Assessment of Variations in Air Quality in Wet & Dry Seasons: A Case Study of Borokiri, Port Harcourt, Nigeria

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Abstract: **This study measured the criteria air pollutants of Borokiri and its environs in order to evaluate the air quality level of the area in comparison with the WHO guidelines/acceptable limits. A portable gaseous emission analyzer, the BOSEAN Gas Detector, which collects and stores data independently was used for the measurement of ambient air quality. The Suspended particulate matter was measured with an EGVOC SPM Monitor, which operates by counting and sizing the number of particles in the air. The measurements were done for both dry and wet season at different times during these seasons. From the findings, only the ozone (O_3) level is safe enough within the study area, with respect to the WHO guidelines. All the other pollutants are highly unsafe for the people of the study area. The particulate matter mean concentrations (both $PM_{2.5}$ and PM_{10}) were lower in wet season compared to dry season. This was attributed to the time of data collection during the wet season, which was during the COVID-19 lockdown, with little or no activities going on in the study area. The rain effect could also have washed down the pollutants.**

Keywords: **Air quality, WHO, Borokiri, Criteria air pollutants, Dry season, Wet season.**

I. INTRODUCTION

Individuals in Port Harcourt in Rivers State, Nigeria, and its environs have since the last quarter of 2016 been encountering adverse environmental impacts of particle contamination. This "twofold air contamination burden"- the yet to be resolved prevailing air contamination and the "additional" development of particle contamination, which a source of environmental wellbeing risk, prompted protests over government inaction in certain areas of the state. In February 2017, a couple of months following the beginning of the contamination, the government declared an Emergency, and set up a Task Force to explore and discover an answer for the issue. Worldwide study stated that particle contamination corresponds decidedly with a range of morbidities and an expanded danger of mortality among exposed populaces.

In spite of the fact that everybody is exposed to some degree of air contamination in the course of their life, there are a few groups of individuals who are more inclined to encounter negative health impacts, including the young, the old and chronically sick. Because of their feeble vulnerable immune systems, these groups are viewed to be defenseless to respiratory and cardiovascular health impacts, identified with both long and momentary exposure to air toxins (Rückerl *et al*., 2011). For instance, individuals who experience long term exposure to vehicle emissions have an expanded risk of asthma (Gehring *et al*., 2010) and higher frequencies of wheezing (Ryan *et al*., 2009). With individuals spending a larger piece of their time at working environments, the exposure of individuals to these harmful poisons ought to be evaluated by measuring the concentration of contaminants.

It is obvious from the literature that most existing researches concentrated on large scale conditions with enormous testing site distances; anyway measurement of these contaminants in miniature size conditions, like working environments, is inadequate. It is imperative to comprehend changes in the degree of toxins, so as to evaluate exposure to these contaminants inside a given microenvironment. Thus, there is a need to evaluate and quantify the ambient concentration of these contaminants in micro scale environments and this was the focal point of this paper. This paper assessed the air quality and the degree of cncentrations of criteria air pollutants in the study region as against WHO standards and acceptable limits.

II. CONCEPTUAL REVIEW

The WHO (2005) Air quality guidelines provide worldwide direction on limits and cutoff points for key air contaminants that present health threats. The Guidelines show that by decreasing particulate matter (PM_{10}) contamination from 70 to 20 micrograms for every cubic meter ($\mu g/m^3$), it is feasible to reduce air contamination-based deaths by approximately 15%.

The WHO standards are applicable globally and depend on specialists' assessment of current scientific proof for:

- Particulate Matter (PM)
- Ozone (O_3)
- Nitrogen Dioxide (NO_2)
- Sulfur Dioxide (SO_2).

Particulate matter (PM)

PM is a typical proxy marker for air contamination. It impacts on a larger number of individuals than other contaminants. The significant make up of PM are sulfate, nitrates, ammonia, sodium chloride, black carbon, mineral dust and water. It comprises of a complex combination of solid and fluid particles of organic and inorganic substances suspended in the air. While particles with a size of 10 microns or less, ($\leq PM_{10}$) can enter and hold up somewhere inside the lungs, the significantly more health harming particles are those of 2.5 microns or less in size, ($\leq PM_{2.5}$). $PM_{2.5}$ can infiltrate the lung barrier into the blood system. Chronic exposure to particles adds to the risk of having cardiovascular and respiratory infections, as well as lung cancer.

Air quality estimations are normally reported as daily or yearly mean concentrations of PM_{10} particles per cubic meter of air volume (m^3). Routine air quality estimations normally portray such PM concentrations as micrograms per cubic meter ($\mu g/m^3$). At the point when adequately sensitive estimation devices are accessible, concentrations of fine particles ($PM_{2.5}$ or smaller), are likewise reported. There is a close, quantitative connection between exposure to high concentrations of smaller particulates (PM_{10} and $PM_{2.5}$) and expanded mortality or morbidity, both daily and over the long run (WHO, 2005).

Ozone (O_3)

Ozone at ground level – not to be mistaken for the ozone layer in the upper atmosphere – is one of the significant constituents of photochemical smog. It is made by the reaction with sunlight (photochemical reaction) of contaminants like nitrogen oxides (NO_x) from vehicle and industry emissions and volatile organic compounds (VOCs) produced by vehicles, solvents and industry. Accordingly, the most significant levels of ozone contamination happen during times of sunny climate. Unreasonable level of ozone in the air can markedly affect human wellbeing. It can lead to problems with breathing, trigger asthma, diminish lung capacity and cause lung infections.

Nitrogen dioxide (NO_2)

As an air contaminant, NO_2 has a number of connected activities. At short-term, concentrations surpassing 200 $\mu g/m^3$, it is a poisonous gas, which causes huge inflammation of the airways.

NO_2 is the principal source of nitrate aerosols, which form a significant part of $PM_{2.5}$ and, within the sight of ultraviolet light, of ozone. The significant sources of anthropogenic emissions of NO_2 are combustion processes (heating, power generation, and engines in vehicles and boats).

Epidemiological investigations have demonstrated that signs of bronchitis in asthmatic kids elevate in relation to long term exposure to NO_2 (WHO, 2005).

Sulfur dioxide (SO_2)

SO_2 is a colourless gas with a sharp smell. It is derived from the combustion of fossil fuels (coal and oil) and the purifying of mineral ores that has sulfur component. The principal anthropogenic source of SO_2 is the combustion of sulfur-containing fossil fuels for domestic heating, power production and motor vehicles. SO_2 has the capacity to impact on the respiratory system and the functions of the lungs, and leads to irritation of the eyes. Inflammation of the respiratory tract leads to coughing, bodily fluid secretion, aggravation of asthma and chronic bronchitis and makes individuals more inclined to diseases of the respiratory tract. Clinic admissions for heart disease and mortality elevates on days with higher SO_2 levels. When SO_2 mixes with water, it forms sulfuric acid; this is the principal component of acid rain, which is a cause for deforestation (WHO, 2005).

WHO Air quality guideline values

Fine particulate matter ($PM_{2.5}$)

10$\mu g/m^3$ annual mean

25 $\mu g/m^3$ 24-hour mean

Coarse particulate matter (PM_{10})

20 $\mu g/m^3$ annual mean

50 $\mu g/m^3$ 24-hour mean

O_3

100 $\mu g/m^3$ 8-hour mean

NO_2

40 $\mu g/m^3$ annual mean

200 $\mu g/m^3$ 1-hour mean

SO_2

20 $\mu g/m^3$ 24-hour mean

500 $\mu g/m^3$ 10-minute mean (WHO, 2005).

III. METHODOLOGY

Study Area

Borokiri is a community within the city of Port Harcourt. It is located south of Old Port Harcourt GRA, Rivers State, Nigeria. It is situated at latitude 4.749° N and longitude 7.035° E. The location is surrounded by Ahoada Street to the north, Okrika Island to the east, Orubiri oilfield to the south and Ship Builders Road to the west. The map of Borokiri is shown in Figure 1:

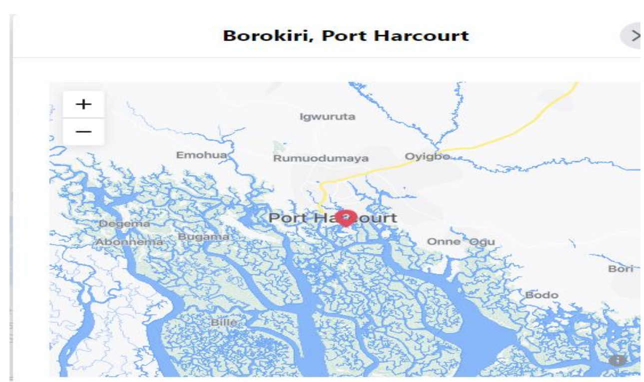

Figure 1: Map of Borokiri

Gaseous Emission / Ambient Air Quality

A portable gaseous emission analyzer, the BOSEAN Gas Detector, which collects and stores data independently was used. Features include a menu driven user interface and LCD display. The meter is manufacturer calibrated and also has self-auto calibration. Gaseous Pollutants are monitored continuously by pulsed fluorescence. In this method, air is drawn through a sample chamber where it is irradiated with pulses of ultra-violet light. Any specified gas of interest in the sample is excited to a higher energy level and upon returning to its original state, light or fluorescence is released. The amount of fluorescence measured is proportional to the gas concentration.

Suspended Particulate Matter (Spm)

Optical Method

The Suspended particulate matter was measured with an EGVOC SPM Monitor. This hand held Aerosol particle counters operates by counting and sizing the number of particles in the air.

The measurements were done for both dry and wet season at different times during these seasons. The mean of the readings were taken for each season and were compared against WHO guidelines. All units were converted to μg/m^3 (1 ppm = 1,000 μg/m^3).

IV. RESULTS

Table 1: Wet and Dry Seasons Concentrations of Criteria Air Pollutants in the Study Area

Location : Borokiri N04^{0}45'32.0" E007^{0}01'31.5"														
Parameters	Dry Season									Wet Season				
					3:00pm	3:30pm	4:00pm	4:30pm	Average	9:15am	9:45am	10:15am	10:45am	Average
So$_x$, (Ppm)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
No$_x$ (Ppm)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ozone (O$_3$) (Ppm)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Particulate Matter Pm$_{2.5}$ (μg/M^3)	53	43	34	40	76	93	86	83	63.6	32	16	24	15	21.7
Particulate Matter Pm$_{10}$ (μg/M^3)	60	48	38	54	87	104	99	96	73.3	37	18	28	17	25

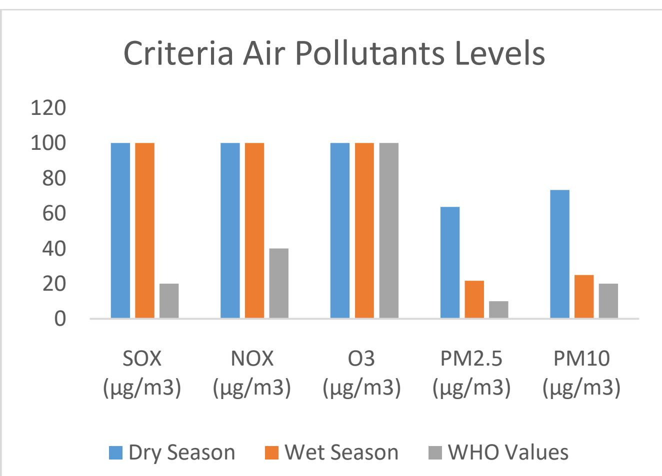

Figure 2: Mean Concentrations of criteria air pollutants in dry and wet season in Borokiri in comparison with WHO guideline values

V. DISCUSSION

From Figure 2, only ozone (O_3) for both dry and wet seasons was within the WHO limits. Sox for both wet and dry seasons were above the WHO limit by 80%; NOx for both wet and dry seasons were above WHO limits by 60%. The average concentration of $PM_{2.5}$ in dry season was above the WHO limits by 84.3, whereas in wet season, the mean concentration of $PM_{2.5}$was higher than the WHO standard by 53.9%. The mean concentration of PM_{10} in dry season was higher than the WHO limits by 72.7% and the wet season mean concentration of PM_{10} was higher than the WHO limits by 20%. In terms of the air quality, once any of the criteria air pollutants is high, the air quality is unsafe for the people. It does not matter which of the criteria pollutants is within the WHO guidelines, if any of the pollutants is higher than the WHO standard, then the overall air quality is unsafe.

VI. CONCLUSION

From the findings, only the ozone (O_3) level is safe enough within the study area, with respect to the WHO guidelines. All the other pollutants are highly unsafe for the people of the study area. The particulate matter mean concentrations (both $PM_{2.5}$ and PM_{10}) were lower in wet season compared to dry season. Though both wet and dry seasons mean concentrations of both $PM_{2.5}$ and PM_{10} are unsafe for the people who reside within the study area.The overall lower values of the pollutants recorded in the wet season could be attributed to the time of data collection in the wet season. The data were collected during the peak of COVID-19 lock down, when no activities were going on. Hence, the sources of the pollution were not operational during this time. Also, the effect of rain fall could have washed down the pollutants' levels.

Despite some of the measurements for this study being taken during the peak of COVID-19 lockdown period, it was recorded that the level of criteria air pollutants were still high compared to WHO acceptable limits. This observation can be attributed to the elevated presence of soot in the city as a result of illegal refining activities in Port Harcourt City.

In 2019, the government of Rivers State Nigeria evaluated the air quality of Port Harcourt and the likely sources of air pollution in the city. Part of the findings of that study was that the sources of air pollution in Port Harcourt included: artisanal refining, emissions from asphalt plants, indiscriminate burning of mixed waste, burning of tyres and vehicular emissions. With the exception of vehicular emissions, all the other sources of air pollution were still ongoing even during the COVID-19 lockdown because majority of them were from the activities of the residents.

It is also noteworthy that some essential services were exempted during the lockdown period. This category of services were allowed to operate during the lockdown and one of such services is the petrochemical industries. Port Harcourt city has two major petrochemical companies who are into fertilizer production and part of the operations involve burning activities. All these must have contributed to the high level of the criteria air pollutants recorded in this study during the COVID-19 lockdown. Next steps would be to ascertain how best to reduce the criteria air pollutants from their sources.

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