Assessment of Atmospheric Pollutant Concentration Levels in Selected Housing Estates in Port Harcourt Metropolitan Fringe Areas, Rivers State

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ABSTRACT

The study assessed air pollutants concentration levels in housing estates in Port Harcourt Metropolis, Rivers, Nigeria. Based on the level of occupancy and accessibility, 10 housing estates in Port Harcourt Metropolitan fringe areas were purposively selected. Random sampling techniques were used to determine sampling locations within the selected estates. Windspeed, relative humidity, temperature, NO_2, H_2S, SPM, SO_2, CO and VOC concentration were measured at selected locations in the sampled estates. The mean temperature varied across study locations, with the highest mean value of 32.1°C in Agip Estate and a lowest of 30.6°C at Terrawood Estate. The highest and lowest mean value of relative humidity across the estates revealed 67.4% and 63.5% respectively, while wind speed revealed a highest mean value of 1.8 m/s and lowest value of 0.2 m/s. NO_2 and SO_2 were 0.3ppm and 0.17 ppm (highest) and 0.01ppm (lowest) in the estates. Elelenwo and Terrawood Estates recorded the highest concentration of VOC (0.65ppm) while the lowest mean concentration of 0.0lppm was recorded at Agip Estate. The highest mean value of 30µg/m^3 was recorded at Elelenwo Estate and lowest mean concentration of 14.5µg/m^3 was recorded in New Heaven estate for SPM. The correlation analysis of wind speed and atmospheric pollutant concentration at 0.05 probability level had a correlation coefficient of 0.04, 0.07, 00.3, 0.06, 0.0.7 and 0.207 for NO_2, H_2S, SPM, SO_2, CO and VOC respectively and was not statistically significant. However, the relationship between RH and H_2S was significant (r=0.002 at 0.005 probability level). Generally, pollutant concentration in the study area did not exceed W.H.O. and NAAQS specified standard. However, activities around the estates should be monitored effectively so as to ensure that pollutants do not exceed the specified limits.

Key words: Air Pollutants, Housing Estates, Fringe Areas

Introduction

Oil exploration in the Niger Delta Region of Nigeria has significant impact on air quality. Anthropogenic activities and unsustainable practices like bush burning etc have further exacerbated the quality of air in the region (Gobo *et al*., 2012). These activities have resulted in the release of harmful substances into the environment.In Port Harcourt metropolis, the rapidly declining air quality has become a major concern occasioned by deterioration of residential and environmental quality. Air pollutants generated from human activities have saturated the environment and the capacity of the environment to accommodate varying air pollutants in the atmosphere without altering its physical and chemical composition has reached its threshold (Obisesan & Weli, 2019).

The implication of this is that these air pollutants may contaminate food through deposition and may lead to various respiratory diseases such as asthma, chronic obstructive pulmonary disease and cancer of the lungs (Hoek *et al*., 2013). Alternatively, these air pollutants transit long distances in the atmosphere and in the process, react with other harmful pollutants to form secondary air pollutants such as ozone and acid rain. Acid rain corrodes the materials used in estate building thereby leading to reduction in both financial and aesthetic value (Burns *et al*., 2016).The passion to own qualitative housing has become a mirage due to industrial and domestic pollution, which impacts on indoor air quality leading to discomfort and high prevalence of respiratory diseases within the residential estates. In Port Harcourt metropolis, priority attention has been given to industrial and oil pollution to the neglect of air quality within residential estates inhabited by families (Zagha & Nwaogazie, 2015).

Considering the fact that most persons spend more time in their residence, it became imperative for a study of this nature to be undertaken. Moreso, the scarcity of literature on air quality assessments in residential estates also necessitated this study to assess the concentration levels of various atmospheric pollutants in selected housing estates in Port Harcourt metropolis. The study also examined the meteorological conditions of the selected residential estates. Specifically, the study also examined the relationship between meteorological conditions and atmospheric pollutant concentration levels within the residential estates.

Materials and Methods

The study was carried out in Port Harcourt Metropolis which is situated between 04°51'30"N and 04°57'30"N and between longitude 06°50'00"E and 07°00'00"E (Figure 1).

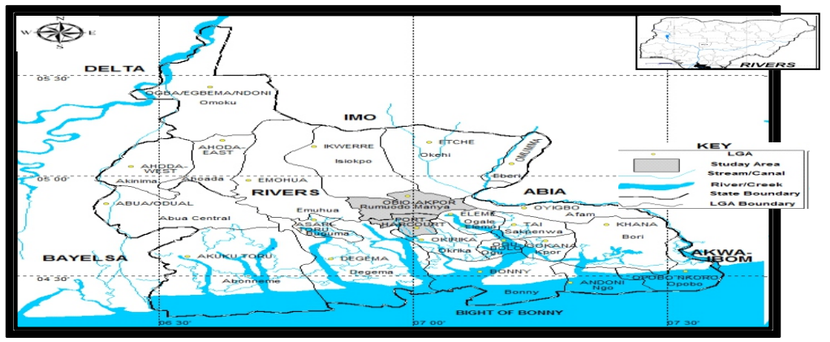

Figure 1: Map of Rivers State depicting the study areas

The metropolis is surrounded by patches of islands, and creeks of the Niger Delta; at a height of approximately 12m above sea level. It is approximately 60km from the crest up stream of the Bonny River. The city experiences heavy rainfall of 2370.5mm while the annual temperature of the region is 28°C and a relative humidity of 80%-100%. Two seasons are experienced in Port Harcourt: the wet season, which starts around April to November ending and the dry season, which begins in November and ends in March (Obisesan & Weli, 2019).

Primary and secondary data were used for this study. The primary data were obtained from direct measurements of windspeed, relative humidity, temperature, NO_2, H_2S, SPM, SO_2, CO and VOC concentration around selected residential estates in Port Harcourt Metropolis. The secondary data sources utilised documents, online publications, textbooks and World Health Organisation standards and National air quality data on ambient air quality standards. The study population constitutes ten (10) estates purposively selected based on the number of residential units and accessibility. The estates selected include Shell Residential Estate (160 Units), Mini Ezekwu/Cocaine Village (120 Units), Rumuogba Housing Estate (110 Units), New Heaven Estate (110 Units), Agip Staff Estate (85 Units), Green Village (80 Units), Tonimas Estate (60 Units), Total Village (60 Units), Elelenwo Housing Estate/Bristow (60Units) and Terra Wood Estate (42 Units). The meteorological parameters that were measured include air temperature, relative humidity, and wind speed while the air

pollutants measured were nitrogen dioxide (NO_2), sulphur dioxide (SO_2), hydrogen sulphide (H_2S), carbon monoxide (CO), volatile organic carbon (VOCs) and suspended particulate matter (SPM). A combined wind vane and Digital Anemometer (Taylor wind scope) were used to measure the wind direction and speed in meters per second (m/s). The air temperature in degrees Celsius C) was measured with a hand held digital thermometer. A logger (Testo 450) was used in determining the relative humidity. The logger is equipped with an atmospheric pressure probe (Barometer) and a relative humidity probe (Hygrometer). A multi RAE PLUS (PGM-50), a programmable Multi Gas monitor with an electrochemical sensor was used for the detection of NO_2, SO_2 and VOCs. H_2S was detected by a Multi Gas Detector (Defender Model D2-2000, manufactured by DW Technologies) with an electrochemical sensor. An ELE Analox Sensor Gas Monitor Model GC 401 was used for the detection of CO while a Met One Instrument, Inc Aerosol Mass Monitor was used to measure Suspended Particulate Matter (SPM). All measurements were taken by holding the equipment to a height of two meters in the prevailing wind direction and readings recorded at stability.

Measurements were taken in the months of January, March, April, May, July, October, November and December. This spanned for a period of eight (8) months covering the dry and rainy seasons. Measurements were conducted between the hours 9.00am - 3.00pm each day. A set of three readings was collected at each sampling point, and the average of the readings evaluated. This procedure was repeated at two (2) hours interval in each of the sampling points to make sure the data obtained are accurate representations of the prevailing conditions. The study utilised quantitative techniques in data presentation and analysis. Mean and standard deviation for the months under study and the various estates were computed. The relationship between meteorological conditions and atmospheric pollutants was tested using the Pearson Product Moment Correlation (PPMC) Statistics. The computer software known as Statistical Package for Social Sciences (SPSS), version 21 was used for the statistical analysis.

Results and Discussion

Results showed that wind speed ranged from a lowest of.0.48m/s in July to a highest of l.47m/s in November as shown in Fig 2. Mean wind speed at the various estatesranged from a lowest of 0.20m/s at the Terrawood Estate to a highest of l.87m/s at Agip Estate as shown in Fig 3.

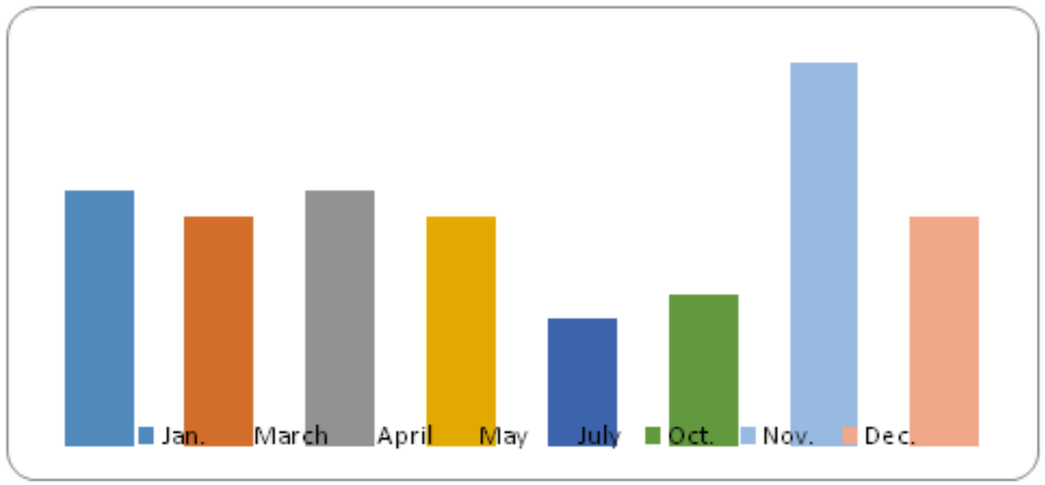

Figure 2: Mean wind speed across the months of sampling.

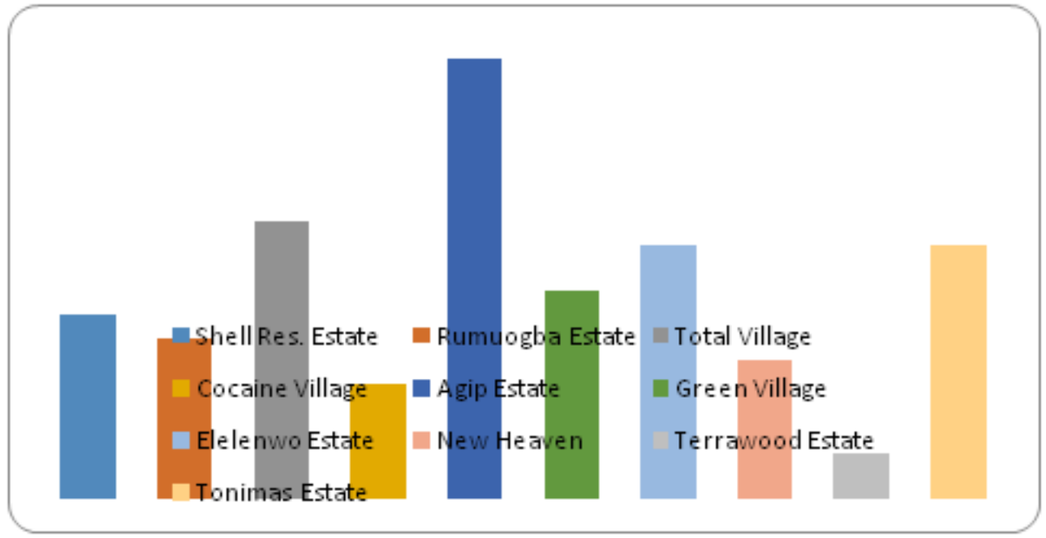

Figure 3: Mean wind speed across the estates.

Results showed that the mean relative humidity across the months of sampling ranged from a lowest of 49.2% in April to a highest of 77.8% in July as shown in Fig 4. A closer look at the figure reveals a declining progression from the peak in July towards December. This is attributed (of course is informal and not be accommodated in an academic paper) to the gradual change from the rain to the dry season. The mean relative humidity at the various estates ranged from a lowest of 63.5% at Green village to a highest of 67.4% at Terrawood Estate as shown in Fig 5. Gobo *et al* (2012) discovered similar results in his study of air pollutants and noise levels in Okrika. It was revealed by their study that the relative humidity ranged from 41.8% to 70.1%.

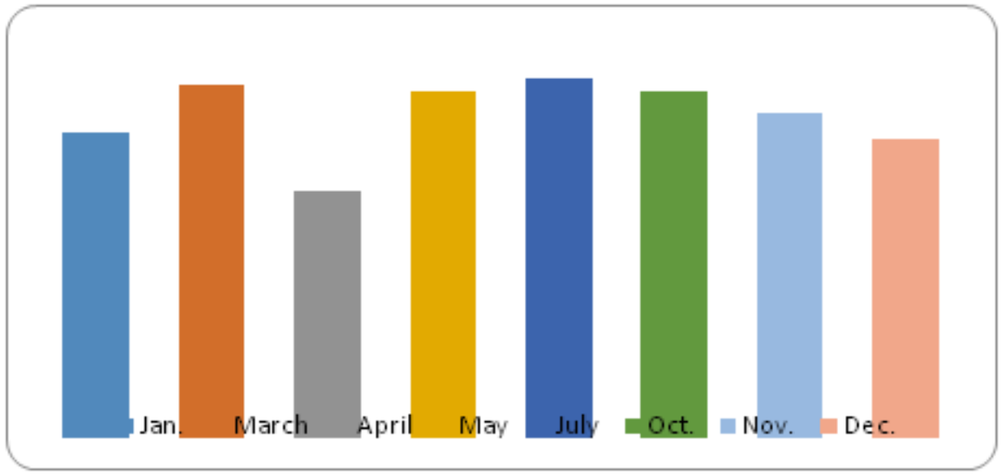

Figure 4: Relative humidity across the months of sampling.

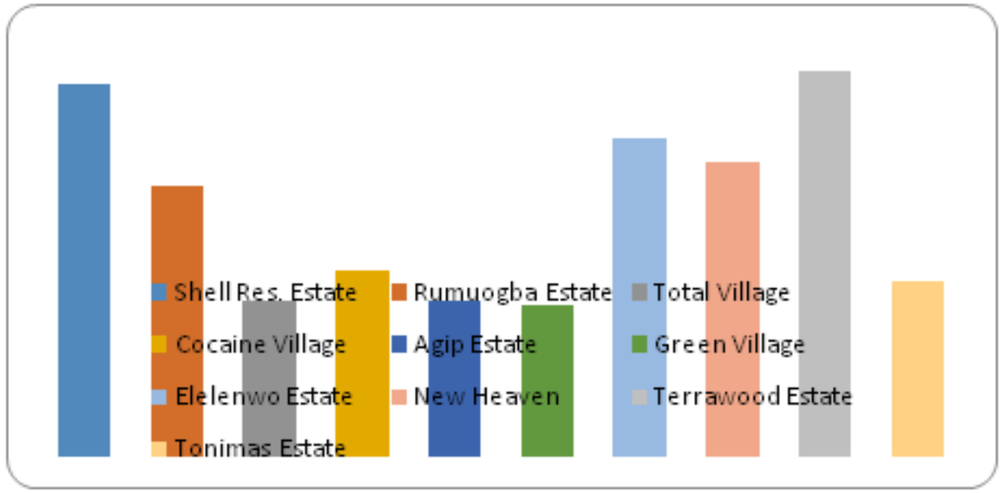

Figure 5: Mean relative humidity across the estates.

Results show that the mean daily air temperature in the various months of sampling ranged from a lowest of 25.9°C in March to a highest of 37.6°C in April as shown in figure 6. The mean daily air temperature across the various estates ranged from a lowest of 30.6°C at Terrawood Estate to a highest of 32.1°C at Agip Estate as shown in figure 7. The finding of the research agrees with the findings of Obanya *et al* (2018) which revealed that temperature ranged from 26.3 to 32.6°C

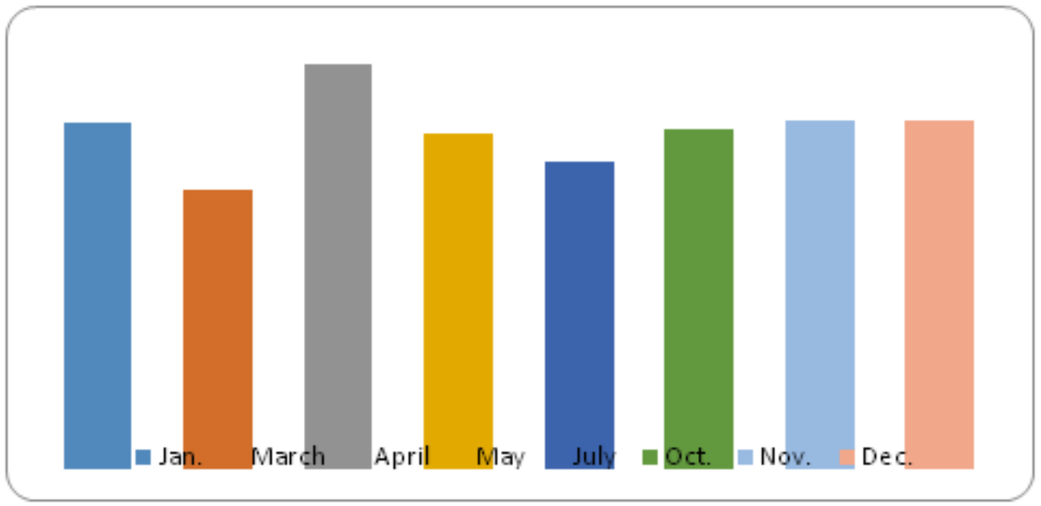

Figure 6: Mean air temperature across the months of sampling.

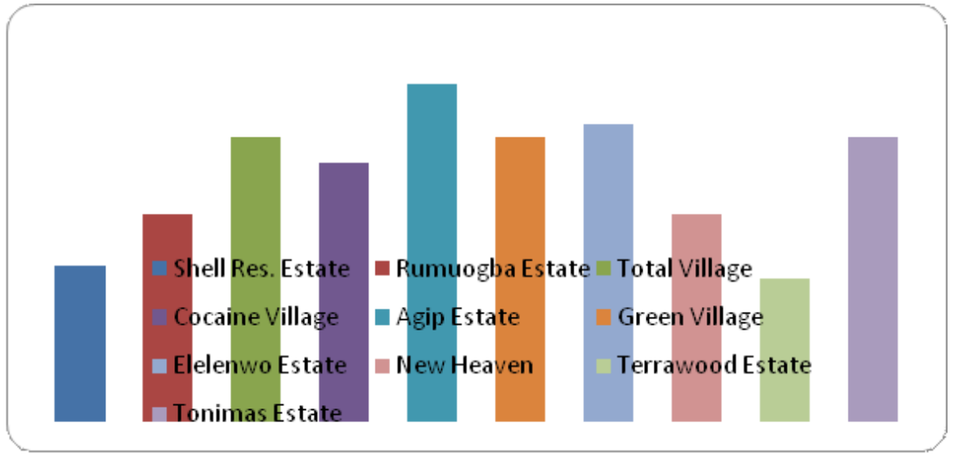

Figure 7: Mean air temperature across the estates.

Results of the mean concentrations of NO_2 as measured in all the estates across the months show that the lowest mean concentrations of 0.0lppm was recorded in the months of July and October, while the highest of 0.3ppm was recorded in May as shown in figure 8. The highest value of 0.3ppm exceeded the Nigerian Ambient Air Quality Standards (NAAQS) limit of 0.04ppm-0.06ppm. This is in conformity to the study carried out by Adoki (2012) who noted that the level of NO_2 was greatly influenced by seasons. The result of the mean concentrations of NO_2 in the estates reveals that the Shell residential area has the lowest concentration while the highest concentration of 0.30ppm was found at the Green village as shown in figure 9.

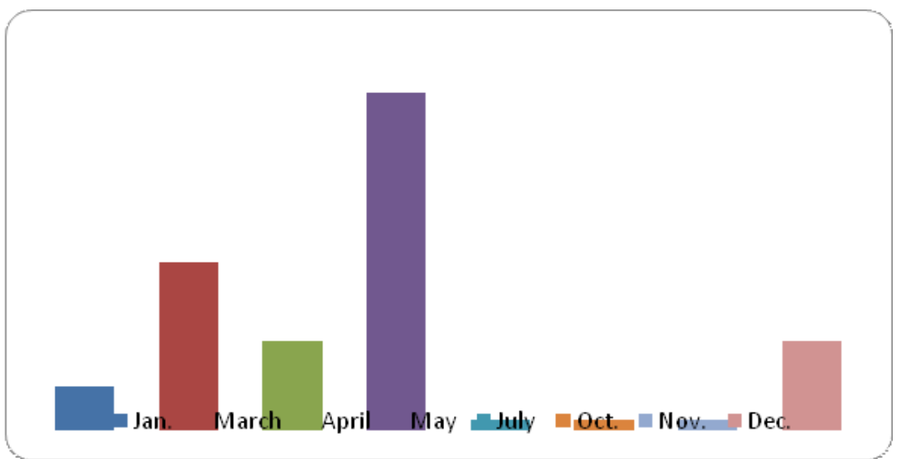

Figure 8: Mean nitrogen dioxide across the months of sampling.

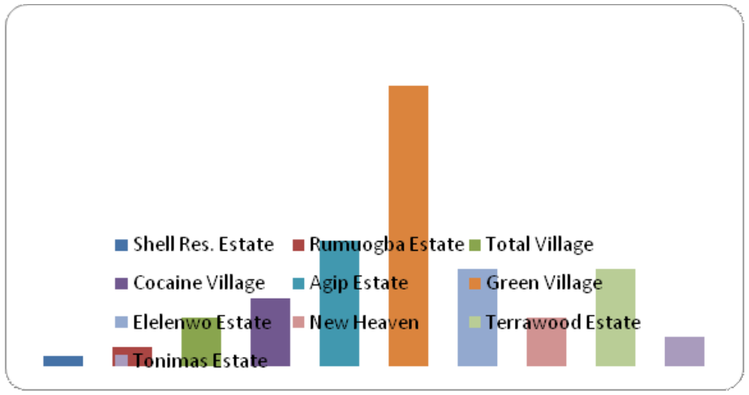

Figure 9: Mean nitrogen dioxide across the estates.

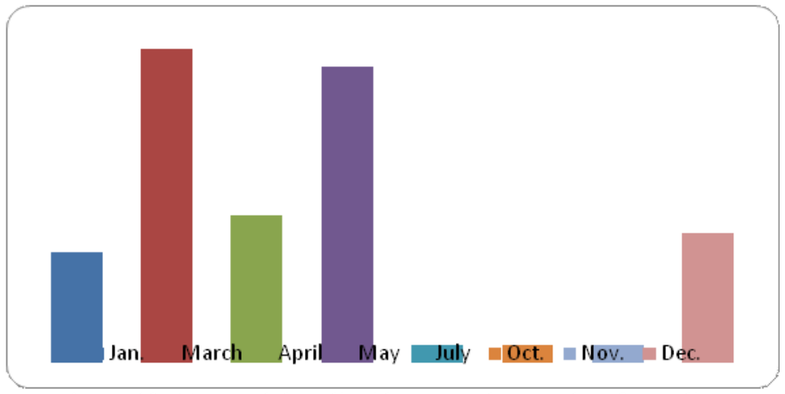

Figure 10: Mean sulphur dioxide across the months of sampling.

Figure 11: Mean sulphur dioxide across the estates.

Results of the mean concentrations of H_2S as measured at all estates across the months show that the lowest mean concentration of 0.11ppm was recorded in the month of November, while the highest mean of 0.80ppm was recorded in April as shown in figure 12. The results of the mean concentration of H_2S at the various estates show a highest mean of 0.9lppm was observed at Cocaine Village/ Mini Ezekwu Estate as shown in figure 13. However, it is still within the limit of 5.76ppm stipulated by NAAQS.

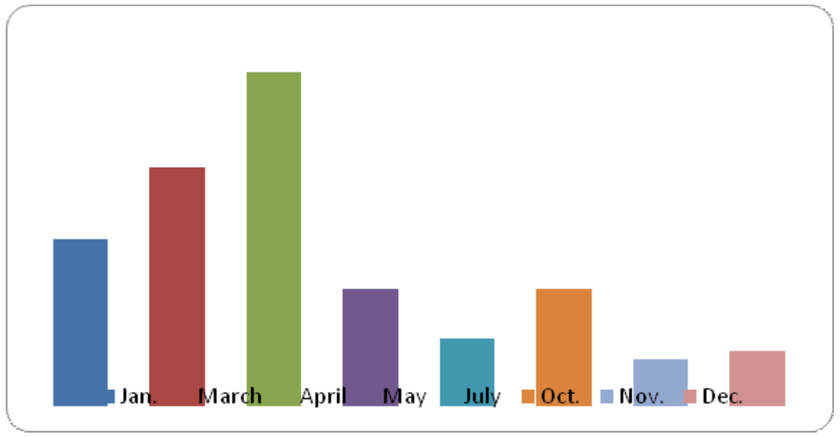

Figure 12: Mean hydrogen sulphide across the months of sampling.

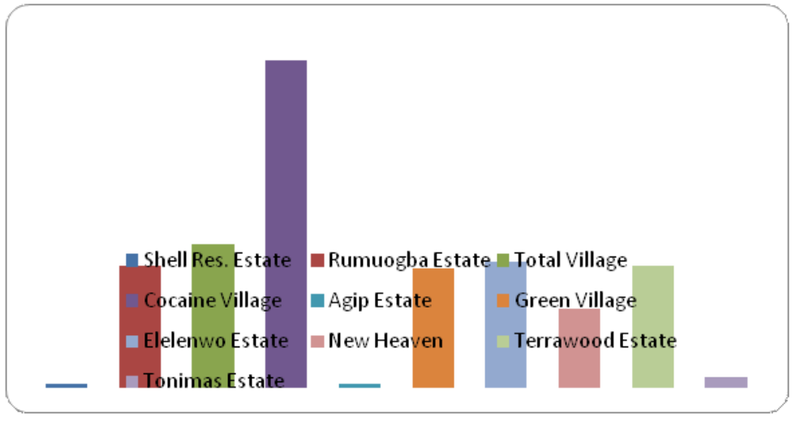

Figure 13: Mean hydrogen sulphide across the estates.

Results of the mean concentrations of CO as measured in all the estates across the months showed that the lowest mean concentration of 1.30ppm was recorded in the month of July, while the highest mean of 2.lppm was recorded in January as shown in figure 14. The results reveal that concentrations at all the estates were within the range of 1.0ppm - 4.3ppm.These values are far below the l0ppm maximum daily averages stipulated by NAAQS.The results of the mean concentration of Carbon Monoxide at the various estates show a highest mean of 3.24ppm was recorded at Total Village, followed by 2.30ppm at Terrawood Estate and 1.90ppm at Green Village as shown in figure 15. At the Agip Estate, the mean value is less than the detectable limit of 1.0ppm. All the measured values fall within the limit of l0ppm stipulated by NAAQS. The result conforms to the findings of Njoku *et al*. (2016) who revealed that the levels of CO in the sampled locations in the city of Lagos were all below the Nigerian FMEnv. regulatory limit of 10 ppm. The study is also in tandem with the findings of Ugbebor *et al*. (2019) who revealed in their study that mean concentrations of Carbon monoxide ranged from 0.5ppm to 2.25ppm.

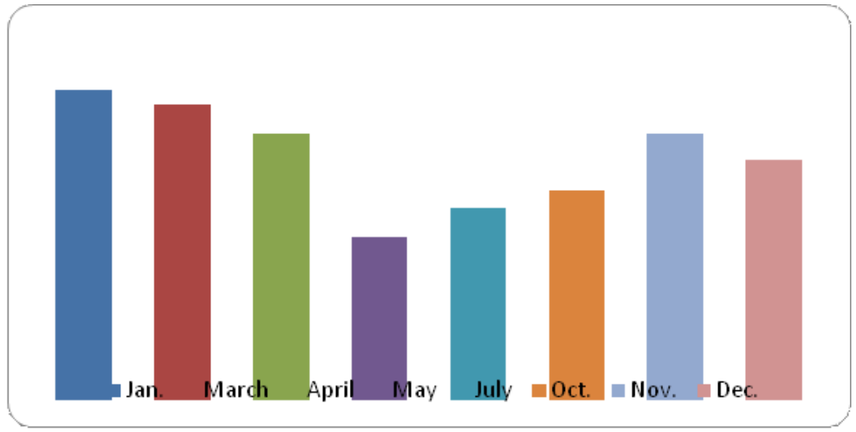

Figure 14: Mean Carbon Monoxide across the months of sampling.

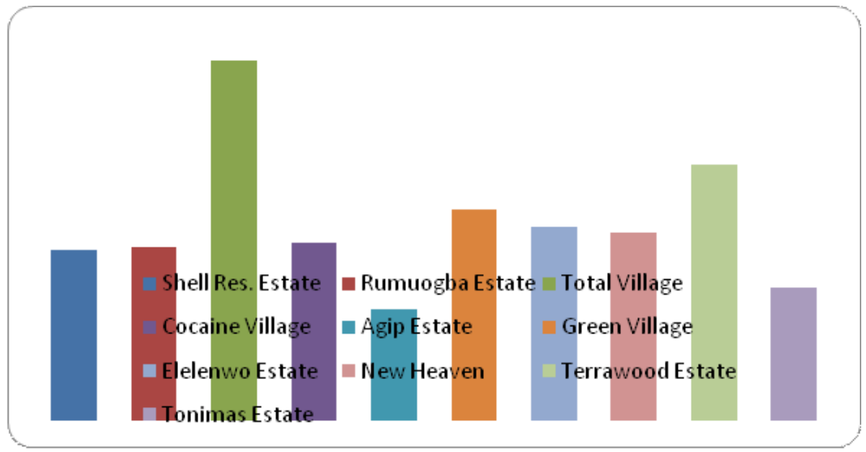

Figure 15: Mean carbon monoxide across the estates.

Results of the mean concentrations of VOC as measured in all the estates across the months showed that the lowest mean concentration of 0.0lppm was recorded in the month of July, while the highest mean of 0.64ppm was recorded in May as shown in figure 16. The results of the mean concentrations of VOC in all the estates under study showed that the lowest mean concentration of 0.0lppm was recorded at Agip Estate, while the highest mean of 0.63ppm was recorded at Terrawood Estate, followed closely by 0.62ppm at Elelenwo Housing Estate as shown in figure 17.

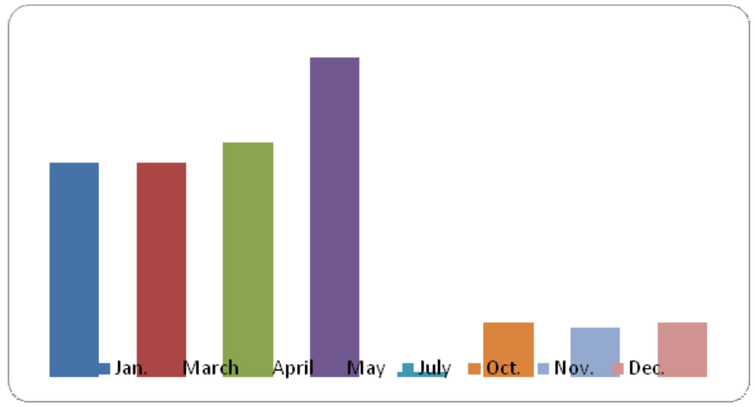

Figure 16: Mean VOC across the months of sampling.

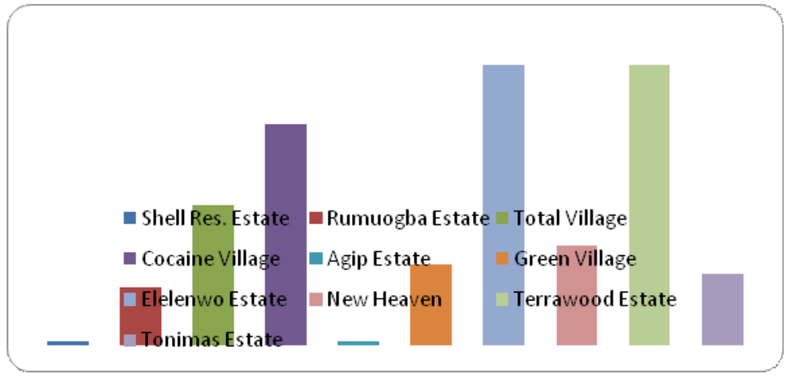

Figure 17: Mean VOC across the estates.

Results of the mean concentrations of SPM as measured at all the estates across the months showed that the lowest mean concentration of 10.0µg/m^3 was recorded in the month of October, while the highest mean of 31.0µg/m^3 was recorded in January as shown in figure 18. The results of the mean concentrations of SPM as measured in all the estates showed that the lowest mean concentration of 14.5µg/m^3 was recorded in New Heaven Estate, while the highest mean of 29.4µg/m^3 was recorded in Elelenwo Housing Estate, followed by 24.8µg/m^3 in Green Village as shown in figure 19. All measured values fall within 250µg/m^3 set by NAAQS. The finding of this research is in tandem with the findings of Akinfolarin *et al.* (2017) who noted that dry season indicated higher concentrations of SPM.

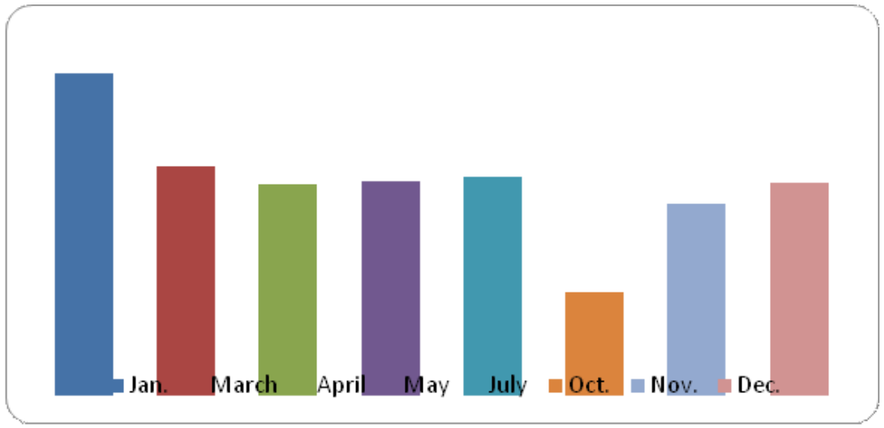

Figure 18: Mean suspended particulate matter across the months of sampling.

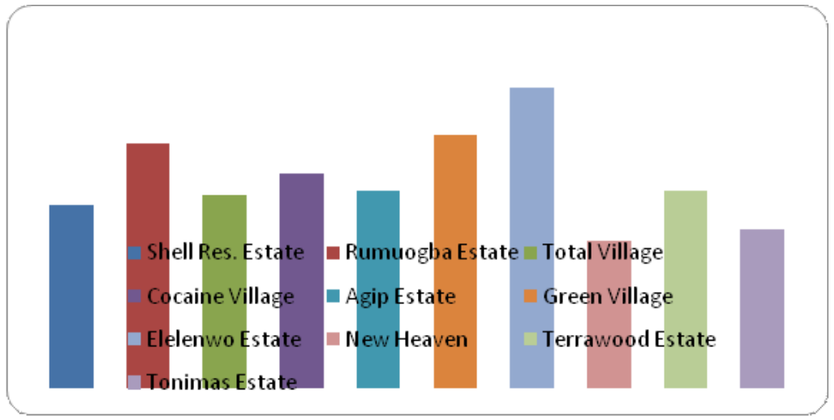

Figure 19: Mean SPM across the estates.

Results of relationship between meteorological condition and atmospheric pollutants tested using the Pearson Correlation Statistics showed that the relationship between wind speed and NO_2, H_2S, SPM, SO_2, CO, and VOC of correlation coefficient (r) of 0.04, 0.07, 0.03, 0.06, 0.07 and 0.207 was not statistically significant and the relationship was very weak. Relative Humidity also showed very low relationship with all atmospheric pollutants; but showed significant relationship of 0.002 with H_2S. Temperature also showed very low relationship with atmospheric pollutants, with no statistically significant relationship as shown in table 1. However, the findings of this research are in contrast to the findings of Abulude *et al*. (2018) who in their research revealed that statistically, there were correlations with the pollutants and meteorological conditions.

Table 1: Pearson Correlation Statistics

Atmospheric Pollutants significant at level	Correlation 0.05 alpha	Meteorological properties		
		Wind speed	Relative Humidity	Temperature
Nitrogen dioxide	Pearson Correlation	-0.041	0.024	-0.037
	Sig. (2-tailed)	0.719	0.832	0.742
	N	80	80	80
Sulphur dioxide	Pearson Correlation	-0.077	0.018	-0.012
	Sig. (2-tailed)	0.497	0.872	0.917
	N	80	80	80
Hydrogen sulphide	Pearson Correlation	0.031	-0.336	0.180
	Sig. (2-tailed)	0.782	0.002	0.110
	N	80	80	80
Carbon monoxide	Pearson Correlation	0.062	-0.053	-0.023
	Sig. (2-tailed)	0.588	0.640	0.843
	N	80	80	80
Volatile organic compounds	Pearson Correlation	0.074	0.026	-0.005
	Sig. (2-tailed)	0.515	0.818	0.968
	N	80	80	80
Suspended particulate matter	Pearson Correlation	0.207	-0.090	0.045
	Sig. (2-tailed)	0.066	0.428	0.691
	N	80	80	80

Conclusion

Findings of this study showed that the concentration levels of most pollutant gases measured within the study period were still within the World Health Organisations (WHO) and NAAQS specified standard. However, people around the vicinity of Green Village could have some adverse health effects like aggravation of respiratory diseases and cardiovascular illnesses if they are consistently exposed to high concentrations of nitrogen dioxide. This could also fade paintings in buildings and even cars and other surfaces.

Moreso, people living around New Heaven Estate are susceptible to some health effects such as irritation of the eyes and respiratory tract if they are consistently exposed to high concentrations of sulphur oxides because sulphur dioxide can easily combine to form sulphuric acid, metals could be corroded. Electrical contacts, paper, textiles, leather, paints etc could also be affected. The study also revealed no significant relationship between meteorological conditions and atmospheric pollutant concentration levels.

Recommendations

Based on the findings of the study, the following recommendations were necessary such as:

1. Since this study has revealed that the concentration levels of most of the pollutant gases measured during the study period were still within the 'stipulated limit', care should be taken in order not to allow these pollutants to exceed the limit as this would be of some serious adverse and detrimental consequences to human and environmental wellbeing.
2. Activities in the housing estates that result in the generation of the pollutants should be reduced or stopped.
3. Routine check and monitoring should be conducted in the various estates; vehicles and equipment used in the estates should be monitored to ensure that excess and unnecessary fumes, particulates, and gases are not produced and emitted.
4. Residents of the various estates studied and those living close to and around these areas should 'always be environmentally conscious and always be on the lookout for

incidences of overexposure to air pollutants.

5. Environmental awareness and enlightenment should be held periodically during meetings of the estate dwellers or during the monthly sanitation exercise.

References

Abulude, F., Dare, F., & Akinnusotu, A., Olatunde, M., & Elisha, J. J. (2018). Assessment of the Indoor Air Quality of Akure, Nigeria. *Preprints,* 2018110586. doi:10.20944/preprints201811.0586.v1

Adoki, A. (2012). Air Quality Survey of some locations in the Niger Delta Area. *J. Appl. Sc. Environ. Manage.*,*16*(1), 137-146.

Akinfolarin, O. M., Boisa, N., & Obunwo, C.C. (2017). Assessment of Particulate Matter-Based Air Quality Index in Port Harcourt, Nigeria. *J. Environ Anal. Chem.*, *4*, 224. doi:10.4172/2380-2391.1000224

Burns, D., Aherne, J., Gay, D., & Lehmann, C. (2016). Acid Rain and its Environmental Effects: Recent Scientific Advances. *Atmospheric Environment*, *146*, 1-4. doi:10.1016/j.atmosenv.2016.10.019.

Gobo, A.E., Ideriah, T.J.K., Francis, T. E., & Stanley, H. O. (2012). Assessment of Air Quality and Noise around Okrika Communities, Rivers State, Nigeria. *J. Appl. Sci. Environ. Manage.*, *16* (1), 75-83.

Hoek, G., Krishnan, R.M., Beelen, R., Peters, A., Ostro, B., Brunekreef, B., & Kaufman, J.D. (2013). Long-term Air Pollution Exposure and Cardiorespiratory Mortality: A Review. *Environmental Health*, *12*, 43. doi:10.1186/1476-069X-12-43

Njoku, K. L., Rumide, T. J., Akinola, M., Adesuyi, A. A., & Jolaoso, A. O. (2016). Ambient Air Quality Monitoring in Metropolitan City of Lagos, Nigeria. *J. Appl. Sci. Environ. Management, 20*(1), 178-185. doi: 10.4314/jasem.v20i1.21

Obanya, H., Amaeze, N., Togunde, O., & Otitoloju, A. (2018). Air Pollution Monitoring Around Residential and Transportation Sector Locations in Lagos Mainland. *Journal of Health and Pollution*, *8*. 180903. doi: 10.5696/2156-9614-8.19.180903

Obisesan, A. & Weli, V.E. (2019). Assessment of Air Quality Characteristics across Various Land-Uses in Port-Harcourt Metropolis. *J. Environ. Pollut. Manage.*, *2*, 106.

Ugbebor, J. N., Yorkor, B., & Amadi, G. (2019). Assessment of Air Quality and its Health Implications on Abuja Campus Residence, University of Port Harcourt, Nigeria. *Journal of Science, Technology and Environment Informatics*, *07*(01), 500-509. doi:10.18801/jstei.070119.52

Zagha, O. & Nwaogazie, I. (2015). Roadside Air pollution Assessment in Port-Harcourt, Nigeria. *Standard Scientific Research and Essays*,*3*(3), 066-074.