International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Evaluation of Gaseous and Particulate Matter Pollutants Levels in Moribund Cement Company (Nigercem) Nkalagu in Ishielu Local Government Area of Ebonyi State.

Ugah Chukwuemeka Stanley [1], *Ozah Eammanuel O* [2] & *Anyira-Fasanmi Mary Ifeoma*[3]

[1] **Department of Sciences, National Institute of Construction Technology and Management, Uromi, Edo State. s.ugah@nict.edu.ng**
[2] **Department of Sciences, National Institute of Construction Technology and Management, Uromi, Edo State. e.ozah@nict.edu.ng**
[3] **Department of Sciences, National Institute of Construction Technology and Management, Uromi, Edo State. m.anyira@nict.edu.ng**

ABSTRACT

The study investigated the evaluation of some gaseous and particulate matter pollutants level in moribund cement company (NigerCem) in Isielu Local Government Area of Ebonyi State. Cement and quarry companies are significant contributors to air pollution worldwide. In Ebonyi State, the abundance of limestone and other rocks has led to the emergence of numerous quarries in recent years, which have substantially contributed to air pollution in the region. This study aimed to conduct a baseline seasonal assessment of particulate matter ($PM_{2.5}$ and PM_{10}) and selected gaseous pollutants, namely NO_2, NH_3, and CO, at the defunct Nigeria Cement Company (NigerCem) in Nkalagu, located in the Ishielu Local Government Area of Ebonyi State. The levels of these particulate and gaseous pollutants were monitored in real-time using programmable gas and particulate portable monitoring instruments. The results show that the seven-week mean concentrations of $PM_{2.5}$ and PM_{10} at the defunct NigerCem ranged from 4.36 to 6.21 µg/m³ and 5.64 to 7.14 µg/m³, respectively, during the wet season. During the dry season, these concentrations increased significantly, ranging from 90.21 to 110.57 µg/m³ for $PM_{2.5}$ and from 107.86 to 142.14 µg/m³ for PM_{10} across all sampled locations. The mean concentrations of the criteria air pollutants NO_2, NH_3, and CO were 0.11 ± 0.17, 3.00 ± 1.41, and 1.43 ± 0.53, respectively, in the wet season, and 0.20 ± 0.005, 6.57 ± 1.41, and 5.14 ± 1.95 in the dry season. Based on the results from all sampled locations, the concentrations of $PM_{2.5}$ and PM_{10} did not exceed the World Health Organization's (WHO) revised particulate matter standard limit during the wet season. However, they exceeded the WHO standard limit during the dry season. These findings from the defunct NigerCem in Nkalagu will serve as a baseline for future assessments, as there is currently no available literature on this subject. In conclusion, the health of people living in the study area is at risk based on a comparison with the WHO's recently updated standard limits.

Keywords: Air, Gaseous pollutants, Particulate matter, Programmable monitors.

INTRODUCTION

Air is a vital mixture of gases surrounding the earth's surface which provides life to human and its environment. Naturally, air is clean and suitable for respiratory needs. However, industrialization has led to a significant increase in air pollution, compromising air quality and rendering it hazardous for human and animal health. With the existence of industries all over the world today, the air we breathe has been considered unsafe due to some particles and some gaseous substances emitted by these industries, and all these accumulated particles led to air pollution. According to the World Health Organization (2019), air pollution is characterized by the deterioration of air quality, resulting from elevated concentrations of chemical, biological, or physical pollutants, or an undesirable presence of impurities, which disrupt the natural balance of atmospheric constituents. Hsin-yi (2012), pointed out that, 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.

Limestone and granites has played an essential role in building construction in human history and due to the abundant of these earth resources, cement and quarry companies have emerged as one of the leading industries in the world today. Despite their great importance to human race, cement and quarry industries have posed a great danger to human existence. The limestone and granite dust has contributed significantly to the imbalance of the environment; especially in air quality. The rapid increase of quarry industries in Ebonyi State Nigeria has been on the high side. Due to their financial benefits, which serves as one the internally generated revenue in the state. Investigating the effects of quarries on local communities and the environment is essential.

According to El-Abssay *et al.* (2011), cement industries and quarry operations constitute significant sources of environmental degradation, causing harm to flora and fauna. Cement production's major environmental consequences include widespread air pollution through dust and gas emissions, contradicting industry assertions of sustainability (Bilen, 2010). Research has shown that the basic components of cement are calcium oxide, silicon dioxide, (Fell *et* *al.,* 2010). Cement production releases toxic pollutants like heavy metals, dioxins, and gases, causing respiratory problems, genetic issues, blood disorders, organ damage, and cancer (Zeleke *et al.,* 2010).

In most developing countries, serious attention is not given to ascertain the quality of air in a working environment. Ignorance and illiteracy on the part of the workers on the dangers of poor air quality has led to workers carrying out activities in environment that pose health risk to them either on the short-term or long-term exposure.

Since the waste products of a cement plant can negatively impact both human health and environmental quality. There is need to carry out a baseline study of the level of pollutants that can be produced and continue to monitor same when the factory become operational so as to ascertain and control the pollutant level to international recommended threshold.

Exposure to these pollutants can have immediate (acute) or long-term (chronic) consequences, influenced by duration and intensity, with prolonged sulphur pollution notably diminishing plant productivity and quality (Varshney *et al.,* 2009).

Generally, particulate matter's detrimental effects are amplified in the presence of co-pollutants, such as nitrogen oxides and ozone. Sulphur dioxide exposure at the ecosystem level alters species diversity by selectively eliminating sensitive species, leading to reduced primary productivity and disrupted trophic dynamics, with cascading effects on animal and microbial populations. Another indirect effect result is from the acid rain which leaches out nutrients from plant canopy and soil. The acidic run-off changes the pH of the receiving waters and adds large quantities of nutrients which disturb the equilibrium of aquatic communities (Varshney *et al.,* 2009).

A 2018 review by the World Health Organization (WHO) revealed that approximately 90% of the global population breathes air exceeding WHO's recommended safe limits for pollutant concentrations. Globally, it has been recorded that over seven million people die prematurely every year due air polluted related issues. The effects of these air pollutant are critical in Africa and Asia, where 90% of the air pollution related deaths have been recorded (WHO 2018). Pollution index suggested that Asia countries has the highest pollution index while few countries in Africa have no enough data for these analyses. Countries in both regions where data were made available showed pollution index from average to maximum (WHO 2018).

Globally, various pollutants are linked to numerous diseases, with this issue not limited to urban or industrial areas, as evident in Africa. Household air pollution from cooking and fossil fuel combustion, even in rural African regions, significantly contributes to this problem. Different sectors emit distinct air pollutants, with varying regional and national contributions.

Air pollution has emerged as a silent killer, posing one of the greatest environmental threats worldwide, with its covert and far-reaching consequences. The rapidity at which it occurs is so facilitated by the huge capacity and spatial mobility properties of the atmosphere. Air pollution can be defined as the introduction of harmful substances into the environment that is capable of reducing the life sperm of human and its ecosystem. It can also be seen as any biological, physical or chemical alteration to the atmosphere. This air pollution occur when harmful gases, dust and smokes enter into the atmosphere and make it difficult for human, plants and animals to survive as the air become dirty. The identified pollutants comprise gases, particulate matter, and liquids that surpass threshold concentrations, leading to diminished air quality and environmental degradation. (Karagulian, 2015).

Industrial processes constitute a significant source of air pollution, with cement and quarry production being notable contributors. A single cement facility can release substantial quantities of pollutants into the atmosphere. Also variations in production levels, fuel types, usage patterns, and dust control technologies impact the quantity and concentration of contaminants emitted. Notably, cement production is identified as the primary source of particulate matter (PM) emissions, contributing 20-30% of total PM emissions and 40% of industrial emissions. (Sánchez Soberón, 2015). The rapid urbanization of global populations has precipitated a substantial rise in cement demand (Adeniran, *et al.,* 2018).

Human activities are harming the environment by contaminating the essential elements that sustain life, such as the water we drink, the air we breathe, and the soil that nourishes the plants we need. While the industrial revolution brought numerous benefits, including technological advancements, societal improvements, and increased access to services, it also had a detrimental side effect: the massive release of air pollutants that pose significant risks to human health. Undoubtedly, global environmental pollution has emerged as a pressing international public health concern, supported by a multitude of evidence. In today's era, urbanization and industrialization have reached alarming levels globally (Sánchez-Soberón, 2015)

MATRIALS AND METHODS

Study area

Ishielu local government area of Ebonyi state is blessed with abundant mineral resources such as lime stone and granite to mention but few. On the area of the abundance, Ezillo and Nkalagu have abundant deposit mineral resources; this abundant mineral deposit in both communities has attracted many companies such as Nigeria Cement Company.

The Nigeria cement company which has acronym as NigerCem (Nkalagu) was established in 1957 as the first cement plant in Nigeria due to the abundant lime stone deposit in Nkalagu community. The company was used to advance the course of nation building after the country's independent in 1960.

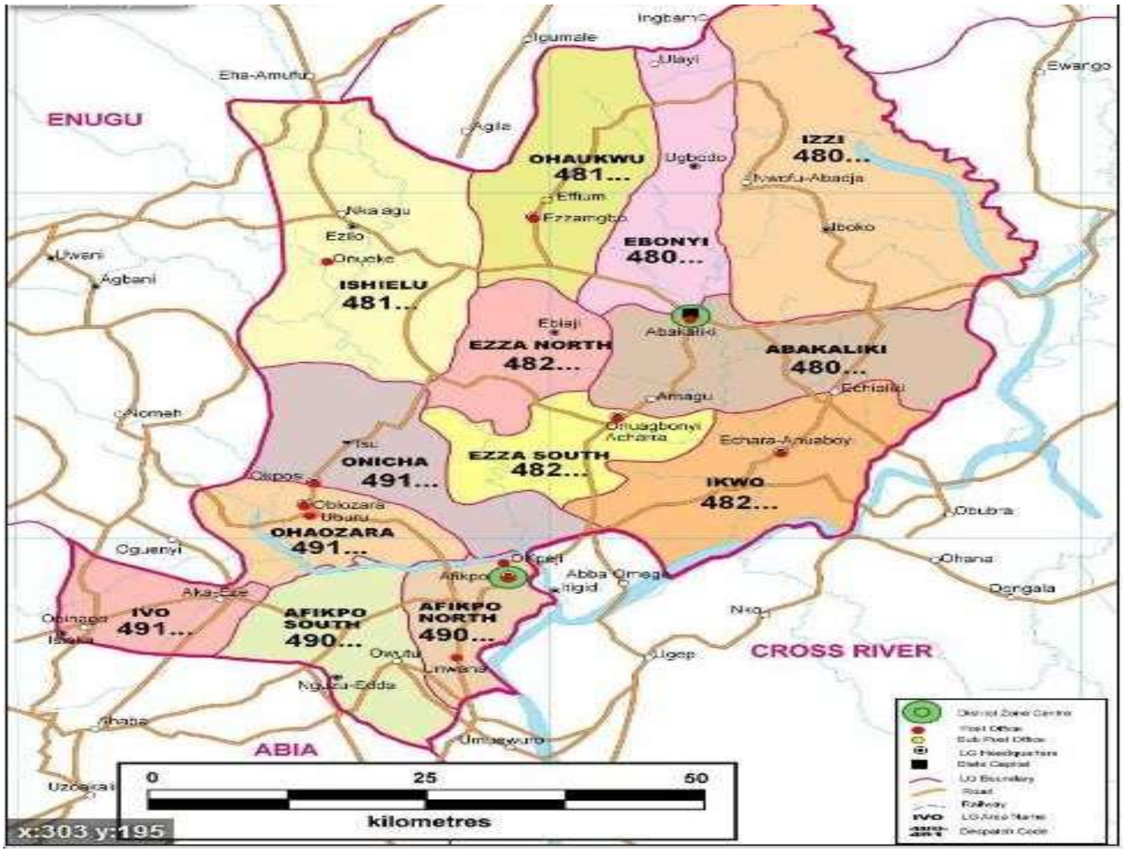

Fig 1: Map of the study area

Site selection

The site selection was done to ensure even coverage of the moribund premises of (Nigeria cement company Nkalagu). The sampling of these pollutants was done during the pink of dry and raining season for a period of seven weeks. A total of five sampling point was selected within the premises.

Sampling of PM ($Pm_{2.5}$ and Pm_{10}) and gaseous pollutants (CO, NH_3 and NO_2).

The concentration of particulate matter with aerodynamic diameter of 10 micrometre or less (PM_{10}) and two and half ($PM_{2.5}$) micrometres in the selected sampling areas of the site were measured using on site digital reads out particulate monitor Diernmern (DM 106) particulate monitor and the gaseous pollutants (CO, NH_3 and NO_2) using Digital Portable Instrument, known as programmable multi-gas monitor (USA make). . At each designated locations, particulate matter ($PM_{2.5}$ and PM_{10}) and gaseous pollutants measurements were obtained by manually holding the instrument approximately 5-6 meter above ground level in ambient air. The reading (results) of each of the parameter were recorded within 3 – 4 minutes of switching on the nub of the instrument. The daily result during the weekly experiment were used to calculate the average mean of the parameter ($PM_{2.5}$, $PM_{10,}$ NO_2, NH_3 and CO) for the wet and dry season, covering a period of seven weeks.

RESULT AND DISSCUSION

RESULTS

The mean concentration of particulate matter of $PM_{2.5}$ and PM_{10} and gaseous pollutants measured in all the study areas during wet and dry season are presented below.

Table 1: The mean concentration of $PM_{2.5}$ and PM_{10} measured during wet season at Nigeria Cement Company (NigerCem) Nkalagu.

Sampling location	Wet Season $PM_{2.5}$ (μg/m^3)	Wet Season PM_{10} (μg/m^3)	Standard Limit WHO	USEPA	NESREA
			$PM_{2.5/10}$	$PM_{2.5/10}$	$PM_{2.5/10}$
NigerCem Junction	4.36 ± 1.01	6.86 ± 1.10	10/15μg/m^3	9/150μg/m^3	20/60 μg/m^3
NigerCem Gate	4.36 ± 0.93	7.14 ± 1.17			
Laboratory Block	4.64 ± 1.01	6.07 ± 1.00			
Quarry Road	6.21 ± 0.98	6.57 ± 0.76			
Residential Block	5.14 ± 1.60	5.64 ± 1.08			

Table 2: The mean concentration of $PM_{2.5}$ and PM_{10} measured during dry season at Nigeria Cement Company (NigerCem) Nkalagu.

Sampling location	Dry Season $PM_{2.5}$ (μg/m^3)	Dry Season PM_{10} (μg/m^3)	Standard Limit WHO	USEPA	NESREA
			$PM_{2.5/10}$	$PM_{2.5/10}$	$PM_{2.5/10}$
			10/15μg/m^3	9/150μg/m^3	20/60 μg/m^3
NigerCem Junction	103.07 ± 36.94	126.93 ± 43.97			
NigerCem Gate	90.21 ± 30.91	107.86 ± 35.25			
Laboratory Block	92.86 ± 36.80	115.79 ± 46.71			
Quarry Road	110.57 ± 72.14	142.14 ± 94.34			
Residential Block	102.29 ± 72.43	123.14 ± 88.2			

Table 3: Mean concentration of (NO_2, NH_3 and CO) measured during wet season at Nigeria Cement Company (NigerCem) Nkalagu.

Sampling location	Wet Season NO_2 (ppm)	Wet Season NH_3 (ppm)	Wet Season CO (ppm)
NigerCem Junction	0.05 ± 0.02	2.86 ± 0.69	1.43 ± 0.53
NigerCem Gate	0.04 ± 0.01	2.14 ± 0.69	0.71 ± 0.49
Laboratory Block	0.05 ± 0.01	0.71 ± 0.49	0.00 ± 0.00
Quarry Road	0.06 ± 0.01	1.71 ± 0.76	0.00 ± 0.00
Residential Block	0.11 ± 0.17	3.00 ± 1.41	0.29 ± 0.49
[a] WHO	0.02	-	9
[b] USEPA	0.02	-	
[c] NESREA	0.04	0.28	4.35

[a]WHO (WHO2021), [b]USEPA (2022), [c]NESREA (2018).

Table 4: Mean concentration of (NO_2, NH_3 and CO) measured during dry season at Nigeria Cement Company (NigerCem) Nkalagu.

Sampling location	Dry Season NO_2 (ppm)	Dry Season NH_3 (ppm)	Dry Season CO (ppm)
NigerCem Junction	0.11 ± 0.07	4.71 ± 1.11	5.14 ± 1.95
NigerCem Gate	0.11 ± 0.07	2.00 ± 0.58	2.71 ± 1.11
Laboratory Block	0.13 ± 0.08	2.14 ± 0.69	1.43 ± 0.53
Quarry Road	0.17 ± 0.07	4.29 ± 0.76	1.86 ± 0.69
Residential Block	0.20 ± 0.08	6.57 ± 1.41	1.57 ± 0.53
[a] WHO	0.02	-	9
[b] USEPA	0.02	-	9
[c] NESREA	0.04	0.28	4.35

[a]WHO (WHO2021), [b]USEPA (2022), [c]NESREA (2018).

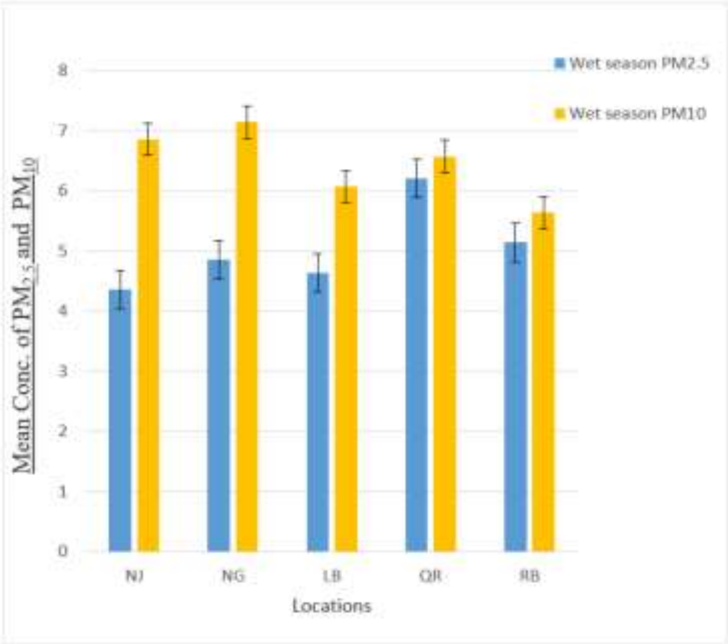

Fig 2: Mean level concentrations of ambient air particulate matter $PM_{2.5}$ and PM_{10} at Nigeria Cement Company during wet season in all sampled locations

The meteorological concentration of particulate matter ($PM_{2.5}$ and PM_{10}) in the sampled location were below the World Health Standard of 10 µg/m^3 for $PM_{2.5}$ and 15µg/m^3 for PM_{10} and Nigeria Environmental Standard and Regulation Enforcement Agency (NESREA) which set the limit of those ambient air quality standard for criteria pollutants and air toxics to 20µg/m^3 for annual, 40µg/m^3 for 24 hours and 60µg/m^3 for annual, 150µg/m^{3}for 24 hours respectively. Both $PM_{2.5}$ and PM_{10} also fall below USEPA particulate matter of 12µg/m^3 for annual and 150ug/m^3 for annual respectively. The maximum concentration value of $PM_{2.5}$ and PM_{10} was recorded at quarry road and NigerCem gate with mean value of 6.21 µg/m^3 and 7.14 µg/m^3 respectively. It was also observed that all the sampled locations do not exceed the new recent review of World Health Organization (WHO, 2021) standard limit of 10 µg/m^3 (annual mean) and 25µg/m^3, 50µg/m^3 (24 hours mean) to 142µg/m^3 respectively.

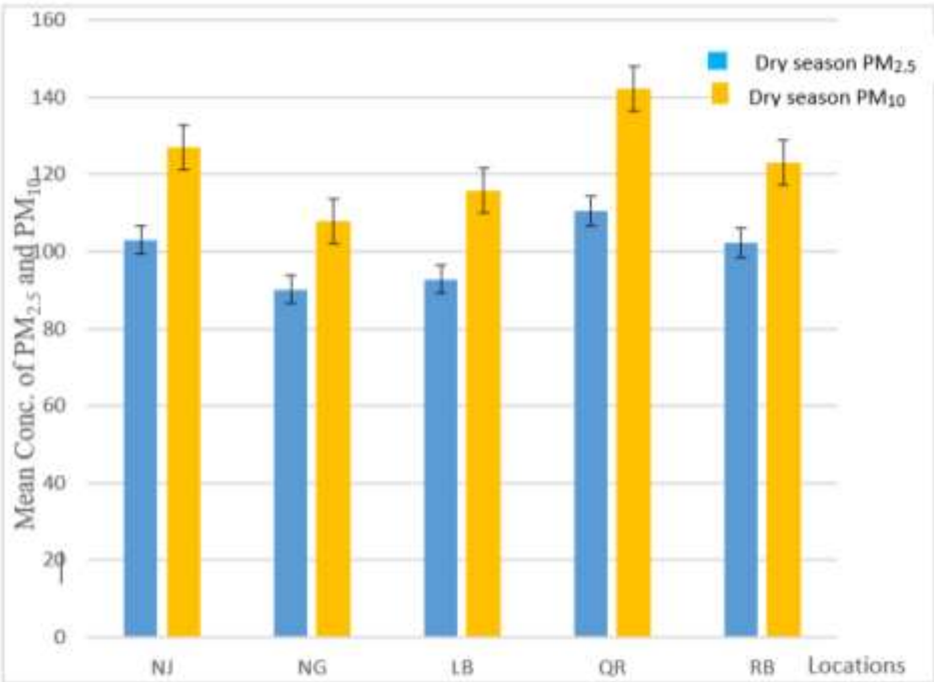

Fig 3: Mean level concentration of ambient air particulate matter $PM_{2.5}$ and PM_{10} at Nigeria Cement Company during dry season in all sampled locations.

The ambient level of particulate matter ($Pm_{2.5}$ and Pm_{10}) measured during the dry season is significantly higher than the wet season result. The maximum mean value of $PM_{2.5}$ and PM_{10} was recorded at Quarry road with mean value 111µg/m^3 and 142µg/m^3 respectively.

Considering the result obtained in all the sampled locations, $PM_{2.5}$ and PM_{10} exceed the recent review of world health organization particulate matter standard limit, and also Nigeria Environmental Standard and Regulation Enforcement Agency (NESREA). All the sampled point of $PM_{2.5}$ exceed the USEPA standard limit of $PM_{2.5}$ of 12µg/m^3 annual average while PM_{10} falls below the standard limit of 150µg/m^3 annual average. This high concentration of particulate matter may be attributed to combination of prevailing weather and metrological conditions within the premises.

1.0 Atmospheric gaseous pollutants (NO_2, NH_3 and CO) analysis at Nigeria Cement Company (NigerCem) Nkalagu.

The cumulative mean concentration of three gaseous pollutants namely, NO_2 NH_3 and CO were measured in five locations within the study area for seven weeks during wet and dry as presented in tables 3 and 4.

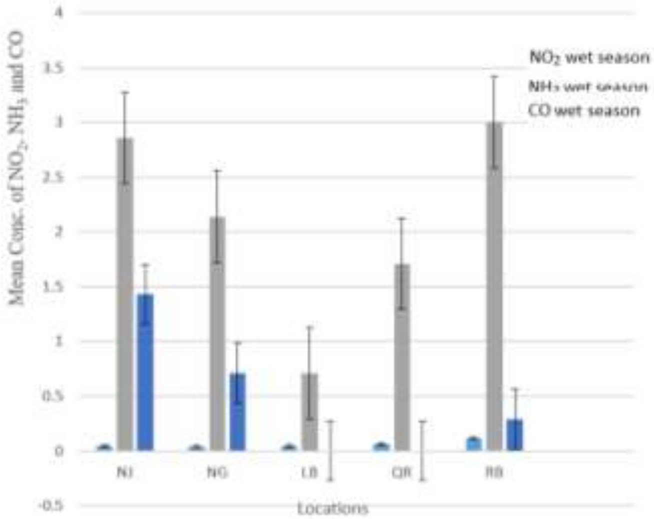

Fig 4: Mean level concentration of all gaseous pollutants sampled in the study area during the wet season at Nigeria Cement Company (NigerCem).

Data obtained from the weekly measurement of air pollutants in the sampled locations for seven weeks during the wet season indicate that the mean concentration of criteria air pollutants ranged from 0.04-0.11, 0.71-3.000 and 0.00-1.64 (ppm) respectively for Nitrogen Oxide (NO_2), Ammonia (NH_3) and Carbon monoxide (CO).

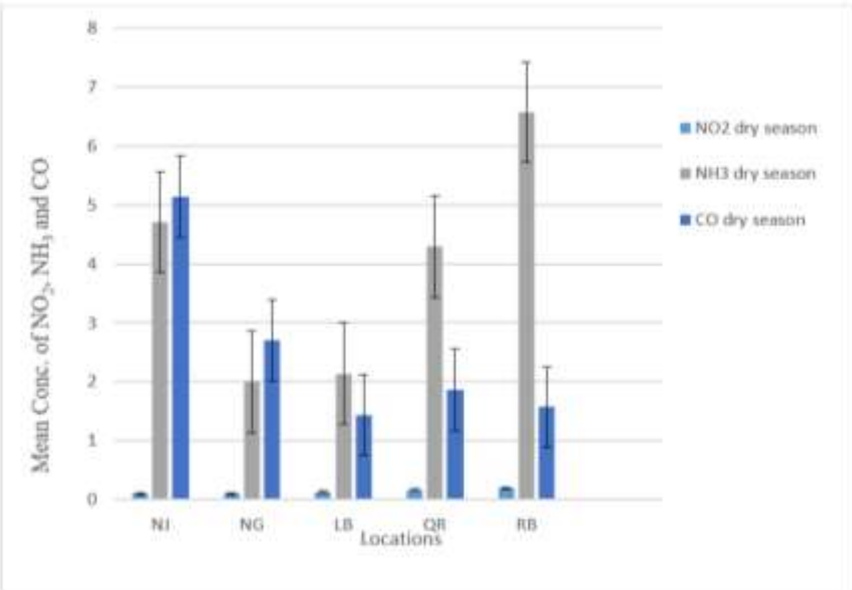

Fig 5: Mean level concentration of all gaseous pollutants sampled in the study area during the dry season at Nigeria Cement Company (NigerCem).

The data obtained during the dry season ranged from 0.11 - 0.20, 2.00 - 6.57 and 1.43 -5.14 (ppm) for Nitrogen Oxide (NO_2), Ammonia (NH_3) and Carbon monoxide (CO) respectively.

1.1 The mean variation of the gaseous pollutants sampled during wet and dry season at Nigeria Cement Company (NigerCem) Nkalagu.

(a) **Nitrogen Oxide (NO_2).**

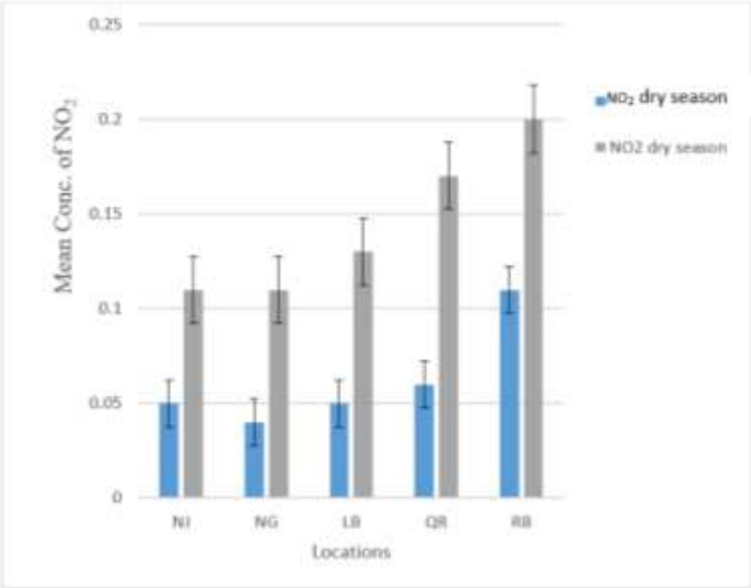

Fig 6: Mean level concentration of NO_2 sampled in various locations during wet and dry season at Nigeria Cement Company (NigerCem).

The mean concentration of NO_2 recorded in seven weeks across the selected location during Net season ranged from 0.04 – 0.11 (ppm) and dry season ranged from 0.11 – 0.20 (ppm).

The concentration of NO_2 in all the location during wet season falls below the world health organization and NESERA standard limit of 0.42(ppm) and 4.09(ppm) for annual average respectively, while few locations maintain the standard limit of National ambient air quality standard (NAAQS) of 0.06 (ppm). Also, during the dry season, all the sampled location falls below the world health organization and NESERA standard limit and above National ambient air quality standard (NAAQS) standard limit of NO_2. The highest concentration of NO_2 during wet and dry season ware recorded at residential block with mean value of 0.11 (ppm) and 0.20 (ppm) respectively. With the high increase of NO_2 in the study area, the host community will be prone to both short-term and long-term exposure of this pollutant which may lead to lung dysfunction, allergic air way inflammation pulmonary function.

(b) Ammonia (NH_3)

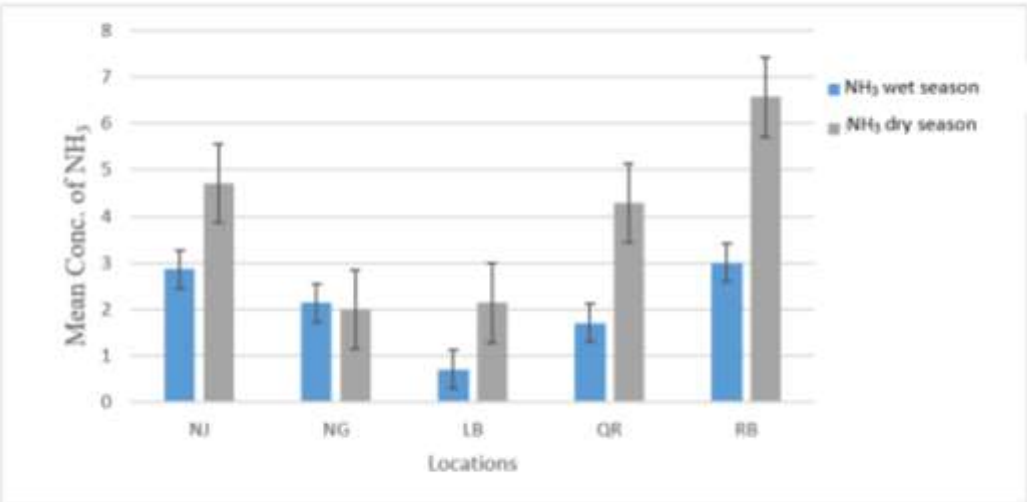

Fig 7: Mean level concentration of NH_3 sampled in various locations during wet and dry season at Nigeria Cement Company (NigerCem).

The levels of ammonia recorded across the various location in seven weeks during wet and dry season ranged from 0.11 – 3.00 ppm and 2.00 – 6.57 ppm respectively. All the NH_3 sampled in all the locations during wet and dry season exceed the NESERA standard limit of 0.14 ppm are annual and 0.42 ppm for 24 hours. The maximum concentration of NH_3 during wet and dry was recorded at the residential block with average mean value of 5.00 ppm and 6.57 ppm respectively. Ammonia is not regulated as criteria air pollutants in the world, since there is no international threshold limit for ammonia in ambient air. The level of ammonia recorded within the moribund cement company may be attributed due to some refuse during around the residential area and agricultural activities such as (faming) going on in the study area, since research has proven that over 70% of ammonia emission comes from agriculture, with around two-thirds coming from livestock one – third from fertilizer and other biomass combustion. With the exceeding of NH_3 in the study area, it implies that dwellers within the residential block will be exposed to this ammonia gas pollutant in both short-term and long term exposure.

(C) Carbon Monoxide (CO)

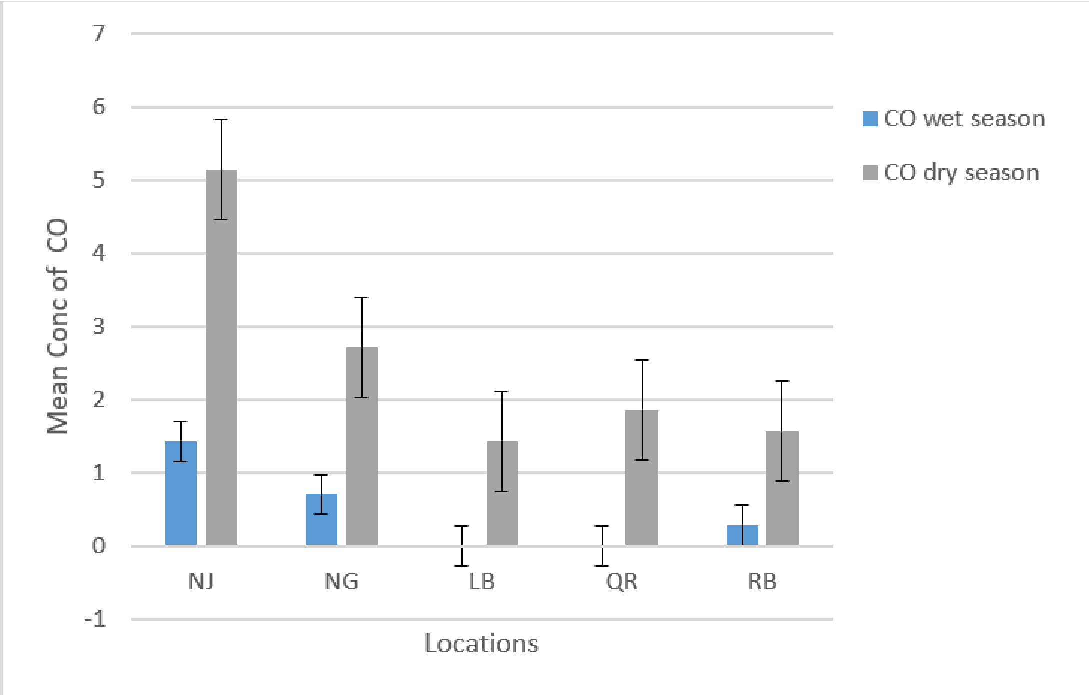

Fig 8: Mean level concentration of CO sampled in the various locations during wet and dry season at Nigeria Cement Company (NigerCem).

The carbon monoxide obtained in the study area during wet and dry season was relatively low to WHO, USEPA and NESERA standard limit of 10 ppm, 25 ppm and 4.08 ppm respectively limit with mean value of 5.14ppm during the dry season. During the wet season, laboratory block and quarry road recorded no presence of carbon monoxide throughout the seven weeks monitoring. The maximum carbon monoxide of 1.43 ppm and 5.14 ppm mean concentration was recorded at NigerCem Junction in both season respectively. This high concentration in both season may be attributed to vehicular movement within the sampling location which is almost five-hundred meters away from the laboratory block and quarry road that recorded zero carbon monoxide emission. Generally, since the emission rate of carbon monoxide is relatively low in the study area, the dwellers or host communities might not be exposed to this pollutants both in short-term and long-term, considering the fact that carbon monoxide is a primary pollutant which has been linked to premature death and cardiovascular.

6.2 Conclusion

Air particulate and gaseous pollutants were present in the particulate matter ($PM_{2.5}$ and PM_{10}) and gaseous pollutants (NO_2, NH_3 and CO) sample obtained from the vicinity of moribund Nigeria Cement Company (NigerCem) Nkalagu and its environs. The particulate matter ($PM_{2.5}$ and PM_{10}) result from the Nigeria Cement Company were below the standard limit of the regulated agencies cited in study during wet season.

REFERENCES

Adeniran, J.A., Yusuf, R.O., Fakinle, B.S., and Sonibare, J.A. (2018). Air quality assessment and modelling of pollutants emission from a major cement plant complex in Nigeria.*Atmos Pollut Res* 10: 257–266

Bilen, S. (2010). Effect of cement dust pollution on microbial properties and enzyme activities in cultivated and no-till soils.*Afr.J. Microbial. Res.,* 4: 2418 – 2425.

El-Abssay, A.A., Hassanien, M.A., Ibrahim, Y.K., and Abdel-Latif, N.M. (2011). Health risk assessment of workers exposed to heavy metals in Cement Klin Dust (CDK). *J.Am.Sci.,* 7: 308 – 316.

Fell, K.M.A., Sikkeland, L.I.B., Svendson, M.V., and Kongerad, J. (2010*)*. Airway inflammations in cement production workers. *Occup. Environ. Med.*, 67: 395 – 400.

Hsin-Yi, C. (2012). The impact of quarrying. Retrieved December 14, 2012, from www.sustainablefloors.co.uk Last, J. M. (1998). *Public health and human ecology* (2nd ed.): 153 – 200.

Karagulian (2015). Contributions to cities' ambient particulate matter (PM): a systematic review of local source contributions at global level. *Atmos Environ* (120): 475 – 483

Sánchez-Soberón (2015): Main components and human health risks assessment of PM_{10}, $PM_{2.5}$, and PM_1 in two areas influenced by cement plants. *Atmos Environ* 120:109 –116.

Varshney, C.K, Garg, J.K, Lauenroth, W.K, and R.K.Heitschmidt (2009). Plant response to sulfur dioxide pollution. 27 – 49.

WHO (2019). Review of Evidence on Health Aspect of Air Pollution-REVIHAAP Project. Bonn, World Health Organisation, Regional Office for Europe.

WHO (World Health Organization) (2021), Air Quality Guidelines. Global Update Geneva, Switzerland.

WHO (2018). Health Effects of Particulate Matter: Policy Implication for Countries in Eastern Europe, Causcas and Central Asia. Copenhagen, World Health Organisation, Regional Office for Europe.

Zeleke, Z.K., B.E. Meon and M. Bratveit, (2010). Cement dust exposure and acute lung function: A cross shift study. *BMC. Pulmonary Med*., 10: 19 – 19.