Journal of Environmental Pollution and Control
Volume 4| Issue 1

Research Article Open Access

Assessment of Particulate Matter, Volatile Organic Compounds, and Suspended Solids in Some Settlements around Port Harcourt Metropolis, Rivers State Nigeria

Ogaji FM[1], Obafemi A[1], Numbere AO[*3] and Ogaji DS[2]

[1]Institute of Natural Resources, Environment and Sustainable Development, University of Port Harcourt, Choba, Nigeria

[2]African Centre of Excellence for Public Health and Toxicological Research (ACE-PUTOR) University of Port Harcourt, Choba, Nigeria

[3]Department of Animal and Environmental Biology, University of Port Harcourt, Choba, Nigeria

[*]**Corresponding author:** Numbere AO, Department of Animal and Environmental Biology, University of Port Harcourt, Choba, Nigeria, Tel: +2348056002989, E-mail: aroloyen@yahoo.com

Citation: Ogaji FM, Obafemi A, Numbere AO, Ogaji DS (2021) Assessment of Particulate Matter, Volatile Organic Compounds, and Suspended Solids in Some Settlements around Port Harcourt Metropolis, Rivers State Nigeria. J Environ Pollut Control 4(1): 105

Received Date: November 17, 2021 **Accepted Date:** November 27, 2021 **Published Date:** November 29, 2021

Abstract

There is a proliferation of particulate matter in the atmosphere within and around the cities because of increased industrial activities. It is thus hypothesized that increase in human activities lead to increase in pollutants concentration inside (*n*=80 houses sampled) and outside residential areas. Thus, to investigate the air quality at different residential areas within indoor and outdoor environment air samples were collected using Particle Counter (Model: HHPC MET), and Gas Monitor (Aeroqual series 500) to determine particulate matters (i.e., PM10, and PM2,5), volatile organic carbon (VOC) and total solid particle (TSP). The results were statistically analyzed with ANOVA, which indicates that there is significant difference between residential areas ($F_{8, 951}$ = 21.07, P=0.001) and between pollutants ($F_{3, 956}$ = 338.3, P<0.001). PM_{10} and TSP had higher concentrations in the morning hours. In contrast, $PM_{2.5}$ had higher concentration in the evening. However, VOC had the least concentration of all substances compared. There is no seasonal difference in pollutant concentration ($F_{1, 1918}$ = 0.48. P=0.49). Nevertheless, concentrations of PM_{10} and VOC were higher during the dry season whereas $PM_{2.5}$ was higher during the wet season. Most of the concentrations were below international standards apart from some high-density areas e.g., Mile 1 Diobu that has higher concentration. The study implies that atmospheric pollutants are common in both indoor and outdoor environment and thus require constant monitoring to prevent deleterious health effects on residents.

Keywords: Air; Anthropogenic Activities; Particulate Matter; Pollution; Refinery

Introduction

Air pollution is generally referred to as the introduction of chemical, biological, and physical substances into the air, which alters the natural air concentration (Chernyaeva and Wang, 2019) [1] by increasing the atmospheric particulate matter. The physical pollutants include dust, solid particles, radioactive materials, isotopes, electromagnetic waves, radio waves, noise, and heat [1] (Chernyaeva and Wang, 2019) [1]. The city is filled with a lot of anthropogenic activities that generates particulate matter that affects the well-being of humans, amongst these activities are industrial operations (Omer, 2008; Ou et al. 2021) [2,3] from small to large scale industries, vehicular activities [4] (Tran et al. 2021), and climatic action e.g., volcano (Burch and Harris, 2021) [5].

Oil and gas exploration also add substantial pollutants into the atmosphere through gas flaring and burning of crude oil (Numbere, 2021) [6]. Smoke, fumes, and soot generated from these processes circulate in the outdoor and indoor environments (Breysse, et al, 2010) [7]. Indoor pollution is caused by combustion of fuels, tobacco, coal, ventilation systems, emissions from furnishings and construction materials (Pérez-Padilla et al. 2010) [8]. Other causes of indoor air pollution include the burning of firewood as fuel wood for cooking (Numbere, 2020) [9] and the use of generating set to power domestic appliances [10,11] (Onwuka et al. 2017; Bibi et al. 2021). The particulate matter once released becomes air borne and travel thousands of kilometers to contaminate the terrestrial and aquatic environments (Lopez et al. 2021) [12]. The burning of crude oil from illegal oil refinery and the emission from car exhaust cause the release of particulate matter into the atmosphere (Singh et al. 2021) [13].

The black soot settles on all objects in the city to accelerate cases of respiratory diseases (e.g., asthma, cough, and emphysema) amongst the residents (Guo et al. 2021) [14]. Currently there is an increase in asthmatic attacks, cough, and catarrh amongst residents of Port Harcourt, which has compounded the health risk of many young and old persons with other preexisting medical conditions (Tsai et al 2012, Akhbarizadeh et al. 2021) [15,16]. There are also cases of increased headaches, dizziness and feelings of fainting and exhaustion because of the breathing of polluted air (Anakwue and Anakwue, 2014) [17]. Black soot tarnishes the paints of buildings and corrode their roofs thereby reducing their aesthetic value. Similarly, black soot coats vehicles and tarnish their colors leading to repeated spray painting within a short period of time (Hasager et al. 2021) [18].

The burning of car tires is also found to be another major cause of increased soot within Port Harcourt. The burning of tires is a major problem in Port Harcourt because it leads to increase in atmospheric pollutants (Ephraim-Emmanuel and Odinioha, 2021) [19]. Volatile organic compounds are also found in the air space of the city because of the operations of refineries and the proliferation of crude oil tank farms around the city (Numbere, 2021) [6]. Furthermore, high solar radiation helps to volatilize crude oil in open tanks leading to the vaporization of harmful gases into the atmosphere (Wan et al. 2021) [20]. In addition, suspended gases migrate into the atmosphere when blown from farm soil during the dry harmattan season (Couto et al. 2021) [21] around October to March every year. This study therefore is aimed at determining the particulate matter concentrations in the atmosphere at different residential quarters at different times of the day following the example of Gobo et al. (2009) [22] in Port Harcourt metropolis. We thus hypothesize that there would be no significant difference between gases in indoor and outdoor environments and between different times of the day.

Our objectives are: (1) to determine the cumulative particulate matter concentration at different residential areas of Port Harcourt, (2) to determine the concentration of particulate matter and other substances inside and outside buildings at differ times of the day, (3) to compare the air quality at different seasons of the year.

Materials and Methods

Description of study area

Port Harcourt is one of the major cities in Nigeria (Figure 1) and serves as the capital of Rivers State (Ayotamuno and Gobo, 2004,

Echendu and Georgeou, 2021) [23,24]. It lies along Bonny River, an eastern tributary of the Niger River, 66km upstream from the Gulf of Guinea, located at the coastal region of Nigeria. Port Harcourt metropolis partly situated in a wetland ecosystem between Latitudes 4° 45' N, and 4° 55' N and Longitudes 6° 55' E and 7° 05' E with 15.83 meters elevation above sea level (Yakubu, 2018) [25]. The city has a flat topography with inadequate drainage facility. Its elevation varies between 3m and over 15m above mean sea level.

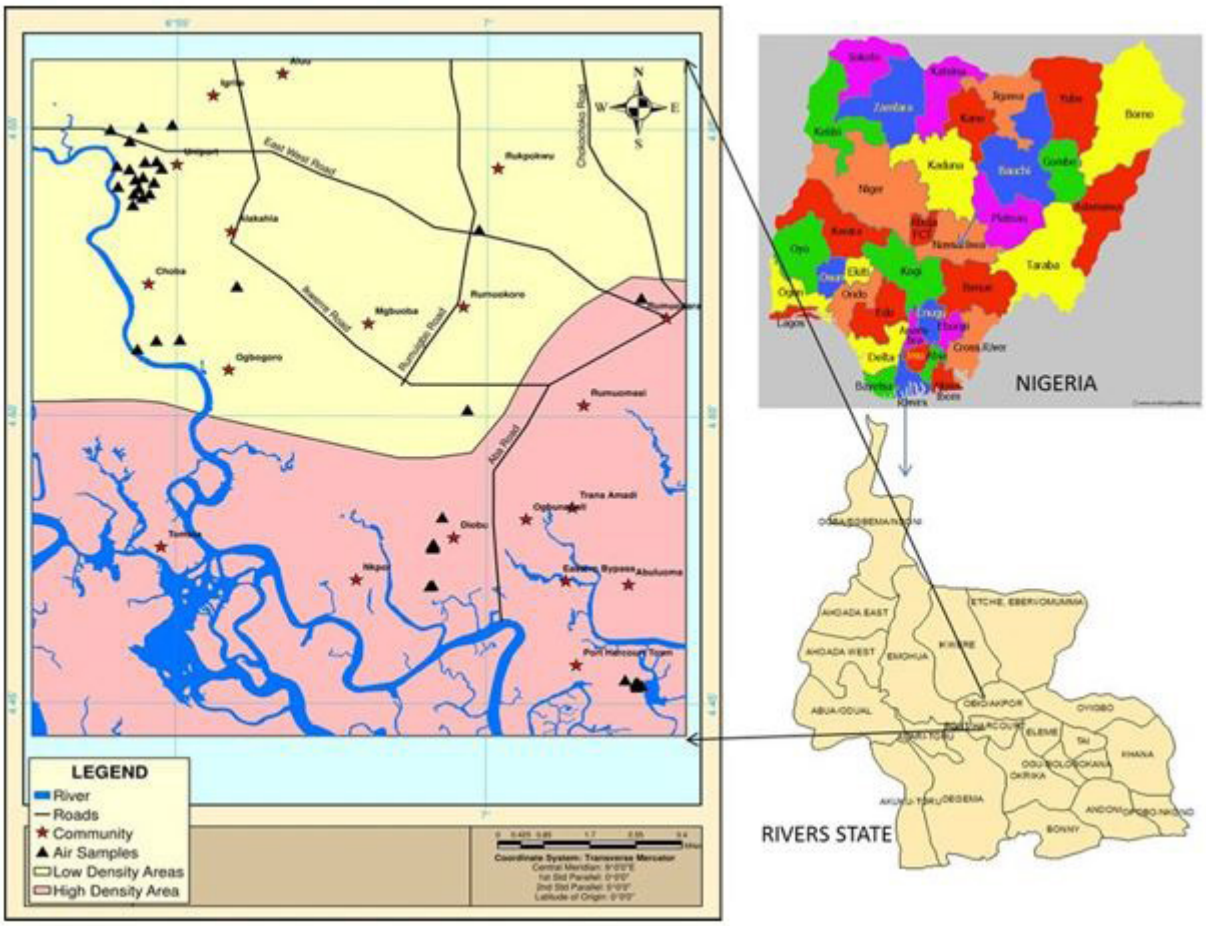

Figure 1: The Study area, Port Harcourt, Nigeria with sampling points

The streams are south flowing streams, which are turbid during the wet season due to the discharge of clay and silt into the drainage channels. In the dry season however, the discharge and turbidity are highly reduced.

Port Harcourt has been under the sub-equatorial climate and experiences longer raining season, which is characteristic of a tropical wet climate with lengthy and heavy rainy seasons of about 182 days with a temporary cessation of rain within the raining season commonly referred to as 'August break' and short dry seasons (Numbere and Camilo, 2018) [26].

Study Population and Sampling Unit

The study was carried out among households in two residential categories which are in high, and low-density areas of the Port Harcourt metropolis (Table 1). In all, nine residential areas were sampled in Port Harcourt for noxious gases and particulate matter inside and outside residential buildings following the examples of Gobo et al. (2009) [22] and Chernyaeva and Wang, (2019) [1]. Different times of sample collections were compared as indicated in Figures 2 and 3, which reveal the cumulative noxious gas and particulate matter concentrations along residential zones in Port Harcourt.

S/No	Residence	Region*	Settlement density
1	Owo Street	Diobu	High
2	Ekwulobia Street	Diobu	High
3	Ndoki Street	Town	Low
4	Nchia Street	Uniport	Low
5	Degema Street	Uniport	Low
6	Ghana ama Street	Uniport	Low
7	Ali cape verde	Uniport	Low
8	Preyi Crescent	Uniport	Low
9	Gambia Street	Uniport	Low

*Part of Port Harcourt city in River State, Nigeria

Table 1: Residential areas around Port Harcourt where samples were collected at different times

Stratified and simple random sampling techniques were used to differentiate these residential areas into two i.e., high density and low-density residential area and to select the streets respectively.

Sampling Equipment

The sampling equipment used in this study were portable hand-held meters to assess air pollutants. These include GPS map Model 76Cx Garmin global positioning systems was used to take the coordinates of the sampling points. Particle Counter (Model Number: HHPC MET one) with range sensitivity of 0.001 was used for measuring PM_{10} and $PM_{2.5}$. Gas monitor (Aeroqual series 500) was used for the assessment of all the gaseous pollutants of the study area. The seris 500 monitor Aeroqual is a portable meter with the highly sensitive replaceable sensors of different gaseous air pollutants. The portable meter measures volatile organic compounds (VOCs).

Selection of Sampling Site

A total number of eighty (n=80) sampling houses were selected in Port Harcourt metropolis using Ministry of Urban Planning and Physical studies and WHO's (2006) [27] guideline for site selection studies for population density, topography, and building cluster. The sampling locations are shown in Figure 1. All the sampling points were geo-referenced using GPS model 76CxGarmain Global Positioning System.

Statistical analysis

Data was analyzed using geospatial and geostatistical techniques with the mean values of the air pollutant concentrations estimated for measurement collected. Statistical test of significance was estimated as null hypothesis for significance testing. The mean, standard deviations and coefficient of variations were also calculated. The p-value represents the probability associated with the outcome of a test of a null hypothesis (Bowling, 2014) [28]. Normality test was carried out to determine whether the data follow normal distribution. An analysis of variance (ANOVA) was done to determine the significance difference between multiple locations and sampling unit (Logan, 2010) [29]. Mann-Whitney test of significance was used to compare the air quality between the high-density area and the low-density area. All analyses were done in R Development Core Team (2013) [30].

Results

Cumulative particulate matter concentration in residential areas

The amount of particulate matter measured inside, and outside residential areas varies as result of differences in activities that occur within (e.g., cooking, smoking, and generating sets) and outside (e.g., vehicles, industries, and commercial activities) the houses as shown by the ANOVA results: ($F_{8, 951}$ = 21.07, P=0.001, Figure 2), and collection times of the samples (P=0.001, Figure 3).

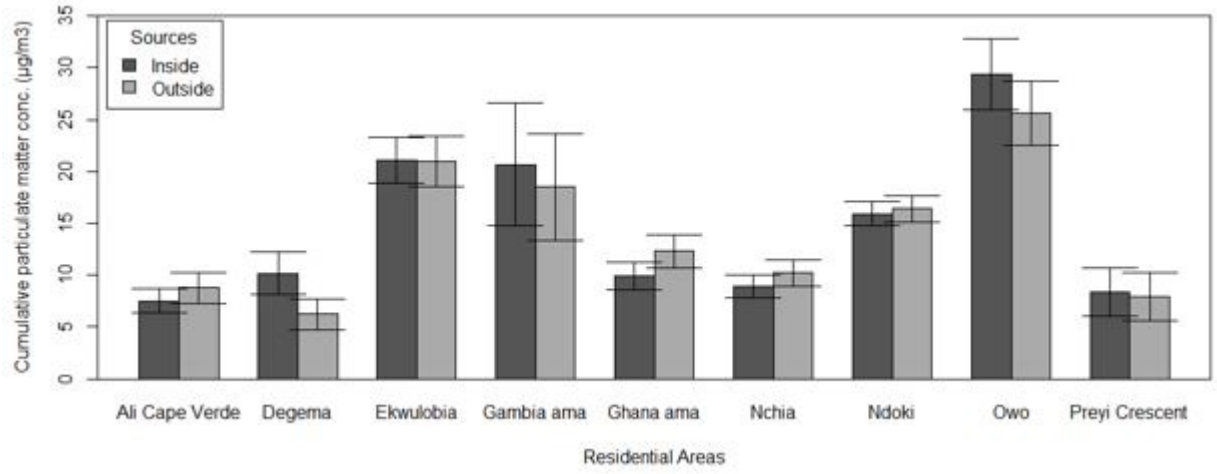

Figure 2: Cumulative particulate matter concentration inside and outside buildings in different residential areas of Port Harcourt, Rivers State, Nigeria

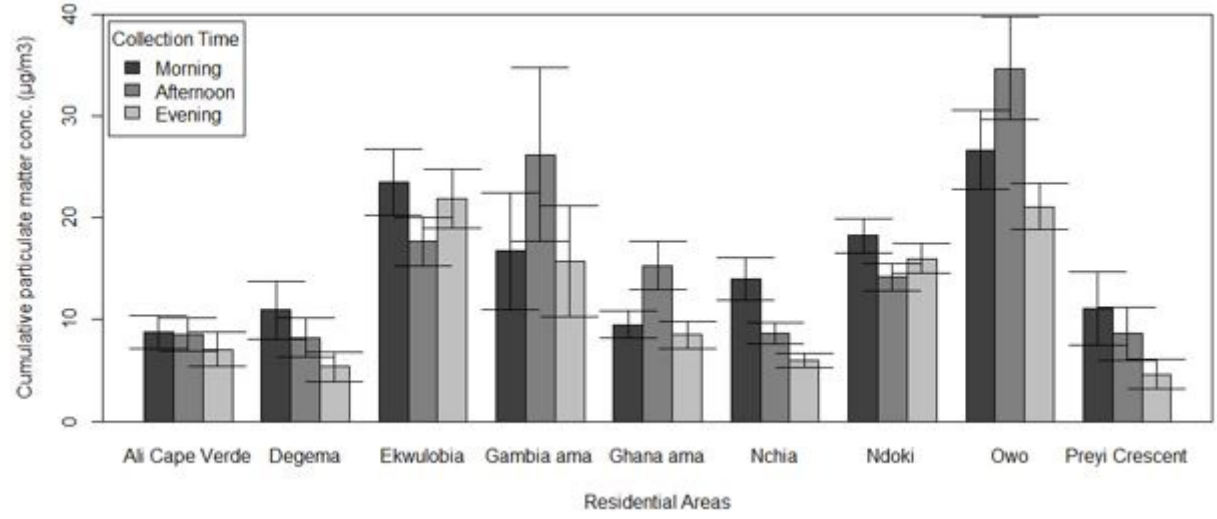

Figure 3: Cumulative particulate matter concentration at different collection times in different residential areas of Port Harcourt, Rivers State, Nigeria

Concentration of particulate matter and other substances

The concentration of particulate matter together with other harmful substances is not too different in indoor and outdoor areas of buildings as shown by the ANOVA result ($F_{1, 958}$ = 0.001, P=0.98; Figure 4). Nevertheless, TSP had the highest concentration followed by PM_{10} and $PM_{2.5}$ while VOC had the least concentration. Furthermore, in terms of collection times, there is difference in the concentration of particulate matter ($F_{2, 957}$ = 4.63, P<0.01; Figure 5). PM_{10} and TSP had higher concentrations in the morning hours. In contrast, $PM_{2.5}$ had higher concentration in the evening. while VOC had the least concentration. Since there was significant

difference at multiple time of sample collection, we did a Tukey HSD test, which revealed that the most significant difference in particulate matter concentration lies between morning and evening collection periods ($P<0.01$). The result indicates that TSP had the highest concentration followed by PM_{10}, $PM_{2.5}$ and VOC.

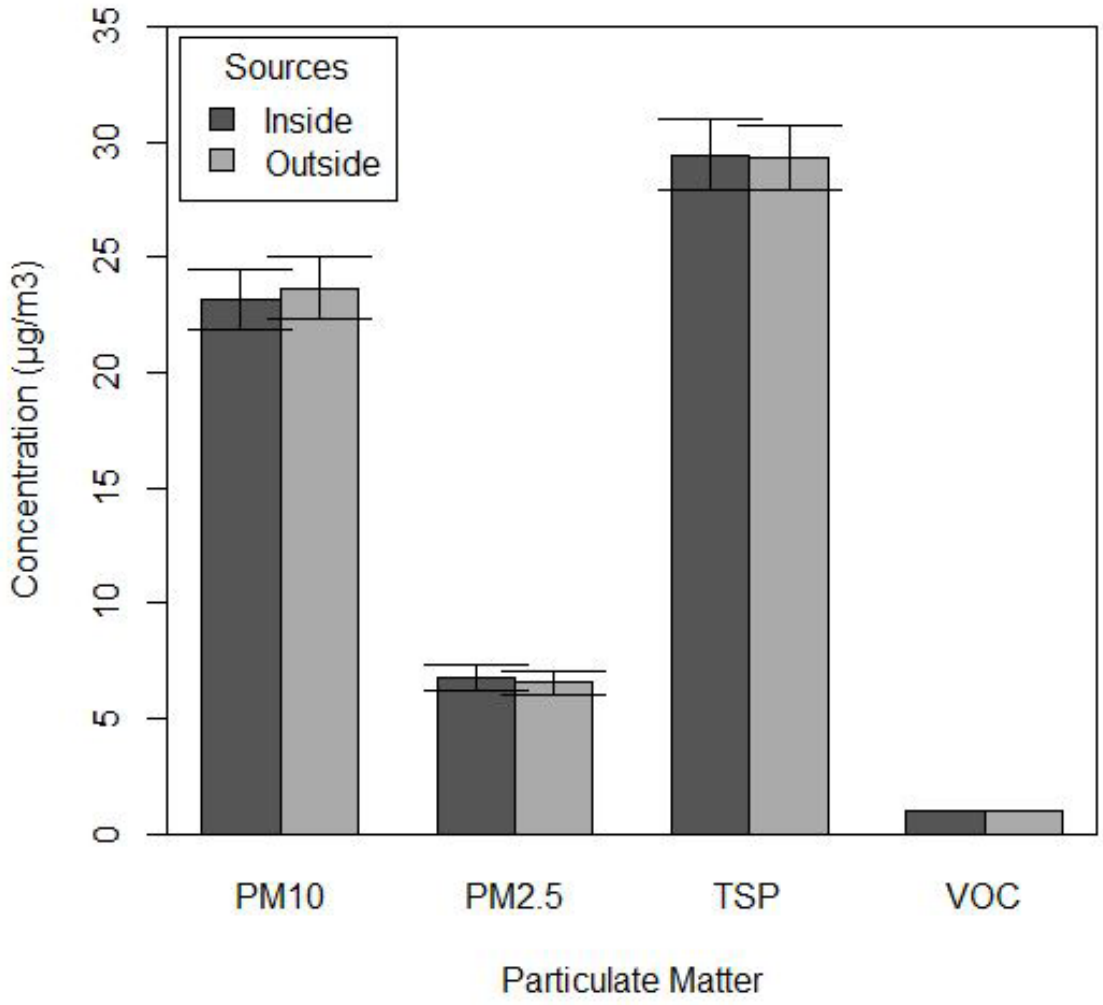

Figure 4: Concentration of some particulate matter within and outside building in some residential areas around Port Harcourt, Rivers State, Nigeria

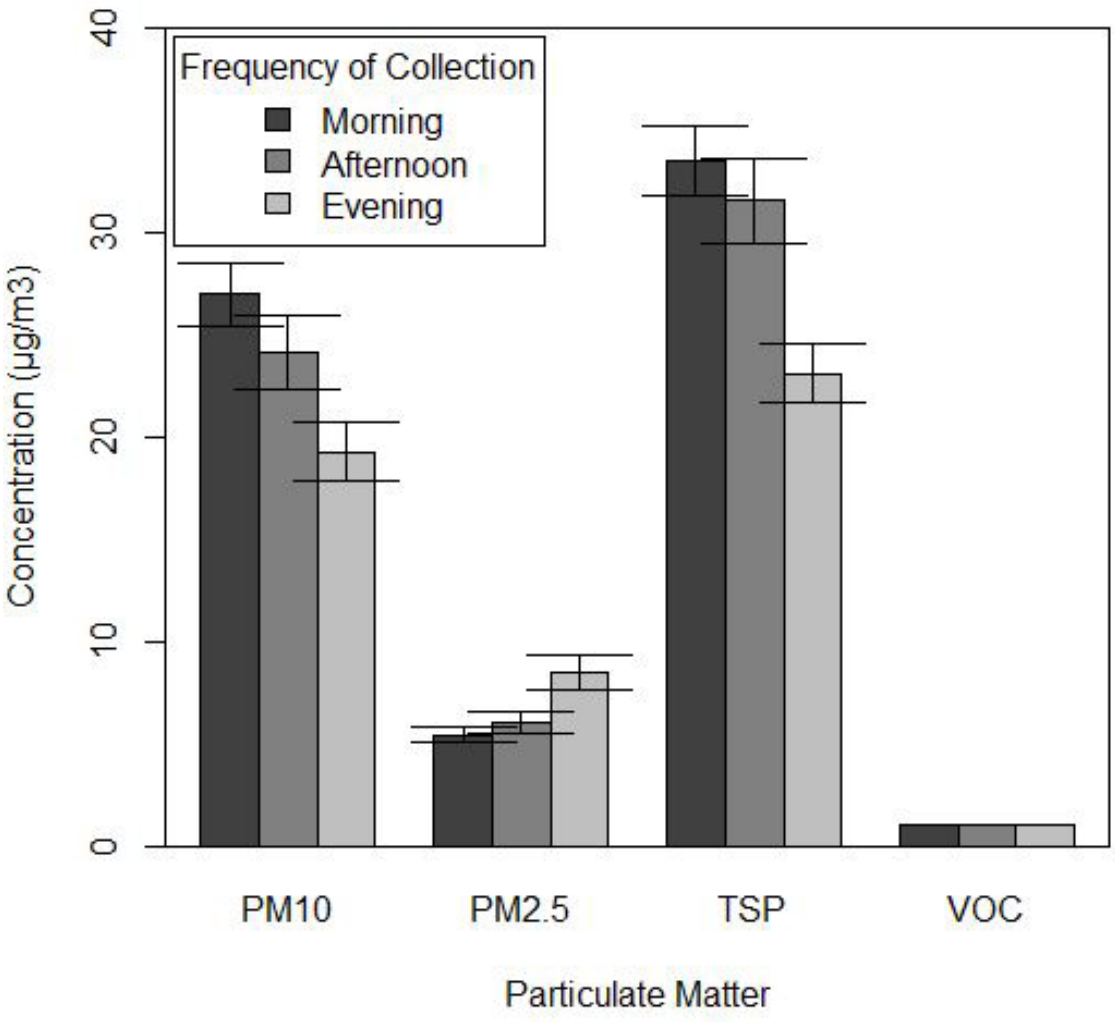

Figure 5: Concentration of some particulate matter at different times of collection gases in and outside some building apartment within Port Harcourt, Rivers State, Nigeria

Seasonal concentration of particulate matter and other substances

In the overall, seasons have limited effect on the distribution of particulate matter within the indoor and outdoor environments according to the ANOVA result ($F_{1, 1918} = 0.48$. P=0.49, Figure 6). However, individually, the bar chart shows that there was seasonal difference in the concentrations of PM_{10}, $PM_{2.5}$ and VOC. Summarily, the concentrations of PM_{10} and VOC were higher during the dry season while concentration of $PM_{2.5}$ was higher during the wet season.

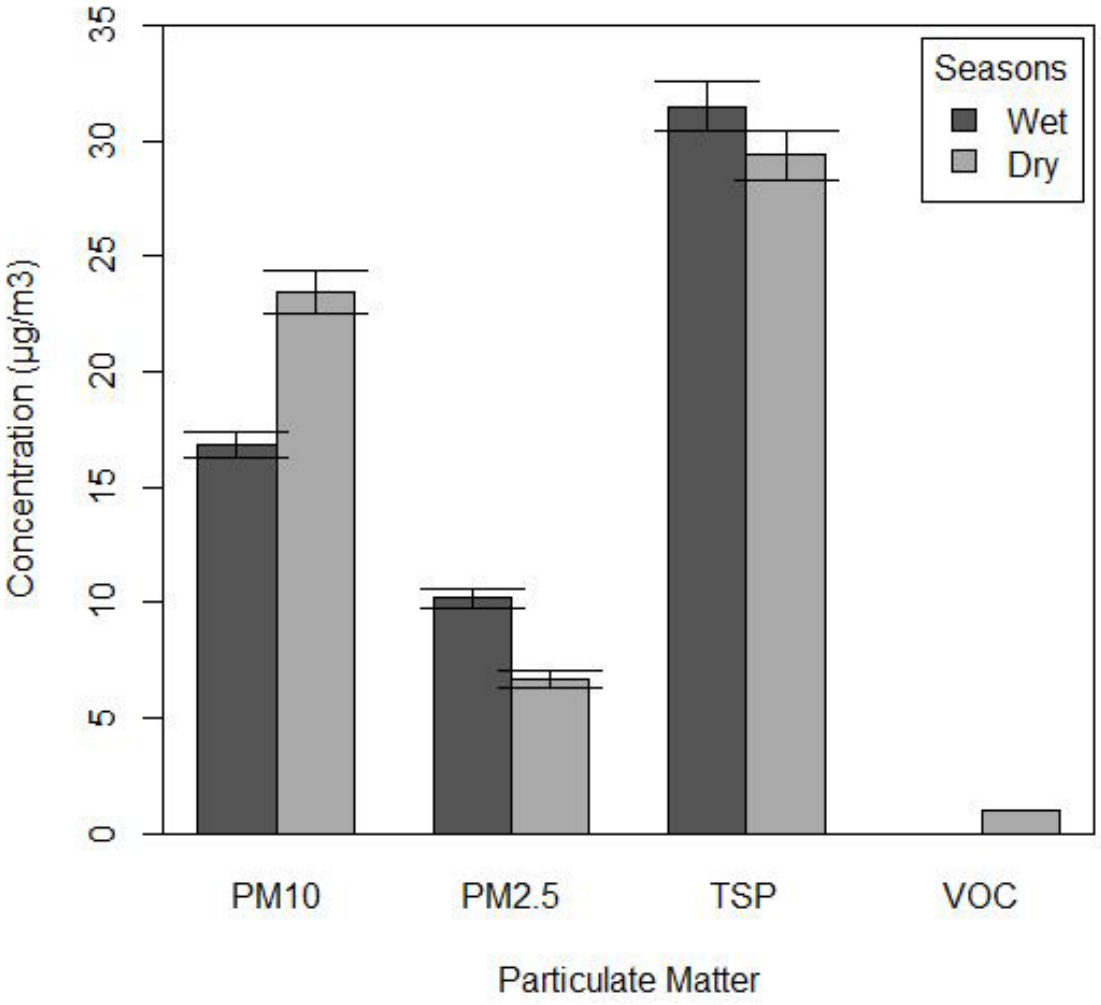

Figure 6: Concentration of some particulate matter during the wet and dry seasons around Port Harcourt, Rivers State, Nigeria

Concentration of pollutants at different settlement densities

Statistical assessment of air pollutants obtained in the high- and low-density areas in both the dry and wet seasons shows that total solid particles (TSP) had the highest concentration during the dry (48.83±18.55 ppm) and wet (44.23±21.70) seasons in high density areas as compared to VOC, PM_{10} and $PM_{2.5}$. Similarly, TSP had the highest concentration in wet season (27.08±18.55 ppm) while PM_{10} had the highest concentration in dry season (30.64±21.75).

In the overall the TSP concentration (118.57µg/m^3) was within the federal ministry of environment (FMEnv) limits of 250 µg/m^3. Similarly, the concentrations of $PM_{2.5}$ and PM_{10} were within WHO limits of 25 and 50 respectively in both the wet and dry seasons.

Discussion

Cumulative particulate matter concentration in residential areas

Cumulatively, the study shows that particulate matter concentrations inside and outside residential buildings vary. This is because different activities do occur inside and outside buildings which contribute to the production and distribution of harmful gases. In the external environment industrial, commercial and traffic activities lead to the proliferation of harmful gases in the atmosphere. Some of these activities include gas flaring from oil industries situated in the city. For instance, Port Harcourt is the host to a major refinery

in the country, the Eleme Petrochemical Industry, which supplies and exports crude oil to other refineries in the country and foreign countries for the purpose sale or refining. The production of crude oil by the Port Harcourt refinery thus serves as the major source of foreign exchange earner for the country. Continuous oil and gas exploration and exploitation to meet the demand for crude oil by the international market has resulted to the continuous flaring of gas without consideration for its health impact on the residents of the city, there is currently a proliferation of respiratory diseases such as asthma in the city (USEPA, 2003, Tran et al. 2020 [4,25].

Commercial activities such as markets and small-scale businesses contribute to urban air pollution by encouraging the burning of municipal wastes in the open and leading to the increase in vehicular activities around commercial centers. In addition, the use of small and giant generating sets to provide electricity to run the factories lead to emission of gases into the urban air space. Increased traffic from vehicular activities within the city is also a major cause of air pollution. This is because of the large population of car owners living within the city who drive to work and other places of interest.

The problem of illegal artisanal refinery around Port Harcourt is a growing problem in the city. This is because of the crude method they adopt in refining the crude oil, which results in the emission of black soot into the atmosphere (e.g., Yakubu, 2018) [25]. This soot infiltrates into residential areas and settles on almost every object within the indoor environment. Cooking, smoking and use of generating sets are some indoor activities that lead to the production of harmful gases. For instance, cooking with firewood and stove lead to the production of smoke and some gases that are derived from incomplete combustion. Residential areas where indoor or outdoor smokings are allowed also have high atmospheric pollutants.

Concentration of particulate matter and other substances at different times

The circulation of atmospheric pollutants is time-dependent; this is because our result shows that morning hours have the highest concentration of most atmospheric pollutants (i.e., PM_{10} and TSP (Figure 5), which is attributed to an increase in vehicular activities during the morning rush hour by workers. Furthermore, there was an increased concentration of $PM_{2.5}$ in the evening, which also shows that evening is a period of high vehicular activity during the time people go back to their houses. Based on our study afternoon has the least concentration of atmospheric pollutants because most persons are at their different worked post leading to a drop in vehicular traffic. Increased vehicular activities also lead to the blowing of roadside sand and dust particles into the atmosphere leading to the increase in solid particulate matter in the air.

Seasonal concentration of particulate matter and other substances

The distribution of atmospheric particulate matter is also not season-dependent as revealed by the statistical analysis. This means industrial, commercial, and vehicular activities have no season of operation at which particulate matter is released into the atmosphere. Therefore, they contribute to continuous production of pollutants into the atmosphere whether during the wet or the dry seasons. However, seasons can affect some pollution-generating activities such as gas flaring from refinery and release of smoke by vehicles. For instance, rainfall can wash away pollutants from the air resulting to "acid rain". Harmattan wind also blow particles of soil into the atmosphere, which mainly occur during the dry season between October and February of each year. However, because of global warning the effect of harmattan in Port Harcourt and neighboring cities have been reduced drastically. This is because now rain falls almost every month from January to December as compared to the past when there were seasonal differences.

Concentration of pollutants at different settlement densities

Another factor that leads to increased atmospheric pollution is the increase in human activities. High density areas have high human population and thus high emission of gases from vehicular, industrial and commercial activities. There is no significant difference between indoor and outdoor environment because pollutants are equally distributed in both environments. The higher indoor concentration of TSP in Mile 1 Diobu is because it is a commercial nerve center of the city and attracts large number of people

who come for business activities. . These business houses are usually powered by multiple generating sets that spew smoke into the internal and external environments. Businesses activities also attract buyers who drive into the area to buy goods or render one service or another. The area also witnesses the entry of commercial vehicles that supply goods and services to the marketers, which results to the increase in atmospheric pollutants in the area. Another significant observation during this study shows that most businesses in the Diobu area of Port Harcourt are established in the residences of people, who convert their living rooms to stalls and shops. These business houses use generating sets to provide electricity.

Conclusion

The study shows that elevated levels of outdoor pollutant led to a resultant elevation of indoor pollutants due to migration and infiltration of particulate matter through doors and windows in apartments. There were higher indoor pollutants in the high-density area during the dry season. The concentration of particulate matters PM_{10} and $PM_{2.5}$ do not show strong seasonal effect in both the high- and low-density residential areas. However, the $PM_{2.5}$ was found to be slightly higher in indoor environment in the low-density areas as compared to the high-density environment. Furthermore, the study indicates that commercial activities increase human activities, which in turn lead to increase in atmospheric pollutants as observed in the Mile 1 Diobu area of Port Harcourt which may be hazardous to health.

Recommendation

Based on this study we observe that in order to reduce the atmospheric pollution in Port Harcourt all kinds of burning activities should be stopped. For instance, the burning of firewood for cooking should be discouraged rather stoves and gas cooking methods should be adopted, which cause less pollution. The open burning of waste material should also be stopped because it emits harmful gases especially when toxic substances like plastics, tires and other petrochemical products are incinerated. Lastly, there should be regulations to prevent heavy duty vehiclesfrom driving during the day to prevent the emission of large volumes of smoke and harmful gases into the atmosphere when people are outside their homes carrying out their various activities.

References

1. Chernyaeva VA, Wang DH (2019) Regional Environmental Features and Health Indicators Dynamics. Pollution of the Earth's Atmosphere and International Air Quality Standards. In IOP Conference Series: Earth and Environmental Science 267 (6p) 062012), IOP Publishing.

2. Omer AM (2008) Energy, environment, and sustainable development. Renew and Sustain Energy Rev 12: 2265-300.

3. Ou J, Zheng L, Tang Q, Liu M, Zhang S (2021) Source analysis of heavy metals in atmospheric particulate matter in a mining city. Environ Geochem and Health 1-13.

4. Tran PT, Adam MG, Tham KW, Schiavon S, Pantelic J, et al. (2021) Assessment and mitigation of personal exposure to particulate air pollution in cities: An exploratory study. Sustain Cities and Soc 103052.

5. Burch SL, Harris SE (2021) Understanding climate change: Science, policy, and practice, University of Toronto Press, Canada.

6. Numbere AO (2021) Impact of Urbanization and Crude oil exploration in Niger Delta mangrove ecosystem and its livelihood opportunities: a footprint perspective In: Agroecological Footprints Management for Sustainable Food System, Springer, Singapore.

7. Breysse PN, Diette GB, Matsui EC, Butz AM, Hansel NN, et al. (2010) Indoor air pollution and asthma in children. Proc the Ame Thoracic Soc 7: 102-6.

8. Pérez-Padilla R, Schilmann A, Riojas-Rodriguez H (2010) Respiratory health effects of indoor air pollution. The Int J Tuberculosis and Lung Disease 14: 1079-86.

9. Numbere AO (2020) Utilization of the mangrove forest for sustainable renewable energy production. Prog in Petrochem Sci 3: 324-9.

10. Onwuka SU, Ezigbo CM, Eneche PSU (2017) Assessment of noise pollution from power generating sets: a case study of Nnewi-North LGA, Nigeria. J Sci Res Report 16: 1-12.

11. Bibi SD, Baig SA, Zeb I, Ali M, Shams DF, et al. (2021) Implication and evaluations of indoor soot particles from domestic fuel energy sources using characterization techniques in northern Pakistan. Microscopy Research and Technique.

12. López AF, Truchet DM, Rimondino GN, Maisano L, Spetter CV, et al. (2021) Microplastics and suspended particles in a strongly impacted coastal environment: composition, abundance, surface texture, and interaction with metal ions. Sci The Total Environment 754: 142413.

13. Singh G, Esmaeilpour M, Ratner A (2021) Effect of polymeric additives on ignition, combustion and flame characteristics and soot deposits of crude oil droplets. Combust Sci and Technol 1-29.

14. Guo C, Lv S, Liu Y, Li Y (2021) Biomarkers for the adverse effects on respiratory system health associated with atmospheric particulate matter exposure. J Hazard Mat 126760.

15. Tsai DH, Lin JS, Chan CC (2012) Office workers' sick building syndrome and indoor carbon dioxide concentrations. J Occupation and Environ Hygiene 9: 345-351.

16. Akhbarizadeh R, Dobaradaran S, Torkmahalleh MA, Saeedi R, Aibaghi R, et al. (2021) Suspended fine particulate matter (PM2. 5), microplastics (MPs), and polycyclic aromatic hydrocarbons (PAHs) in air: Their possible relationships and health implications. Environ Res 192: 110339.

17. Anakwue RC, Anakwue AC (2014) Cardiovascular disease risk profiling in Africa: Environmental pollutants are not on the agenda. Cardiovascular Toxicol 14: 193-207.

18. Hasager F, Bjerregaard JD, Bonomaully J, Knap H, Afshari A, et al. (2021) Indoor Air Quality: Status and Standards. Air Pollution Sources, Statistics and Health Effects 135-62.

19. Ephraim-Emmanuel BC, Ordinioha B (2021) Exposure and Public Health Effects of Polycyclic Aromatic Hydrocarbon Compounds in Sub-Saharan Africa: A Systematic Review. Int J Toxicol 40: 250-69.

20. Wan G, Bei L, Yu J, Xu L, Sun L (2021) Products distribution and hazardous elements migration during pyrolysis of oily sludge from the oil refining process. Chemosphere 132524.

21. Couto FT, Cardoso EHC, Costa MJ, Salgado R, Guerrero-Rascado JL, et al. (2021) How a mesoscale cyclonic vortex over Sahara leads to a dust outbreak in South-western Iberia. Atmospheric Res 249: 105302.

22. Gobo AE, Ubong IU, Ede PN, Inyang IS (2009) Indoor and outdoor air quality in selected restaurants and canteens in Port Harcourt Metropolis, Nigeria. Afr J Environ Pollut Health 7: 4-13.

23. Ayotamuno JM, Gobo AE (2004) Municipal solid waste management in Port Harcourt, Nigeria: Obstacles and prospects. Management of environmental quality: an international journal.

24. Echendu A, Georgeou N (2021) 'Not Going to Plan': Urban Planning, Flooding, and Sustainability in Port Harcourt City, Nigeria, In: Urban Forum, Springer, Netherlands.

25. Yakubu OH (2018) Particle (soot) pollution in Port Harcourt Rivers State, Nigeria—double air pollution burden? Understanding and tackling potential environmental public health impacts. Environments 5: 2.

26. Numbere AO, Camilo GR (2018) Effect of pollution and seasonal changes on litter fall and accumulation in mangrove forest (Rhizophora species) of the Niger Delta, Nigeria. J Environ Sci and Technol 11: 86-94.

27. World Health Organization (2006). Air quality guidelines: global update 2005: particulate matter, ozone, nitrogen dioxide, and sulfur dioxide, Geneva, Switzerland.

28. Bowling A (2014) Research methods in health: investigating health and health services, McGraw-hill education, UK.

29. Logan M (2010) Biostatistical design and analysis using R: a practical guide, John Wiley and Sons, England.

30. R Development Core Team (2013) R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria.

31. USEPA (2003) Air Quality Index: A Guide to Air Quality and Your Health (EPA-454/K-03-002), USA.

Submit your next manuscript to Annex Publishers and benefit from:

- Easy online submission process
- Rapid peer review process
- Online article availability soon after acceptance for Publication
- Open access: articles available free online
- More accessibility of the articles to the readers/researchers within the field
- Better discount on subsequent article submission

Submit your manuscript at
http://www.annexpublishers.com/paper-submission.php