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Original Research Article

Spatial Patterns of Particulate Matter and Respiratory Health Risks in Parts of Port Harcourt Metropolis

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Abstract

The rapid and continuous growth of Port Harcourt, Nigeria, have contributed to a surge in vehicular traffic, prompting concerns regarding air pollution and its health implications. This study to analyzed the spatial distribution of Particulate Matter (PM) in Port Harcourt and their possible effects on the respiratory health of residents of Port Harcourt Metropolis. Utilizing Geographic Information Systems (GIS) for mapping, air quality monitoring, this study identified pollution hotspots and investigated the prevalence of related respiratory health risks. The results demonstrate significant variations in PM concentrations across the study area, with high-emission zones associated with elevated rates of some respiratory illnesses. These findings emphasize the need for targeted interventions in air quality management and public health policies to reduce the detrimental effects of PM on respiratory health.

Keywords: *Spatial Distribution, Vehicular Emissions, Air Pollution, Health Impact, Health Risks, Port Harcourt, Nigeria, Air Quality, Urban Health, Pollution Awareness, Public Health, Environmental Health, Particulate Matter*.

1.0 INTRODUCTION

Clean air is fundamental to human life, yet air pollution continues to represent a major threat to this vital need and to the health of the environment on a global scale. This environmental issue is especially prevalent in urban settings, where air pollution is regarded as one of the most critical challenges. The monitoring of atmospheric pollutants, especially particulate matter and nitrogen oxides, is a complex undertaking [1]. Port Harcourt, which serves as the capital of Rivers State in the South-South region of Nigeria, is a rapidly developing city. This growth is reflected in its significant population and high levels of industrial and traffic activity. Consequently, the city's roads are frequently congested due to the increasing number of residents, with cars being the main factor behind air pollution [2]. Emissions by vehicles, comprising particulate matter (PM), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and carbon monoxide (CO), are correlated with numerous detrimental health effects, notably respiratory disorders including asthma, Chronic Obstructive Pulmonary Disease (COPD) and bronchitis [3].

Understanding how vehicular emissions are spatially distributed and their implications for respiratory health is critical for the development of effective environmental and public health policies. While air pollution is a well-recognized challenge in urban areas globally, there is a notable deficiency in studies that thoroughly explore the spatial characteristics of vehicular emissions in Port Harcourt and their direct relationship with respiratory health risks [4, 6].

Utilizing Geographic Information Systems (GIS) as a monitoring system presents advantages in estimating the spatial distribution of air quality, in contrast to traditional methods such as fixed monitoring stations, which constrain the understanding of pollutant distribution [7]. GIS has proven to be an invaluable tool for monitoring, with applications that include spatially assessing air quality in a region and developing spatial models to anticipate future air quality conditions in the area of study [8]. This paper explored the spatial distribution of particulate matter ($PM_{2.5}$ and PM_{10}) in parts of Port Harcourt Metropolis.

2.0 MATERIALS AND METHODS

2.1 Study Area

Port Harcourt is an emerging Mega City. It is undergoing an expansion initiative called the Greater Port Harcourt City (GPHC), which seeks to develop the city in phases over an extended timeframe. The GPHC includes six additional local government areas (LGAs) that are integrated into the original city. This study, however, focuses on the Metropolis, which encompasses the historical city areas of Port Harcourt City and Obio/Akpor LGAs.

Located in the Niger Delta region, Port Harcourt has a population that surpasses 1.8 million. The city is a significant center for the oil and gas industry, where road transportation is essential to the local economy. However, it faces persistent traffic congestion, which contributes to increased emissions from automobiles [3].

2.3 Sampling Techniques

2.3.1 Air Quality Monitoring

Air quality monitoring was conducted along four selected major roads (Port Harcourt-Aba Expressway, Ikwerre Road, Ada-George Road and Iwofe Road) across Port Harcourt Metropolis using the AEROQUAL 500 portable air quality measuring device. The primary pollutants measured were $PM_{2.5}$ and PM_{10}. Six monitoring sites were situated at major junctions along each of the four selected major roads. Air quality monitoring was carried out daily in the wet and dry season for 7 days consecutively.

2.3.2 Spatial Analysis Using GIS

Geographic Information Systems (GIS) was employed to map the spatial distribution of Particulate Matter ($PM_{2.5}$ and PM_{10}) across the study area. The data collected from air quality monitoring were used to generate the Spatial plots.

2.3.3 Health Data Collection

Health survey questionnaires were distributed within the neighbourhood of each of the selected roads. These included data on the prevalence of air pollution related respiratory illnesses. The health data were then compared with the emission hotspots.

2.4 Data Analysis

The SPSS software version 26 was used to analyse the data. Statistical techniques employed include the mean, Standard deviation (SD) and correlations.

3.0 RESULTS AND DISCUSSION

3.1 Results

3.1.1 $PM_{2.5}$ and PM_{10} during Dry and Wet Seasons in the Study Area

The dry and wet season distributions of $PM_{2.5}$ is presented in figure 1. The highest levels of $PM_{2.5}$ was found around the Ikwerre Road and Aba Road axis., representing 51.59ppm and 46.86ppm, respectively. Across the study area, the difference in $PM_{2.5}$ levels in the dry and wet seasons was statistically significant ($p=0.008$). Furthermore, t-test statistic for PM_{10} also revealed a statistically significant difference between the dry and wet season data at $p<0.001$(Figure 2).

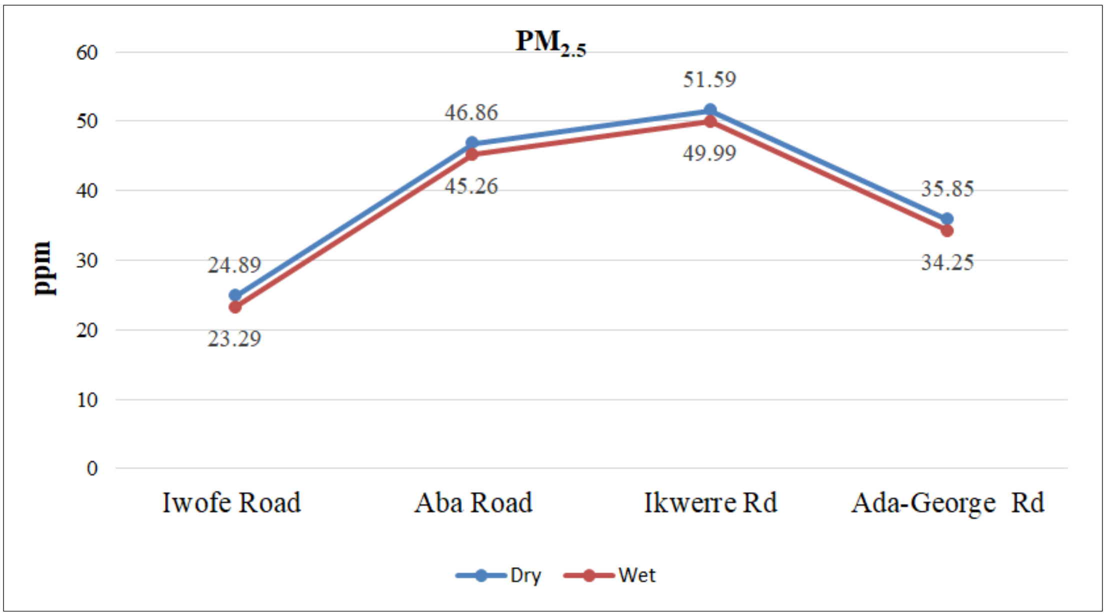


Figure 1: Distribution of $PM_{2.5}$ During Dry and Wet Seasons

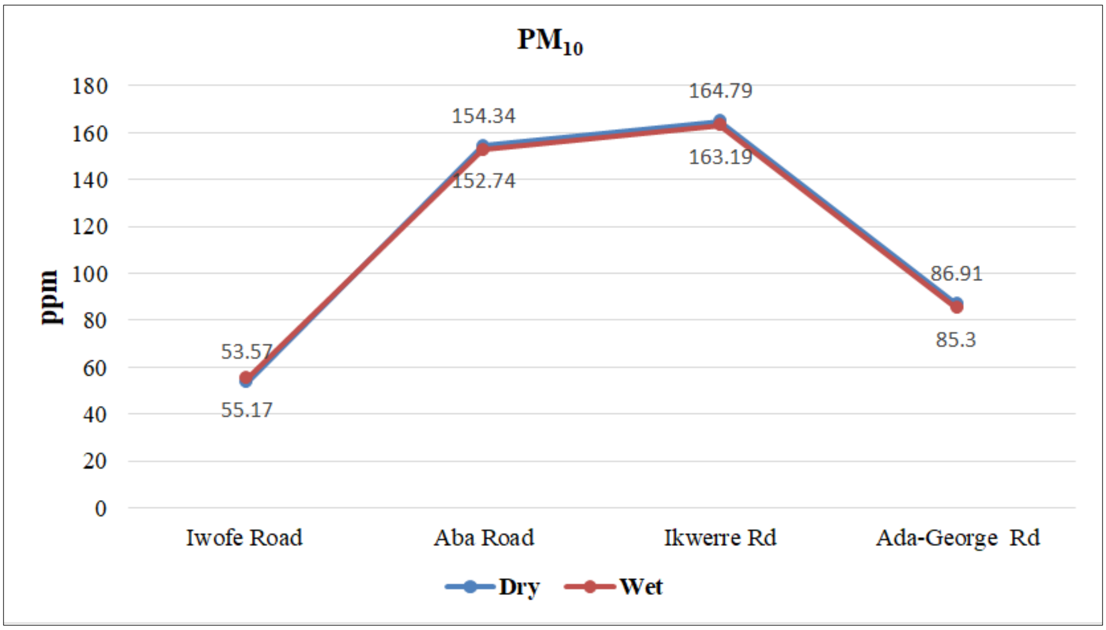


Figure 2: Distribution of PM_{10} during Dry and Wet Seasons

3.1.2 Spatial Distribution of $PM_{2.5}$ in Port Harcourt Metropolis

The World Health Organisation (WHO) Air Quality Guideline (AQG) concentration for $PM_{2.5}$ is 15ug/m^3. Although all parts of the metropolis had $PM_{2.5}$ values exceeding the WHO Air Quality Guideline (AQG) values of 15ug/m^3 daily ambient level, Rukpokwu, Rumuodumaya and Rumuokoro geographical area (North-East and South-East of the study area) had the highest $PM_{2.5}$ distribution of 48.63 – 56.52ug/m^3 (The Red Area in the GIS Map) (Figure 3.1), representing more than three times the WHO AQG value. Similarly, Waterlines and Garrison Axis also had very high $PM_{2.5}$ distribution (48.63 – 56.52 ug/m^3). Wimpy and Mile 3 Diobu, also had isolated very high $PM_{2.5}$ values of 48.63 – 56.52 ug/m^3 (Red Area in GIS Map), three times higher than the WHO AQG. However, the Water-Side, Ignatius Ajuru University Area and Big Tree Axis (the West and South-West axis of the study area) had $PM_{2.5}$ values of 17.09 - 24.98ug/m^3 (Green Area in GIS Map) which is close to the WHO AQG of 15ug/m^3.

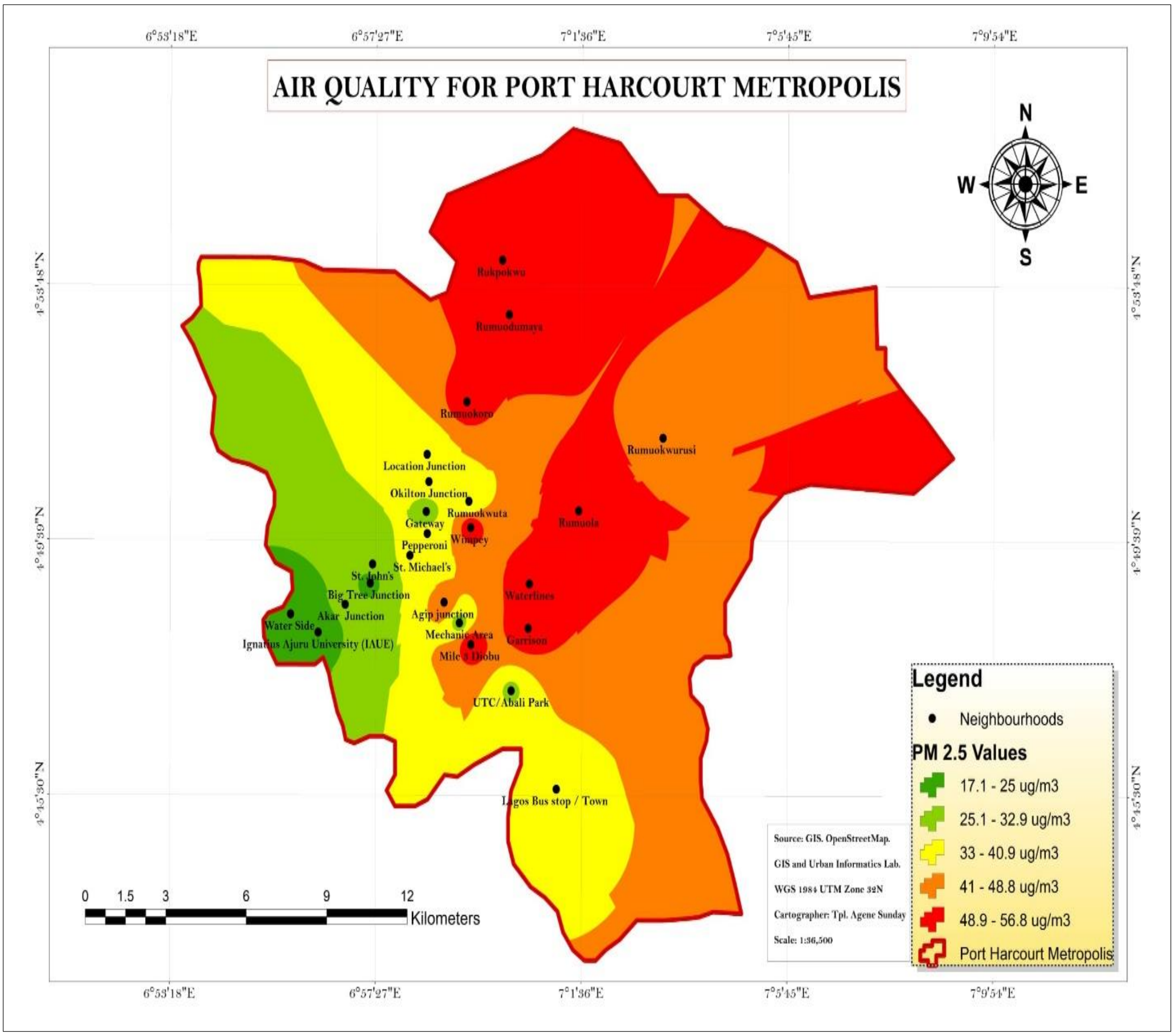


Figure 3.1: Spatial Distribution of Particulate Matter 2.5 (PM2.5) in Port Harcourt Metropolis

3.1.2 Spatial Distribution of PM_{10} in Port Harcourt Metropolis

The WHO AQG concentration for PM_{10} over 24-hour period is 45ug/m^3. The GIS map shows a high distribution of very high concentration of $PM_{2.5}$ (144.52 – 173.38ug/m^3) towards the North-East and South -East axis of the study area. Ikwerre Road (Rumuokoro, Rumuodumaya, Rukpokwu, Wimpy and Mile 3 Diobu) axis and the PH-Aba Road axis (Rumuokwurusi, Rumuola,Waterlines and Garrison areas)(Figure 3.2). These values represent over three times the WHO AQG values of 45ug/m^3. Furthermore, some areas in the Iwofe Road Axis (Waterside, Ignatius Ajuru, Akar Road and Big Tree Market) meet the WHO AIQ values of 45ug/m^3 (Around the West of the study area). Specifically, Waterside (29ug/m) and Ignatius Ajuru University Area (40.4ug/m^3), were below the WHO AQG concentration (Figure 3.2).

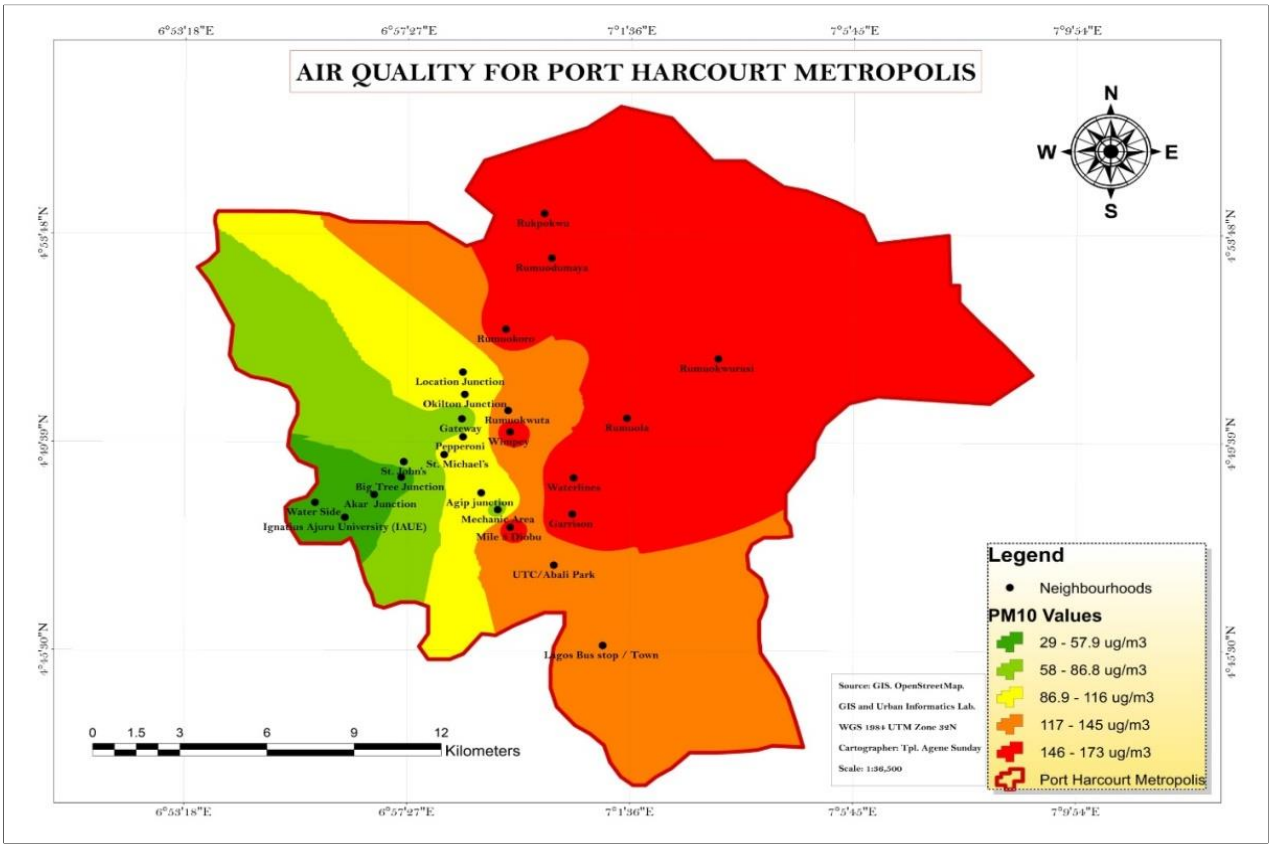
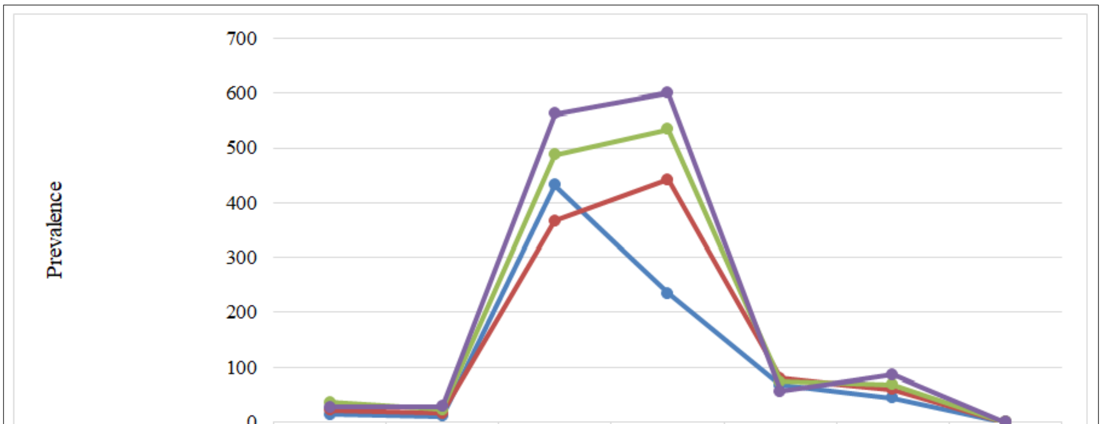


Figure 3.2: Spatial Distribution of Particulate Matter (PM_{10}) in Port Harcourt Metropolis

3.2 Prevalence of Respiratory Health Issues Associated with Vehicular Emissions

Figure 3.7 presents the prevalence of respiratory health issues associated with vehicular emissions.

The figure revealed a spike in most of the illnesses around the Iwofe and Ada George axis of the study area. This area represents the most polluted part of the study area as can be gleaned from Figure 3.1 to 3.6. The most prevalent respiratory health challenges include "Regular Coughing", and "Shortness of Breath". More serious respiratory diseases in the area were Congestive Obstructive Disease (COPD), Rhinitis and Chronic Bronchitis. There was no record of lung cancer.



	COPD	Asthma	Regular Coughing	Shortness of Breath	Rhinitis	Chronic Bronchitis	Lung Cancer
PH-Aba Expressway	14	11	432	235	67	44	0
Ikwerre Road	22	16	367	442	80	59	0
Ada-George Road	36	23	487	534	74	68	0
Iwofe Road	27	28	563	601	56	87	0

Figure 3.7: Prevalence of Respiratory Health Diseases in the Study Area

4.0 DISCUSSION

Spatial distribution of $PM_{2.5}$ and PM_{10} shows a pattern, mainly highest around the Rumuokoro, Rumuodumaya and Rukpokwu axis on Ikwerre Road. Also, Garrison and Waterlines showed similar high concentrations of $PM_{2.5}$ and PM_{10}. Isolated high red spots (highest concentrations) were also noticed around Wimpey and Mile 3 areas for $PM_{2.5}$, and Rumuokwurursi and Rumuola for PM_{10}. There was stastidtically signofcant difference netween the levels of $PM_{2.5}$ and PM10in wet and dry seasons at ($p=0.008$ and $p<0.001$ for $PM_{2.5}$ and PM_{10}, respectively). Levels of pollutants in the dry season were higher than in the wet season.

The study found the Iwofe and Ada George axis as the hotspots of most of the illnesses around the of the study area, which corresponds with the most polluted axis of the study area. This is demonstrated in the spatial analysis maps This area represents the most polluted part of the study area as can be gleaned from Figure 3.1 to 3.6. The most prevalent respiratory health challenges include "Regular Coughing", and "Shortness of Breath". More serious respiratory diseases in the area were Congestive Obstructive Disease (COPD), Rhinitis and Chronic Bronchitis. There was no record of lung cancer.

5.0 CONCLUSION

This study underscores the urgent need for policy interventions to mitigate the health risks associated with vehicular emissions in Port Harcourt. The spatial patterns of pollution identified in this study can be used to guide targeted interventions, such as improved traffic management, the promotion of cleaner technologies, and enhanced public health education.

6.0 RECOMMENDATIONS

This study advocates for the development of comprehensive and targeted educational campaigns aimed at highlighting the hazards of vehicular emissions, with a specific focus on their detrimental effects on the health of residents of Port Harcourt Metropolis.

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