m^3 for Iwaye and Baaki Ake respectively. Except Iwaye (28.4±3.15 µg/m^3) and Isara (31.4±2.15 µg/m^3), other locations were higher than the control (33.4±0.91 µg/m^3). Therefore, it can be inferred that quarrying increased the PM_{10} of the surrounding environments around the quarries. The WHO Limit (45 µg/m^3) was higher than all the PM_{10} values across the locations with the exception of Ilagbe (46.0±3.15), Baaki Ake (51.0±3.13) and Igodo (49.7±2.17). However, there were significant differences among the values across locations. Oguntoke, et al. [6] reported that the results of their study showed that the highest mean SPM levels among the selected quarries vary between 26.0±1.36 mg/m^3 and 11.03±1.52 mg/m^3. The AQI for PM_{10} (wet season) at Iwaye (26.3), Idode (40.9), Isara (29.0), Ogbere (40.4), Ilagbe (42.6), Adelokun (35.7), Baaki Ake (47.2), Igodo (46) and control (30.9) all are within AQI values of 0 – 50; indicating good health.

The reason why some of the results in Table 3 were below WHO limit (15 and 45 µg/m^3) for $PM_{2.5}$ and PM_{10} respectively is that the sampling was carried out in the nearby hamlet or village; rather than the inwards or immediate frontage of the quarry sites. Hence, the dusts or particulate matters could have settled or subsided before reaching nearby villages. This trend has been observed by several authors including [9, 13] .

The t – test of Particulate Matter in Dry and Wet Season was presented in Table 3; where there were significant differences (variance) among the values of particulate matter; ($PM_{2.5}$ and PM_{10} in the dry season and $PM_{2.5}$ and PM_{10} in the wet season respectively). This implies that the values of the $PM_{2.5}$ and PM_{10} in the dry season were higher than that of the $PM_{2.5}$ and PM_{10} in the wet season. There were significant differences among the values of $PM_{2.5}$ across locations in both seasons. Also, there were significant differences among the values of PM_{10} across locations in dry season and wet season. These results were in agreement with the results obtained by Rikhtegar, et al. [12]; such that the dry season was occasioned by excessive dust deposition.

Table 4 shows the values of gaseous pollutants in dry and wet season. In the dry season, the CO_2 values range between Idode (382.±4.15 µg/m^3) and Adelokun (422±2.75 µg/m^3). Except Igodo (412±1.95 µg/m^3), Baaki Ake (416±5.82 µg/m^3) and Adelokun (422±2.75 µg/m^3) that were higher than the control (402±5.43 µg/m^3); other five locations were lower. This implies that quarry activities reduced the CO_2 of the air composition [14]. However, all these values in all locations were within the WHO Limit (400 µg/m^3) except Adelokun (422±2.75 µg/m^3), Baaki Ake (416±5.82 µg/m^3) Igodo (412±1.95 µg/m^3) and the control. This can be attributed to the anthropogenic activities like bush burning, cooking with firewood, heavy duty vehicular emission and so on that is ongoing in and around these locations. When the CO_2 is out of the limit, it could result in headaches, sleepiness, stuffy air, poor concentration, loss of attention, increased heart rate, slight nausea, drowsiness and poor air.

The CO values were within 0.01±0.00 – 0.02±0.00 µg/m^3 across locations and all the values were within the ambit of the control site (0.01±0.00 µg/m^3) except Ilagbe and Baaki Ake (0.02±0.00 µg/m^3) which means that quarrying does not increase the value of CO content of the air composition. However, all locations were lower than the WHO limit (4 µg/m^3). Peter, et al. [15] reported that the carbon monoxide at a distance of 250 m away from the Akpoha quarry site was 1600 µg/m^3 and at the edge of the quarry (3200 µg/m^3). Moreover, CO is a blood pollutant; it tends to form carboxyl-haemoglobin that prevent oxygen from being converged to the blood stream. More so, it impairs normal breathing and portends serious health implication [11].

Among the NO_2 values, Adelokun was the highest with 8.43±1.63 μg/m^3; while Iwaye was the lowest with 5.15±1.60 μg/m^3. None was lower than the control (5.12±1.60 μg/m^3) which implies that quarrying increased the content of NO_2 of the air composition around quarries. All the values across locations were lower than the WHO limit of 25 μg/m^3. More so, NO_2 is a toxic gas which causes significant inflammation of the airways. Hence, it should not be allowed to exceed the WHO Limit. Peter, et al. [15] asserted that at the Ishiagu quarry site in the dry season, the following values of NOx values were recorded at various distances; edge (40.5 μg/m^3); 250 m (38.5 μg/m^3); 500 m (30.6 μg/m^3); 750 m (15.5 μg/m^3).

SO_2 ranges between 6.44±1.61 μg/m^3 (Iwaye) – 9.63±1.56 μg/m^3 (Igodo) across location and among these; none was lower than the control (5.64±1.69 μg/m^3). This implies that quarry activities increased the amount of SO_2 in the air component around quarries [1]. However, all the SO_2 values across the locations were lower that the WHO Limit (40 μg/m^3). The following values of SOx were recorded in the dry season at the various distances from Ishiagu quarry site by Peter, et al. [15]; edge (90.6 μg/m^3); 250 m (75.5 μg/m^3); 500 m (60.4 μg/m^3); 750 m (25 μg/m^3).

None of the values of the Ozone (O_3) (18.3±1.60 – 27.0±2.67 μg/m^3) were lower than the control (17.2±2.60 μg/m^3). This implies that quarrying affects the O_3 content of the surrounding air component around quarries [14]. All the values from various locations were lower than the WHO Limit (100 μg/m^3). However, excessive ozone in the air can have a serious effect on human health such as breathing problems, asthma, reduced lung function and lung diseases.

In the wet season, the values of CO_2 range between 365.91±2.60 – 405.98±2.60 μg/m^3; with Idode (lowest) and Baaki Ake (highest) respectively and except Idode (366±2.60 μg/m^3), Isara (379±1.67 μg/m^3) and Ogbere (373±2.60 μg/m^3) that were lower than the control (380±1.61 μg/m^3), other five locations were higher. This implies that quarrying during rainy season increased the amount of CO_2 in the air around quarries [1]. However, the CO_2 is an agent of global warming. Hence, it is very dangerous to the environment. None of these values of the CO_2 across locations were higher than the WHO limit (400 μg/m^3) and there was significant difference between the dry and wet season values of CO_2.

The amount of the CO content in the air during wet season around quarries were between 0.00±0.00 – 0.01±0.00 μg/m^3; with Iwaye (lowest) and Igodo (highest) respectively. Except Iwaye (0.00±0.00 μg/m^3) that was lower than the control (0.01±0.00 μg/m^3), other locations were within the frame of control [1]. The implication of this is that quarrying does not affect the CO content of the air around quarries. Comparing these values of CO with WHO Limit (4 μg/m^3) revealed that none was higher. There was no significant difference between the dry and wet season values of CO.

None of the values of NO_2 (4.66±2.10 – 7.75±1.40 μg/m^3) in different locations was lower than the control (3.42±2.60 μg/m^3). This means that quarry activities increased the content of NO_2 in the air during wet season. Moreover, none of the values of different locations was higher than the WHO standard of 25 μg/m^3. According [15], the Ishiagu quarry site in the rainy season recorded the following values of NOx at various distances; (30.2 μg/m^3); 250m (28.5 μg/m^3); 500 m (25 μg/m^3); 750 m (8.6 μg/m^3). The implication of this is that whenever it rains NO_2 in atmosphere, it will definitely react with rain water and form corresponding acid; which is the nitric acid (HNO_3), on getting to the soil that have abundant of metals deposit and free radicals; the acid will react with them and form corresponding salt of nitrate; that could be eventually washed into nearby surface water or leached into the groundwater by rain runoff. In the aftermath that the water bodies containing nitrate is consumed by infants, there is possibility that the nitrate will be absorbed into their blood, prevent O_2 transportation, and can cause a disease called blue baby syndrome or methaemoglobinaemia. There was significant difference between the values of NO_2 in dry and wet seasons. All the values of SO_2 in all locations (6.01±1.61 – 9.17±0.60 μg/m^3) were higher than the control (5.52±1.63 μg/m^3) with no exception [1]. This means that quarry activities increased the content of the SO_2 in the air around quarries during the wet season. All values of SO_2 (6.01±1.61 – 9.17±0.60 μg/m^3) were lower than WHO permissible limit of 40 μg/m^3. The implication of this is that whenever, it rains, the SO_2 will react with rain water and form H_2SO_4 and when it is washed into the nearby surface water and soil; will makes them more acidic. This is very dangerous for consumption, laundry and agricultural purpose. There was significant difference between the values of SO_2 in dry and wet seasons.

Ozone (O_3) ranges between 14.9±2.60 – 24.5±1.69 μg/m^3; with Iwaye (lowest) and Igodo (highest) respectively. Four locations were lower than the control (19.6±0.91 μg/m^3); while four locations were higher [14]. All the values were lower than the WHO limit (100 μg/m^3). The reduction in the values of the O_3 in some locations during the wet season was as a result of low production in those quarries during wet season. There was significant difference between the dry and wet season values of O_3.

The values of gaseous pollutants sampled during dry season were relatively higher than those of wet season. This is because most of these gases will dissolve in the rain water and formed corresponding acids that will eventually be washed down to the soil. Hence, it will make the atmosphere a bit free from all the gases. Also, for the fact that there is no much activities of the quarries during wet season, there is likelihood of less pollution of the atmosphere with these sampled gases [12].

4. CONCLUSION

As regard the air component compounds such as CO_2, only three locations like Adelokun, Baaki ake and Igodo (dry season) were affected and surpassed WHO Limit. In wet season only Idode, Isara, Ogbere were not affected but the rest locations were affected with only Adelokun, and Baaki ake that above WHO limit. CO in all locations were not affected in both seasons with the exception of Ilagbe and Baaki ake but within WHO Limit in dry season. In case of NO_2, all locations were affected in both seasons but within the WHO limit. There were increment in the values of SO_2 in all locations (dry and wet seasons) but within WHO limit. In dry season all locations were affected with increment in O_3 level but within WHO limit; whereas in wet season only four locations were affected namely Ilagbe, Adelokun, Baaki ake and Igodo; the remaining were not affected by the quarry activities. Concerning particulate matter ($PM_{2.5}$ and PM_{10}), the surrounding locations were affected in dry season and higher than their corresponding WHO Limits, with the exception of Iwaye, Isara, and Adelokun (PM_{10}). In wet season the particulate matter of $PM_{2.5}$ affects Ilagbe, Baaki Ake and Igodo and all locations were higher than the WHO Limit, while PM_{10} affected all locations with the exception of Iwaye and Isara and only Ilagbe, Baaki Ake and Igodo were higher than the WHO Limit. The reason why most results in dry season were higher than wet season is not far–fetched. This is because construction and infrastructure sectors that are the major end users of the quarry products are always on break during wet season; hence low patronage of the quarry products and the quarry activities are lesser. It can be concluded that some parameters are outrageous and very dangerous to human health and environment e.g. $PM_{2.5}$ and PM_{10}; while those that are dangerous and within the regulatory limit could become outrageous e.g. CO, NO_2; if care is not taken, they might aggravate to uncontrollable level that could grossly affect the environment and human health.

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