EVALUATING AIR QUALITY DIFFERENCES: PM POLLUTION IN PORT HARCOURT VS. ILORIN VIA LOW-COST SENSORS

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ABSTRACT
Air pollution, particularly particulate matter (PM) pollution, poses significant dangers to public health and the environment. Port Harcourt and Ilorin, two major Nigerian cities, exhibit varying levels of industrial development, traffic density, and climate conditions, which may influence PM concentrations. However, limited studies have compared air quality between these cities using low-cost sensors, which offer an affordable alternative to conventional monitoring systems. Therefore, this study presents a comparative analysis of PM concentrations ($PM_{1.0}$, $PM_{2.5}$, and PM_{10}) in Port Harcourt and Ilorin, Nigeria, using high-frequency measurements from Clarity Node-S sensors deployed at River State University, Port Harcourt and the University of Ilorin ,Ilorin. The data, obtained at 60-minute intervals from January 2022 to February 2023, were calibrated to measure particle mass concentrations (µg/m³) across six size bins (0.3–10 µm). The results of the analyses show high pollution levels in both cities, with Port Harcourt having significantly higher concentrations across all PM sizes. Mean $PM_{1.0}$ (35.87 µg/m³), $PM_{2.5}$ (64.06 µg/m³) and PM_{10} (65.19 µg/m³) levels in Port Harcourt far exceeded WHO annual guidelines (5 µg/m³ and 15 µg/m³, respectively). the PM concentration was observed to be higher in the dry-season (December–February); this is probably linked to Harmattan winds and dusts. Statistical analysis emphasized right-skewed distributions (skewness: $PM_{2.5}$ = 1.05, PM_{10} = 1.29) and high kurtosis (PM_{10} = 2.37), confirming frequent extreme events. Ilorin's PM levels, though lower, also exceeded WHO standards, with mean $PM_{1.0}$ (27.41 µg/m³), $PM_{2.5}$ (39.89 µg/m³) and PM_{10} (47.63 µg/m³). In the Statistical analysis a kurtosis of −0.67 to −0.98 was obtained, which suggests less excesses than Port Harcourt. The maximum values of $PM_{2.5}$ (155.05 µg/m³) in Port Harcourt is about 2.7 times higher than the Ilorin's peak (57.51 µg/m³) and about six times higher than the WHO 24-hour limit (25 µg/m³). This result shows that both cities exhibited unsafe AQI levels during its maximum, which demands an urgent intervention. The findings reveal the contributions of traffic, industry, and climate to urban PM pollution and the associated health implications. Therefore, an expanded low-cost sensor networks, strict emission regulation in Port Harcourt is advised, to safeguard public health.

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Keywords: Particulate matter, air pollution, low-cost sensors, WHO guidelines, Port Harcourt, Ilorin, public health, air quality index

INTRODUCTION

Air pollution is a physical, biological or chemical alteration to the air in the atmosphere which occurs when any harmful gases, dust, smoke enters into the atmosphere and makes it difficult for plants, animals and humans to survive (Cole and Gray, 2015). It stands as a key danger to the health status of human, and it is more observable in many countries in West Africa as well as other industrialized nations (WHO, 2014). Since, the inception of exploration of oil and gas in Nigeria, Nigeria has experienced an increase in economic growth. As a result, our environment has become contaminated, unconducive and hazardous for man's peaceful inhabitation.

Particulate matter (PM) pollution is a significant environmental and public health concern in Nigeria, with varying concentrations across different regions due to industrialization, urbanization, and geographical factors (Owoade et al., 2021). The disparity in pollution levels across difffrent cities depicts the influence of localized sources and climatic conditions on air quality. Despite these variations, Nigeria lacks a robust national air quality monitoring network, making localized studies critical for understanding exposure risks and informing policy (Oladimeji et al., 2022).

Globally, the World Health Organization (WHO) sets air quality guidelines, recommending annual mean limits of 5 $\mu g/m^3$ for $PM_{2.5}$ and 15 $\mu g/m^3$ for PM_{10} to mitigate health risks (WHO, 2021). However, Nigerian cities frequently exceed these limits, with Port Harcourt recording $PM_{2.5}$ levels as high as 68 $\mu g/m^3$ during peak pollution periods (Nduka et al., 2020). With these continuous high rates in particulate matter pollution; affordable monitoring solutions, such as low-cost sensors become an imperative. This will help to bridge data gaps and support regulatory system where there is scarcity of funds (Oladimeji et al., 2022). Given Nigeria's rapid industrial development, evaluating air quality disparities between cities like Port Harcourt and Ilorin is essential for developing context-specific pollution control strategies (Owoade et al., 2021). While Port Harcourt's pollution is driven by industrial activities, Ilorin's challenges stem from natural and anthropogenic dust sources, necessitating different approaches (Adeniran et al., 2019). Studies have shown that PM10 levels frequently exceed WHO guidelines, particularly during the dry season when harmattan dust and reduced precipitation lead to poor air quality (Ogunjobi et al., 2018). Low-cost sensors present an opportunity to explore air quality data, fostering public awareness and policy action. According to (WHO) 2021; future research should focus on enhancing sensor networks, integrating community engagement, and aligning findings with WHO standards to reduce health risks. Addressing Nigeria's PM pollution crisis demands collaborative efforts among researchers, policymakers, and communities to achieve a sustainable air quality improvement.

Particulate matter pollution, especially fine particles ($PM_{2.5}$ and PM_{10}), is linked to severe health problems, including respiratory and cardiovascular diseases (World Health Organization [WHO], 2021). In Nigeria, studies have linked high PM pollution to increased hospital admissions for asthma and bronchitis, particularly in children and the elderly (Owoade et al., 2021). Long-term exposure to PM can lead to chronic bronchitis, asthma aggravation, and increased mortality rates (Cohen et al., 2017).

Port Harcourt's residents face heightened risks due to the aftermath effects of industrial and traffic-related emissions, while Ilorin's population struggles with seasonal dust exposure (Nduka et al., 2020; Adeniran et al., 2019). Without effective mitigation strategies, the economic burden of air pollution-related illnesses will continue to strain Nigeria's healthcare system (Oladimeji et al., 2022). Industrial activities, particularly oil and gas operations, dominate Port Harcourt's economy and contribute significantly to its air pollution trends. Studies have shown elevated levels of $PM_{2.5}$ and PM_{10}, frequently exceeding the World Health Organization (WHO) guidelines, especially near industrial zones and high-traffic areas (Nduka et al., 2018). Additionally, the city faces recurring events of black soot pollution, which has been linked to illegal oil refining, gas flaring, and vehicular emissions (Anejionu et al., 2015). Recent air quality monitoring efforts indicate worsening pollution trends, particularly in densely populated and industrialized neighborhoods like Eleme and Woji (Adeniran et al., 2019). The combination of industrial emissions, urbanization pressures, and climatic factors makes Port Harcourt a critical area for air quality research, highlighting the need for continuous monitoring and policy interventions to mitigate health and environmental risks.

Another major problem is environmental degradation, as PM contributes to reduced visibility, acid rain, and ecosystem damage (Karagulian et al., 2015). PM pollution affects low-income communities, near industrial zones or high-traffic areas (Landrigan et al., 2018).

From the literature review, some studies attribute high PM levels mainly to vehicular emissions (Adeniran et al., 2019), while others emphasize industrial activities and biomass burning (Owoade et al., 2020). These conflicting theories create ambiguity in formulating effective air quality policies. By analyzing Clarity Node-S measurements from both Port Harcourt and Ilorin, this study will contribute empirical evidence to clarify dominant pollution sources in each city, helping resolve these theoretical variations. In recent years, Ilorin has experienced rapid urbanization and population growth, leading to increased anthropogenic activities that impact air quality. While industrial activities are less intensive compared to cities like Port Harcourt or Lagos, major sources of particulate matter pollution in Ilorin include vehicular emissions, domestic biomass burning, and occasional dust storms during the harmattan season (Taiwo et al., 2014).

Low-cost sensors offer a viable solution for expanding air quality monitoring in Nigeria, providing real-time, localized data to assist the scarce regulatory measurements (Kumar et al., 2015). These sensors have been successfully deployed in other low-income regions to assess spatial and temporal pollution trends, enabling targeted interventions (Snyder et al., 2013). In Port Harcourt and Ilorin, such sensors could identify pollution hotspots, seasonal variations, and source contributions, empowering communities and policymakers to adopt evidence-based mitigation measures (Oladimeji et al., 2022).

A significant literature exists in existing studies on particulate matter (PM) pollution in Nigeria, as most research has focused on heavily industrialized cities like Lagos and Abuja, leaving secondary cities such as Port Harcourt and Ilorin underrepresented (Owoade et al., 2020). While some studies have examined air pollution in Port Harcourt due to its oil industry, Ilorin—a less industrialized but rapidly urbanizing city—has received minimal attention (Nduka et al., 2018). This oversight limits the understanding of how varying urban and industrial activities influence PM levels across different Nigerian cities. The present study addresses this gap by conducting a comparative analysis of PM pollution in both cities, providing insights into how different urban and economic profiles affect air quality. Moreover, this study intends to adopt the use of statistical analyses, including temporal trend assessments and air quality index (AQI) comparisons, this will ensure a robust evaluation of the pollution patterns in both cities. By adopting this approach, the research provides a more comprehensive procedure for future air quality studies in similar urban environments.

Study Area

Port Harcourt is a major urban center located in southern Nigeria, serving as the capital of Rivers State. Geographically, it lies between latitudes 4°45' N and 4°55' N and longitudes 6°55' E and 7°05' E, situated along the Bonny River in the Niger Delta region (Anejionu et al., 2015). The city experiences a tropical monsoon climate characterized by high humidity, significant rainfall, and relatively stable temperatures averaging 27°C throughout the year (Nduka et al., 2018). The wet season typically lasts from April to October, with heavy precipitation often exceeding 2,000 mm annually, while the dry season spans November to March, marked by reduced rainfall and occasional harmattan winds carrying dust from the Sahara (Adeniran et al., 2019). These climatic conditions influence air pollution dispersion, often leading to higher concentrations of particulate matter (PM) during the dry season due to reduced atmospheric cleansing from rain.

Ilorin is a city in North Central Nigeria, serving as the capital of Kwara State. Geographically, it is located between latitudes 8°30' N and 8°35' N and longitudes 4°30' E and 4°35' E, situated approximately 300 kilometers northeast of Lagos (Adelekan & Gbadegesin, 2005). The city lies within the transitional zone between the tropical rainforest of southern Nigeria and the savanna vegetation of the northern region, giving it a unique ecological characteristic. Ilorin experiences a tropical savanna climate with distinct wet and dry seasons. The wet season typically lasts from April to October, with peak rainfall occurring between June and September, while the dry season spans November to March and is characterized by the influence of harmattan winds carrying dust from the Sahara Desert (Adefolalu, 2007). Annual rainfall averages about 1,200mm, with temperatures ranging between 21°C and 37°C throughout the year (Ogunjobi et al., 2018).

METHODS AND MATERIALS

Sources of data:

The study utilized particulate matter ($PM_{1.0}$, $PM_{2.5}$, and $PM_{10.0}$) concentration data obtained from Clarity Node-S air quality monitoring stations installed at two strategic locations: Rivers State University in Port Harcourt and the University of Ilorin. These sensors were selected due to their proven reliability in measuring fine and coarse particulate matter in urban environments (Sousan et al., 2021). The dataset covers a comprehensive 14-month period from January 2022 to February 2023, capturing seasonal variations in air quality across both cities. Measurements were recorded at 60-minute intervals to ensure high temporal resolution, which is critical for analyzing diurnal patterns and short-term pollution events (Miskell et al., 2018).

All raw data were accessed and downloaded from the Clarity.io cloud-based platform (https://www.clarity.io), which provides real-time and historical air quality measurements from networked sensors. Following data acquisition, a rigorous quality assurance process was implemented to ensure dataset integrity. This involved removing duplicate entries, filtering out sensor malfunction periods (as indicated by null or anomalous values), and applying calibration corrections where necessary (Zusman et al., 2022). The validated hourly PM measurements were subsequently processed into daily mean concentrations for each pollutant ($PM_{1.0}$, $PM_{2.5}$, and $PM_{10.0}$) to facilitate trend analysis and reduce the influence of transient measurement fluctuations. This data aggregation approach aligns with established air quality research methodologies that use daily averages to assess long-term exposure risks (WHO, 2021). The use of identical sensor models at both study locations ensured methodological consistency in measurements, while their installation at university campuses provided representative urban background pollution levels, avoiding direct interference from localized emission sources like industrial stacks or major roadways (Feinberg et al., 2019). Following data validation, hourly measurements were aggregated into daily mean concentrations for each pollutant parameter. This temporal normalization reduces stochastic variability while preserving meaningful pollution trends (WHO, 2021). The processed data was exported in CSV format and subjected to comprehensive statistical analysis using Microsoft Excel.

Particulate matter:

Particulate matter (PM) is classified by aerodynamic diameter, with different size fractions exhibiting distinct properties, sources, and health impacts.

PM_{10} (particles ≤ 10 μm) represents the coarse fraction that can penetrate the upper respiratory system. These particles primarily originate from natural sources like wind-blown dust, sea spray, and pollen, as well as anthropogenic activities including construction, road dust resuspension, and industrial processes (WHO, 2021). While PM_{10} can irritate the eyes, nose, and throat, its larger size prevents deep lung penetration, making it less hazardous than finer fractions (Brook et al., 2010). However, chronic exposure remains concerning as these particles often carry adsorbed toxic compounds, including heavy metals and polycyclic aromatic hydrocarbons (PAHs), which may leach upon deposition in the respiratory tract (Jalava et al., 2015).

$PM_{2.5}$, (particles ≤ 2.5 μm) poses greater health risks due to its ability to reach the alveolar region of the lungs and enter systemic circulation. Dominated by combustion byproducts from vehicles, power plants, and biomass burning, $PM_{2.5}$ has a longer atmospheric residence time (days to weeks) compared to PM_{10} (hours to days) (Seinfeld & Pandis, 2016). Epidemiological studies consistently associate $PM_{2.5}$ exposure with cardiovascular disease, respiratory illness, and premature mortality, even at concentrations below regulatory limits (Pope et al., 2020).

PM_1 (particles ≤ 1 μm) represent the most penetrative fraction, capable of crossing pulmonary membranes and reaching extrapulmonary organs. Generated predominantly through high-temperature combustion processes (e.g., diesel engines, industrial flares), these nanoparticles exhibit unique physicochemical properties due to their nanoscale dimensions (Oberdörster et al., 2005). Their high particle number concentration and large surface area enhance biological reactivity, potentially triggering inflammatory responses at cellular levels (Heal et al., 2012).

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Data Analysis

WHO recommended safe limits

The World Health Organization (WHO) sets guidelines for air quality to minimize health risks associated with particulate pollution. These guidelines are based on annual and daily average concentrations (WHO 2021):

$PM_{2.5}$ (Fine Particles)

- Annual mean: 5 µg/m³ (reduced from 10 µg/m³ in 2005 guidelines)
- 24-hour mean: 15 µg/m³ (reduced from 25 µg/m³)

PM_{10} (Coarse Particles)

- Annual mean: 15 µg/m³ (reduced from 20 µg/m³)
- 24-hour mean: 45 µg/m³ (reduced from 50 µg/m³)

Statistical analyses

Standard deviation was used to measure the dispersion of PM concentrations around the mean, indicating variability. The equation for sample standard deviation is:

$$s = \sqrt{(\Sigma(x_i - \bar{x})^2 / (n - 1))} \qquad (1).$$

where x_i is each PM concentration value,

$\bar{x}$ is the mean,

and n is the number of observations. This equation quantifies the consistency of PM levels, with higher values indicating greater variability due to factors like seasonal changes.

RESULTS AND DISCUSSION

1. Port Harcourt (Dry Season)

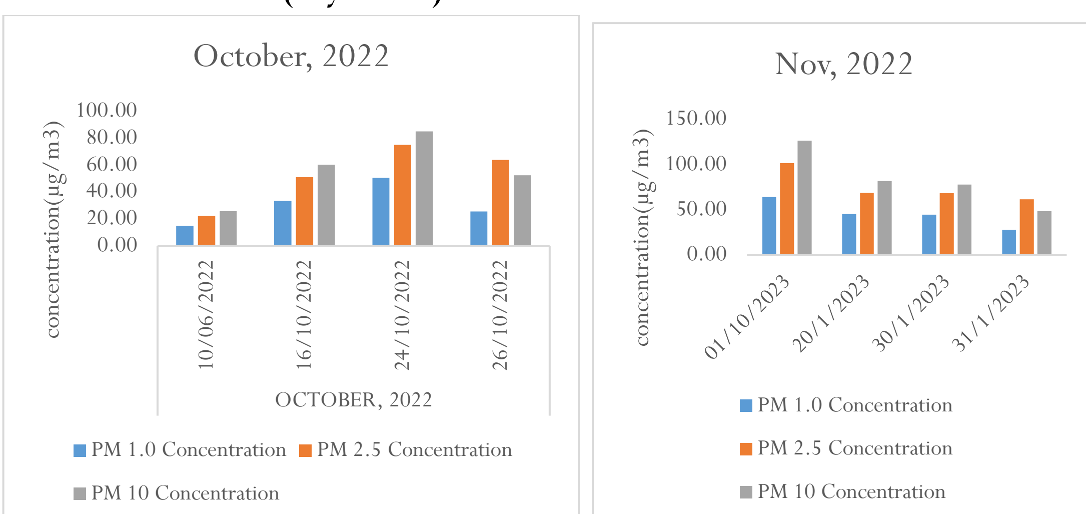

Figure 1: Concentration levels of PM 1.0, PM 2.5 and PM 10.0 in the month of Oct and Nov, 2022 (Port Harcourt)

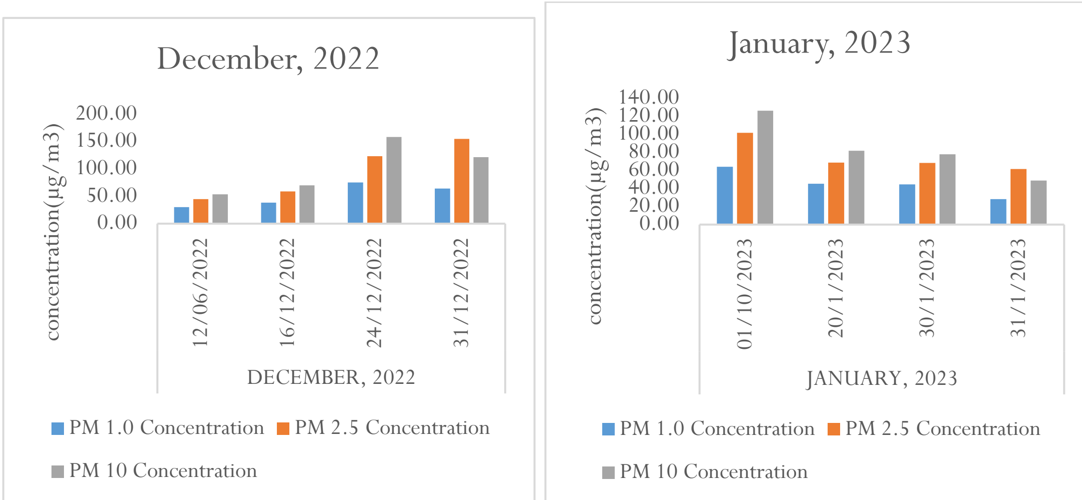

Figure 2: Concentration levels of PM 1.0, PM 2.5 and PM 10.0 in the month of December, 2022 and January, 2023 (Port Harcourt)

Figure 3: Concentration levels of PM 1.0, PM 2.5 and PM 10.0 in the month of February and March, 2023 (Port Harcourt)

Port Harcourt (Wet Season)

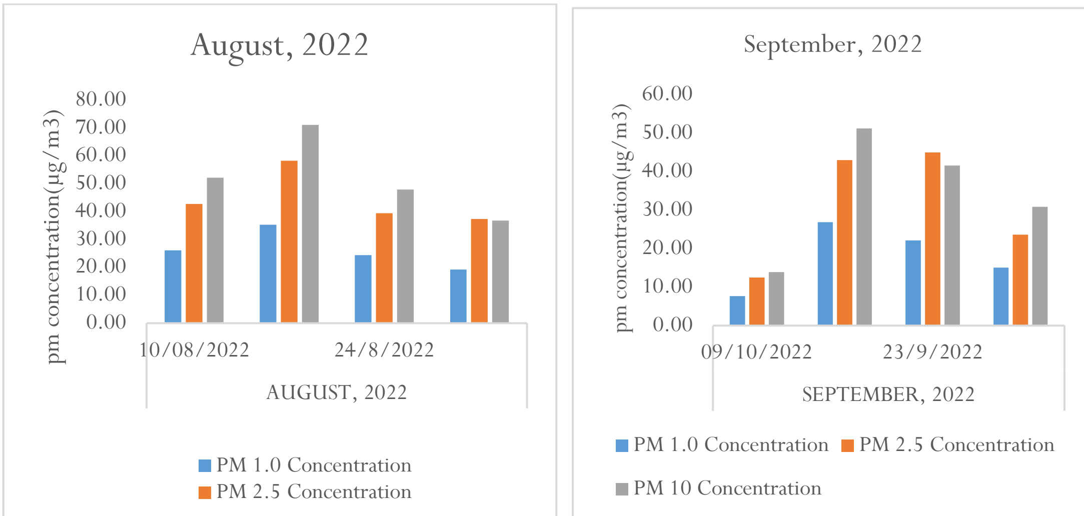

Figure 4: Concentration levels of PM 1.0, PM 2.5 and PM 10.0 in the month of August and September, 2023 (Port Harcourt)

Ilorin (Dry Season)

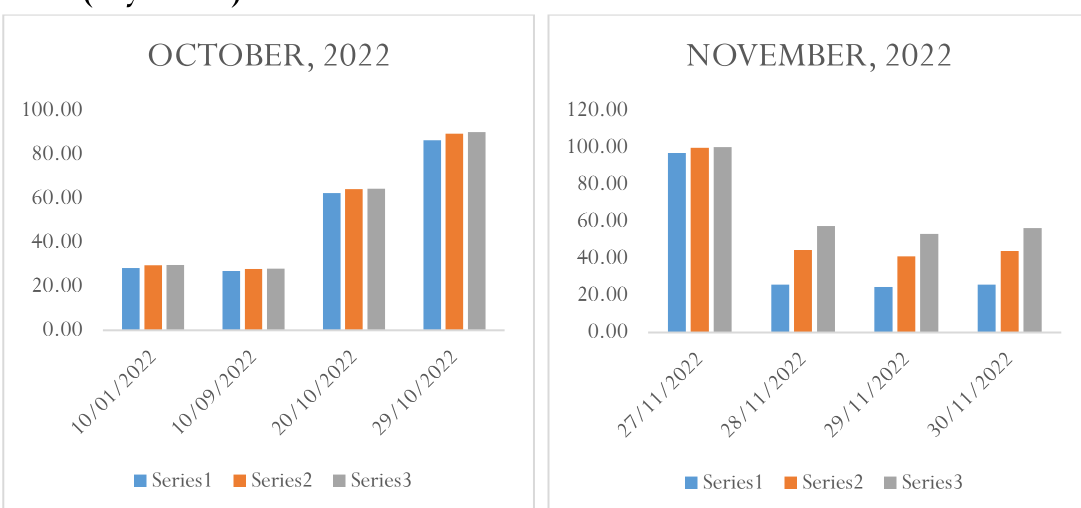

Figure 5: Concentration levels of PM 1.0, PM 2.5 and PM 10.0 in the month of October and November, 2022 (Ilorin)

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Figure 6: Concentration levels of PM 1.0, PM 2.5 and PM 10.0 in the month of December and January, 2022 (Ilorin)

Ilorin (Wet Season)

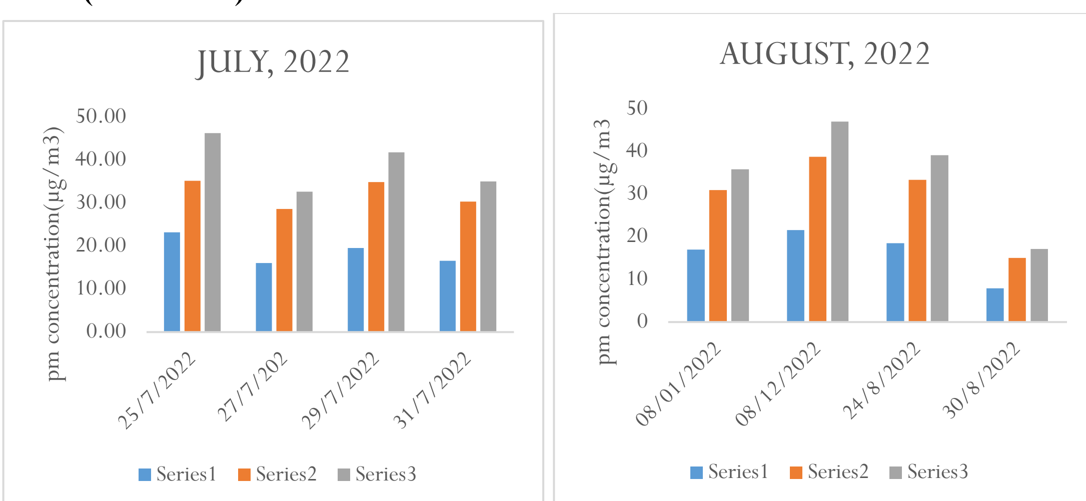

Figure 5: Concentration levels of PM 1.0, PM 2.5 and PM 10.0 in the month of July and August, 2022 (Ilorin)

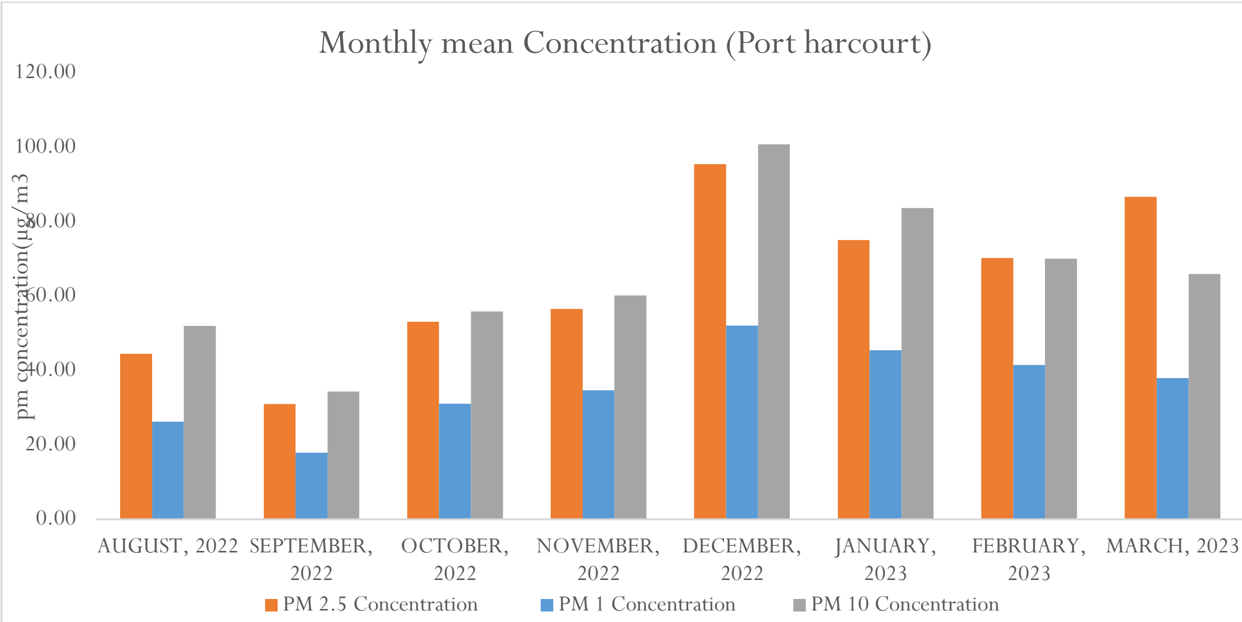

Figure 6: Monthly Mean Concentration levels of PM 1.0, PM 2.5 and PM 10.0 (2022- 2023) (Port Harcourt)

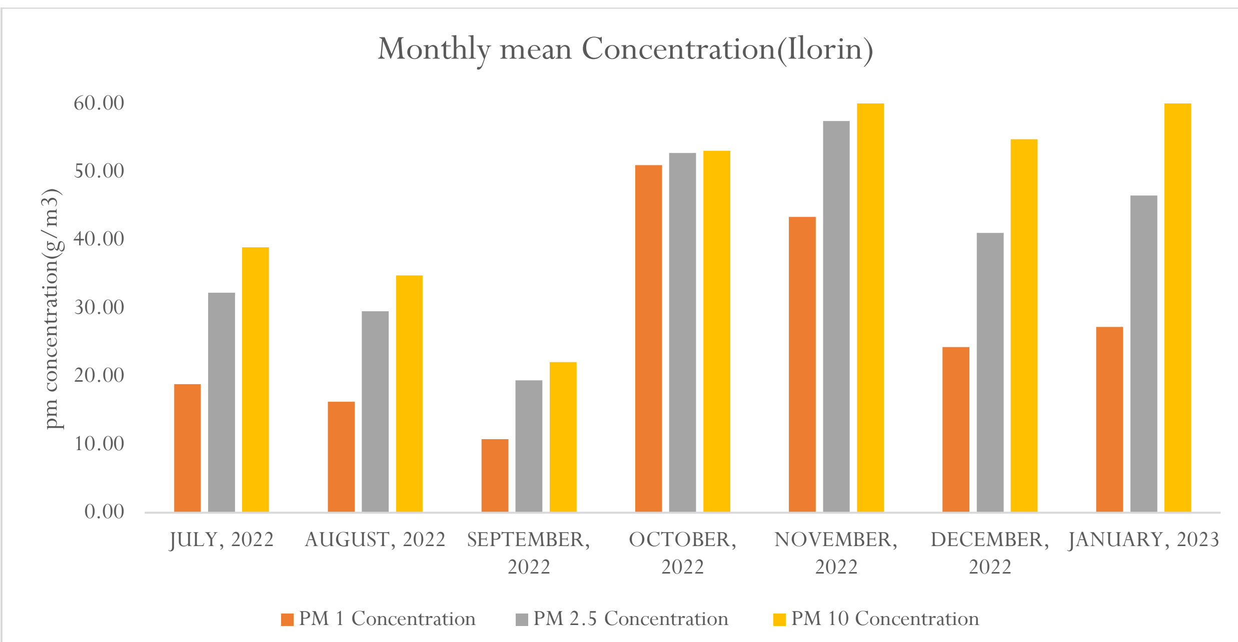

Figure 7: Monthly Mean Concentration levels of PM 1.0, PM 2.5 and PM 10.0 (2022) (Ilorin)

Statistical Analysis

The results of the statistical analysis of the concentration of the particulate matter in Port Harcourt and Ilorin, are given below.

Table 1: Result of the Statistical Analysis for Port Harcourt Station

	PM 1.0(μg/m³)	PM 2.5(μg/m³)	PM 10(μg/m³)
Mean	35.87	64.06	65.19
STD	15.42	30.25	30.06
VAR	237.85	915.10	903.58
MAX	75.40	155.05	158.48
MIN	7.68	12.46	13.89
Kurtosis	0.33	1.59	2.37
Skewness	0.68	1.05	1.29

Table 2: Result of the Statistical Analysis for Ilorin Station

	PM 1.0(μg/m³)	PM 2.5(μg/m³)	PM 10(μg/m³)
Mean	27.41	39.89	47.63
STD	14.69	13.57	16.18
VAR	215.94	184.19	261.82
MAX	51.02	57.51	66.94
MIN	10.81	19.45	22.12
Kurtosis	-0.67	-1.06	-0.98
Skewness	0.78	-0.20	-0.45

Table 3: Comparison between PM concentration in Port Harcourt station and Ilorin station

	PORTHARCOURT			ILORIN		
	PM1.0 (μg/m³)	**PM2.5 (μg/m³)**	**PM10 (μg/m³)**	**PM 1.0 (μg/m3)**	**PM 2.5 (μg/m3)**	**PM 10 (μg/m3)**
Mean	35.87	64.06	65.19	27.41	39.89	47.63
STD	15.42	30.25	30.06	14.69	13.57	16.18
VAR	237.85	915.1	903.58	215.94	184.19	261.82
MAX	75.4	155.05	158.48	51.02	57.51	66.94
MIN	7.68	12.46	13.89	10.81	19.45	22.12
Kurtosis	0.33	1.59	2.37	-0.67	-1.06	-0.98
Skewness	0.68	1.05	1.29	0.78	-0.2	-0.45

Discussion of Results

The monthly mean concentrations of particulate matter (PM) in Port Harcourt from August 2022 to March 2023 reveal notable seasonal variations in air pollution levels. PM_{10} consistently recorded the highest concentrations, peaking at approximately 120 μg/m³ in December 2022, followed by $PM_{2.5}$, which reached around 100 μg/m³ during the same period. PM_1 concentrations were comparatively lower but still significant, with levels hovering between 40–60 μg/m³. The elevated PM levels in December coincide with the harmattan season, a period characterized by increased dust transport from the Sahara Desert and heightened local combustion activities, including bush burning and fossil fuel use for heating (Nduka et al., 2021). This seasonal spike aligns with findings from other Nigerian cities, such as Lagos and Kano, where harmattan-driven PM surges have been documented (Ede & Edokpa, 2017).

The gradual decline in PM concentrations from January to March 2023 suggests improved air quality as the harmattan season decreases. However, PM levels remained above the World Health Organization (WHO, 2021) 24-hour guidelines ($PM_{2.5}$: 15 μg/m³, PM_{10}: 45 μg/m³), underscoring persistent air pollution challenges. Compared to cities like Ilorin and Abuja, where $PM_{2.5}$ averages range between 30–50 μg/m³ during harmattan (Oguntoke et al., 2019), Port Harcourt's PM levels are markedly higher, likely due to industrial emissions, gas flaring, and vehicular pollution (Nwachukwu et al., 2020).

The monthly mean concentrations of particulate matter (PM) in Ilorin from July 2022 to January 2023 demonstrate distinct seasonal variations, though with notably lower pollution levels compared to industrial cities like Port Harcourt. PM_{10} concentrations were consistently the highest, peaking at approximately 50 μg/m³ in December 2022, followed by $PM_{2.5}$ (40 μg/m³) and PM_1 (30 μg/m³). This pattern mirrors the seasonal influence of the harmattan period, when increased dust transport from the Sahara Desert elevates PM levels across West Africa (Ede & Edokpa, 2017). However, Ilorin's peak PM_{10} in December was less than half of Port Harcourt's 120 μg/m³ during the same period, stressing the city's relatively better air quality due to fewer industrial emissions and less vehicular emissions (Oguntoke et al., 2019).

From July to October 2022, PM levels remained stable (PM_{10}: 20–30 μg/m³), reflecting the cleaner wet season when rainfall suppresses dust and combustion-related particles. The gradual rise from November to December aligns with harmattan onset, though Ilorin's $PM_{2.5}$ (40 μg/m³) and PM_{10} (50 μg/m³) maxima were still below Port Harcourt's harmattan peaks ($PM_{2.5}$: 100 μg/m³, PM_{10}: 120 μg/m³) (Nduka et al., 2021). Ilorin's moderate pollution levels suggest geographic and anthropogenic advantages. Nevertheless, all recorded values exeeded WHO (2021) 24-hour guidelines ($PM_{2.5}$: 15 μg/m³, PM_{10}: 45 μg/m³), emphasizing Nigeria's prevalent poor air quality.

The statistical analysis of particulate matter (PM) concentrations in Port Harcourt and Ilorin reveals significant differences in air quality between the two cities. In Port Harcourt, the mean PM levels were substantially higher, with $PM_{1.0}$ at 35.87 μg/m³, $PM_{2.5}$ at 64.06 μg/m³, and PM_{10} at 65.19 μg/m³, compared to Ilorin, where mean concentrations were lower at 27.41 μg/m³ ($PM_{1.0}$), 39.89 μg/m³ ($PM_{2.5}$), and 47.63 μg/m³ (PM_{10}). These values exceed the World Health Organization (WHO, 2021) 24-hour guidelines ($PM_{2.5}$: 15 μg/m³, PM_{10}: 45 μg/m³), indicating poor air quality in both locations, though Port Harcourt's pollution levels are more severe. The higher PM levels in Port Harcourt can be attributed to industrial activities, vehicular emissions, and frequent gas flaring from oil exploration, which are major pollution sources in the Niger Delta region (Nduka et al., 2021). In contrast, Ilorin, while still polluted, has comparatively lower industrial activity and less intense vehicular traffic, leading to relatively better air quality (Oguntoke et al., 2019).

The variability in PM concentrations, as indicated by standard deviation (STD) and variance (VAR), was more pronounced in Port Harcourt, particularly for $PM_{2.5}$ (STD: 30.25, VAR: 915.10) and PM_{10} (STD: 30.06, VAR: 903.58), compared to Ilorin ($PM_{2.5}$ STD: 13.57, VAR: 184.19; PM_{10} STD: 16.18, VAR: 261.82). This suggests that Port Harcourt experiences wider fluctuations in air pollution, likely due to irregular industrial emissions and pollution events such as gas flaring (Nwachukwu et al., 2020). The maximum PM values in Port Harcourt ($PM_{2.5}$: 155.05 µg/m³, PM_{10}: 158.48 µg/m³) were very high, far more than those in Ilorin ($PM_{2.5}$: 57.51 µg/m³, PM_{10}: 66.94 µg/m³), supporting the city's severe pollution problem.

The distribution of PM concentrations also differed between the two cities. Port Harcourt exhibited positive skewness ($PM_{1.0}$: 0.68, $PM_{2.5}$: 1.05, PM_{10}: 1.29) and positive kurtosis ($PM_{1.0}$: 0.33, $PM_{2.5}$: 1.59, PM_{10}: 2.37), indicating a right-skewed distribution with frequent moderate levels and occasional extreme peaks. In contrast, Ilorin showed negative kurtosis ($PM_{1.0}$: -0.67, $PM_{2.5}$: -1.06, PM_{10}: -0.98) and mixed skewness ($PM_{1.0}$: 0.78, $PM_{2.5}$: -0.20, PM_{10}: -0.45), suggesting a flatter distribution with fewer extreme values. This contrast highlights that while both cities experience pollution, Port Harcourt's air quality is more frequently disrupted by severe pollution activities. Previous studies in Nigeria have recorded similar trends, with industrial cities like Port Harcourt showing higher PM levels than less industrialized regions (Ede & Edokpa, 2017). The findings show the need for air quality management strategies, particularly in Port Harcourt, where pollution sources are more intense and variable.

CONCLUSION

The study carried out an investigation on the variations of the particulate matter pollutions in Port harcourt and Ilorin, Nigeria from July 2022 to March, 2023. The results of the analyses show a significant differences in the air quality between Port Harcourt and Ilorin, with Port Harcourt exhibiting substantially higher concentrations of particulate matter across all measured sizes (PM_1, $PM_{2.5}$, and PM_{10}). The seasonal analysis revealed that both cities experience peak pollution levels during the harmattan period, though Port Harcourt's PM concentrations were evidently more severe, reaching levels more than double of the measurements recorded in Ilorin. This difference can be primarily attributed to Port Harcourt's industrial activities, including oil exploration and gas flaring, coupled with higher vehicular emissions, which worsen air pollution in this region. In contrast, Ilorin's relatively lower pollution levels reflect a reduced industrial activities and less congested traffic conditions, though it still exceed the WHO guidelines, particularly during the harmattan season.

The statistical analysis further shows the variability and intensity of air pollution in Port Harcourt, where higher standard deviations and variances indicate more pronounced fluctuations in PM levels compared to Ilorin. The right-skewed distribution of PM concentrations in Port Harcourt, with frequent moderate levels and occasional extreme peaks, points to the city's vulnerability to pollution events, such as industrial emissions and gas flaring. On the other hand, Ilorin's flatter distribution and lower peak values suggest a more stable but still concerning air quality profile. These findings are consistent with previous studies that have identified industrial and urban areas in Nigeria as hotspots for air pollution, while less industrialized regions like Ilorin experiences relatively low air quality challenges.

This study calls for an urgent need for targeted air quality management strategies to each of the cities. For Port Harcourt, interventions should prioritize reducing industrial emissions, regulating gas flaring, and improving vehicular emissions standards. In Ilorin, efforts should focus on mitigating harmattan-related dust and addressing localized sources of combustion. Both cities would benefit from enhanced air quality monitoring and public awareness campaigns to mitigate the health risks associated with prolonged PM exposure. The results in both locations however shows the general public health challenge posed by air pollution in Nigeria, necessitating immediate policy actions at regional and national levels to safeguard the health of humans and the environments.

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