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DIURNAL VARIATION OF AIR QUALITY IN PORT HARCOURT CITY LOCAL GOVERNMENT AREA, RIVERS STATE

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Abstract
An investigation to assess the diurnal variation in ambient air quality in selected areas of Port Harcourt City Local Government Area (PHALGA) was carried out. Five sample sites (Borokiri, Lagos Bus-Stop, Mile One, Old GRA and Amadi roundabout) were purposively chosen to cover the major zones that make up the Local Government Area. The portable Aeroqual 200/300 series and Aeroqual $PM_{2.5/10}$ were used for the determination of gases and particulate matter respectively. The assessment was carried out morning and evening (in each visit), twice monthly for two months (November and December 2019). The results obtained (Mean±SD) in µg/$m^3$for morning/evening are, Ozone (0.063±0.017/0.039±0.022), Methane (13.80±4.54/ 9.75±5.67), Carbon Monoxide (0.080±0.051/0.094±0.043), Carbon Dioxide (840.450±181.293/836.300±303.929), Ammonia (0.120±0.011/ 0.100±0.031), Hydrogen Sulphide (0.044±0.015/ 0.028±0.020), Volatile Organic Carbon (8.715±1.704/ 9.850±5.021),PM_{10} (0.052±0.009/ 0.024±0.007). The observed results showed a significant variation between morning and evening values but both fell within the permissible limits of the World Health Organization, United States Environmental Protection Agency and National Environmental Standards and Regulations Enforcement Agency (NESREA) meaning that the air in Port Harcourt Local Government Area is relatively free of pollutants. However, it is recommended that air quality monitoring should be carried out periodically and extensively to forestall a possible health hazard in the case of a relapse of the present status into a full-blown pollution

Keywords: Diurnal variation, Air quality, Port Harcourt City Local Government Area, Rivers State

Introduction

Air is a mixture of gases, liquids, and solid particles and is a natural resource vital to man. The quality of air is determined by the uses made of air and by the pollution injected into it by man. Clean air is an important aspect of quality of life. Therefore, as population growth, urbanization, industrialization, and the number of vehicles and other sources increase, the impact of air pollution on the quality of life becomes more obvious and notable (Akhionbare, 2009). A recent publication by the World Health Organization, (2019) indicates that urban outdoor air pollution increased by 8% between 2008 and 2013 globally and that air pollution is responsible for an estimated 7 million deaths annually or one in eight premature deaths every year (African Clean up Initiative, 2019). The United Nations (UN) environmental view of global air pollution published by the African Clean up Initiative, (ACI, 2019) also state that each year 6.5 million people die prematurely because of poor air quality and 2 million deaths are recorded every year as a result of indoor air pollution, where 800,000 of these are children below the age of five. Similarly, Magaji et al. (2015) have shown that breathing polluted air all year round can shorten life by one to three years and also damage our environment.

The air quality status of Port Harcourt City Local Government Area (PHALGA) of Rivers State in the Niger Delta region of Nigeria has been a major problem/concern confronting the various levels of government (Tawari et al., 2012). Especially with the appearance of carbon black (black soot) in the air environment of Port Harcourt city, which has become a source of worry to all stakeholders in recent times (Renner et al., 2017; Yakubu, 2017; Akindejoye, 2018) due to its adverse health consequences.

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Since November 2016, Port Harcourt has been affected by 'strange black soot' of a relatively unknown source (The Guardian, 2017). A joint study in 2020 by both Federal (including NESREA officers) and State authorities has affirmed the severity of the black soot in Port Harcourt and its environs and implicated illegal refining (commonly called kpo-fire), destruction/burning of illegally refined petroleum products by security personnel, burning of the tyre, gas flaring, activities of asphalt plants and the use of tyres to process the skin of slaughtered animals in abattoirs as contributory factors (Ibiene, 2020).

Aim and Objectives of the study

This study was therefore carried out with the intent of determining the influence of diurnal perturbation (if any) on the present air quality status of Port Harcourt City Local Government Area. Specifically, the objectives of the study are to:

1. determine the concentration of gases in the morning
2. determine the concentration of gases in the evening

Materials and Methods

Five (5) sampling stations covering the entire Port Harcourt City Local Government Area were purposively selected, taking into cognizance the different land-use patterns.

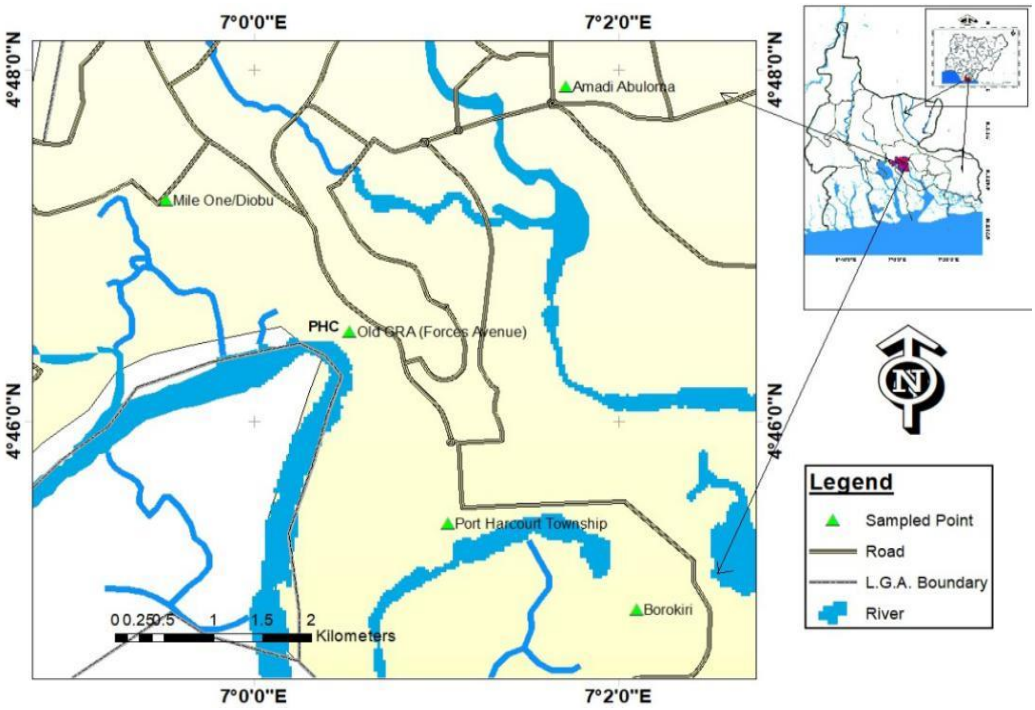

Fig 1: Map of Port Harcourt City showing the Sampling Points

The five (5) sampling locations and their geographical coordinates in Port Harcourt City Local Government Area (PHALGA) of Rivers State are **(1)**Borokiri axis (Back of Comprehensive School): 04^0 44' 17"N &07^0 02' 01"E, **(2)**Port Harcourt Township (Lagos Bus stop): 04^0 45' 42"N & 07^0 01' 07"E, **(3)**Old GRA (Forces Avenue): 04^0 46' 51"N &07^0 0' 53"E, **(4)**Mile 1/ Diobu axis: 04^0 47' 26"N & 06^0 59' 52"E, and **(5)** Amadi ama- Abuloma axis (Amadi round about): 04^0 47' 46"N & 07^0 01' 37"E

The air quality assessment (covering gases and particulate matter) was carried out twice daily (morning and evening/night) every 2 weeks between November and December 2019. The Aero Qual 200/300 series equipment (lightweight, easy-to-use noxious gas detector for obtaining outdoor and indoor air quality of an environment) was used to measure the concentration of noxious gases. Each of the gases of interest (ozone, methane, carbon monoxide, volatile organic compounds, hydrogen sulphide, carbon dioxide, and ammonia) has its own sensor. The Aeroqual series 200/300 when fitted with a particular sensor of interest was switched on and held or placed about 2m above the ground level to avoid any form of obstruction, it was allowed for about 3 minutes for

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processing, after which the concentration was read off on the screen and recorded. AeroQual PM2.5/10 a portable particle counter was also used to check the particulate matter in the air by fitting the sensor of interest as it is programmed to measure particle sizes of 2.5 and 10 microns respectively, depending on the sensor. It was also switched on and held or placed about 2m above the ground level to avoid any form of obstruction, allowed for about 3 minutes for processing after which the concentration was read off on the screen and recorded. The results recorded are shown in Table 1.

Results

Table 1: Results of Air Quality Parameters of Port Harcourt City Local Government Area (PHALGA) in Rivers State during the Period of Study.

S/NO	PARAMETER ($\mu g/m^3$)	MORNING ASSESSMENT		EVENING ASSESSMENT	
		RANGE	MEAN± SD	RANGE	MEAN± SD
1.	OZONE	0.048-0.090	0.063±0.017	0.00-0.055	0.039±0.022
2.	METHANE	9.75- 20	13.80±4.54	5.5- 19.5	9.75±5.67
3.	CO	0.00-0.1275	0.080±0.051	0.030-0.150	0.094±0.043
4	CO_2	667- 1125.75	840.450±181.293	582- 1260.5	836.300±303.929
5	NH_3	0.1-0.125	0.120±0.011	0.075-0.15	0.100±0.031
6	H_2S	0.023-0.063	0.044±0.015	0.00-0.055	0.028±0.020
7	VOC	7.15-11.525	8.715±1.704	4.525- 17.45	9.850±5.021
8	PM_{10}	0.038-0.062	0.052±0.009	0.019-0.035	0.024±0.007

The result shows that the mean values of all the gases are higher in the morning except for CO and VOC which were found to be higher in the evening

Discussion of findings

Carbon dioxide was recorded as the most abundant gas in the study area with a mean value of 840.450±181.293 in the morning and 836.300±303.929 $\mu g/m^3$ in the evening. The observed mean values for carbon dioxide in this investigation fell within the wider range of 446 - <<5000 $\mu g/m^3$ recorded by Nwachukwu et al. (2012) in their assessment of the effect of air pollution on Rivers people. It is however much higher than the range of 2.16 – 7.33ppm recorded in an environmental impact assessment on the Benisede Catchment Area Field Development Plan (FDP) Phase II by Shell Petroleum Development Company, (2005). This disparity conforms with an earlier observation of Chris, (2018) that deforestation and industrialization contribute to the heightening of carbon dioxide, which could lead to a variety of health effects and also contributes to air pollution in its role in greenhouse effects. The analysis of variance (ANOVA) between periods (morning and evening) of sampling shows that there is a significant difference at $p < 0.05$ but no significant variation across stations.

The mean hydrogen sulphide values are 0.044±0.015 $\mu g/m^3$ and 0.028±0.020 $\mu g/m^3$ for morning and evening, respectively. From the investigation of Ugbebor et al. (2019) on 'Assessment of air quality and its health implications on Abuja campus residence, University of Port Harcourt, Nigeria', the hydrogen sulphide concentration range of 0.25 - 0.38 was recorded. Similarly, Nwokocha et al. (2015) in their study on the measurement, survey and assessment of air quality in Port Harcourt South-South reported a mean value of 0.268 and Maduforoh (2019) in his inquiry on the impact of dumpsites on air quality in Nigeria (a case study of Port Harcourt metropolis) reported a range of 0.40-0.92. The concentrations of hydrogen sulphide reported are all above/ higher than the range observed in this present study, while that (3.2-780) of Nwachukwu et al. (2012) is significantly higher. The analysis of variance (ANOVA) between periods of sampling showed a significant difference at $p < 0.05$ however across stations there was no significant variation.

Results recorded for Ozone ranged from 0.039±0.022- 0.063±0.017 $\mu g/m^3$ across stations and periods of sampling, this is comparable to the range of 0.04-0.10$\mu g/m^3$as reported by Ishaya et al. (2017) in their investigation on urbanization gradient in Apo District of FCT, Abuja. The low magnitude of ozone observed in this investigation corroborates the earlier assertion by Greenfacts (2016) that the study area with human presence and or activities result in the reduction of ozone in the atmosphere which is expected because ozone unlike other air pollutants tends to be lower in urban areas as it disappears when it reacts with other pollutants such as nitric oxide. It also reveals that the concentrations of ozone in the atmosphere during the morning hours are generally higher than the corresponding evening values. The analysis of variance (ANOVA) between the morning and evening of sampling revealed that there is a significant difference at $p < 0.05$.

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During the period of investigation, the mean concentration of Methane varied from 9.75±5.67 - 13.80±4.54 µg/m^3in the evening and morning respectively, which reveals that the concentration of methane in the atmosphere during the morning hours is generally higher than the corresponding evening values across all locations. However, the observed mean values are lower than the range of 21.25-32.50µg/m^3 recorded by Ugbebor et al (2019) as well as the permissible limits of the reference air quality standard. The observed difference could be a result of varying prevalent activities in the study areas and differences in the time and season of sampling. There was significant variation between the period of sampling at $p < 0.05$ level of confidence.

The mean concentration of NH_3 in the study area throughout the investigation varied from 0.100±0.031 in the evening to 0.120±0.011 µg/m^3 in the morning across stations though NH_3 was not recorded in all the stations in both morning and evening assessments on the first day of investigation. The concentration of ammonia observed in this study compares favourably with the range and mean values of 0.15 - 0.19 and 0.81µg/m^3 recorded respectively by Nzekwe (2014) and Nwokocha et al. (2015). Similarly, the observed values of this study fall within the range of 0.00-1.63µg/m^3 recorded by Ugbebor et al., (2019) in their assessment of air quality and its health implications on Abuja Campus residents, University of Port Harcourt. The range of values reported by Nwachukwu et al., (2012), 4.2 – 12.4µg/$m^3$is are higher than that observed in this investigation. It is thought that the variations in the concentration of Ammonia in the different studies are a result of varying activities in the study areas. It is pertinent to ensure that Ammonia levels are within permissible limits as exposure to high concentration has been shown by ATSDR (2004) to lead to coughing, throat and lung damage and irritation of the eyes and skin. The analysis of variance (ANOVA) between the morning and evening of sampling shows that there is a significant difference at $p < 0.05$ between periods of sampling, however across stations, there was no significant variation during the study.

During this study, the mean concentration of carbon monoxide varied from 0.080±0.051 µg/m^3 in the morning to a slightly higher value of 0.094±0.043 µg/m^3 in the evening, however, both mean values are significantly lower than the value of 39.6154 reported by Nwokocha et al. (2015) which they attributed to oil production activities that were prevalent in the study areas. The very low concentration of carbon monoxide recorded in this investigation is probably a result of the fact that the study was carried out in residential areas where there are no oil production activities. Fairly higher values were also reported by Ugbebor et al. (2019) in their research on the Assessment of air quality and its health implications on Abuja campus residence, University of Port Harcourt Nigeria (with a range of 0.5 - 2.25) and Ishaya et al. (2017), who recorded a range of 1.96-2.14, 1.72-2.11 and 1.40-2.19 respectively in 3 zones (Core zone, Transitional and Peripheral Zone) in their 'assessment of air quality along an urbanization gradient in Apo district of Abuja the Federal Capital Territory of Nigeria. Furthermore, a Survey on the effects of air pollution on diseases of the people of Rivers State, Nigeria by Nwachukwu et al. (2012) reported a range of 0.002-32µg/m^3 in various selected locations in the Niger Delta. The analysis of variance (ANOVA) between morning and evening revealed that there was no significant difference obtained between the period of sample collection, as well as across sampling stations during the study.

In this present study on air quality assessment, the mean volatile organic compound (VOC) concentration varied from 8.715**±1.**704 µg/m^3in the morning to 9.850±5.021 µg/m^3in the evening, this value is within (though lower than) the range of 0.3 - 315 recorded by Nwachukwu et al., (2012) but it is higher than the value of 0.10 – 1.52ppm observed from an Environmental Impact Assessment (EIA) report of Benisede Catchment Area Field Development Plan (FDP) phase II carried out by Shell Petroleum Development Company, (2005). There was no significant spatial variation but temporal variation at $p < 0.05$.

The comparison of the mean concentration values of PM_{10} in the various sample stations, as well as the two periods (morning and evening) of sampling throughout the study, reveals that the concentration of PM_{10} in the atmosphere during the morning hours is generally higher than the corresponding evening values across all locations. The mean values recorded for PM_{10} in the morning and evening are respectively 0.052±0.009 µg/m^3 and 0.024±0.007 µg/m^3. This is slightly lower than the range of 0.09 -2.13µg/m^3 reported by Ishaya et al., (2017). It is however significantly lower than the mean and range of 9.965µg/m^3 and 65.50 - 428.00µg/m^3 as reported by Nwokocha et al. (2015) and Ugbebor et al. (2019) respectively. The analysis of variance (ANOVA) between the morning and evening of sampling revealed that there is a significant difference at $p < 0.05$ however across stations there was no significant variation.

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Conclusion

Though the mean concentration of all the air quality parameters of interest in this study showed significant temporal (morning/evening) variation, significant spatial variation was not observed in any of them. Nonetheless, both the morning and evening values are within the air quality permissible limits of the National Environmental (Air Quality Control) Regulations, 2014 by the National Environmental Standards and Regulations Enforcement Agency (NESREA) as well as those of the United State Environmental Protection Agency (USEPA) and WHO, meaning that the air in Port Harcourt Local Government Area is relatively free of pollutants. Thus, affirming the position of Nzekwe (2014), the study areas have little or no problems on health challenges arising from the deterioration of air quality. However it is recommended that air quality monitoring (like this study) should be carried out periodically and extensively to forestall a possible health hazard in the case of a relapse of the present status into full-blown pollution and that Governments at all levels (Federal, State &Local) within the country should create public awareness on air quality and serious tree planting, Government and or its agencies should be more proactive in the enforcement of all environmental treaties, guidelines, laws, regulations, standards and should be on constant compliance monitoring on the activities that will have more negative impacts on our environment and create awareness on tree planting to improve the quality of the air we breathe since our environment is fragile by nature and as the only planet where life can exist

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