

## RESEARCH ARTICLE

TEMPORAL VARIATIONS OF PM<sub>10</sub> AND PM<sub>2.5</sub> IN LUGBE, FCT ABUJA NIGERIAAmarachukwu Enumah<sup>a</sup>, Abdullahi Mohammed Evuti<sup>a</sup>, Kamoru Adio Salam<sup>a</sup>, Yahaya Sayyadi Mohammad<sup>b</sup> and Samuel Shamaye Silas<sup>c</sup><sup>a</sup> University of Abuja Faculty of Engineering Abuja, FCT Abuja, Nigeria<sup>b</sup> Ibrahim Badamasi Babangida University, Lapai, Nigeria<sup>c</sup> University of Calabar, Calabar, Nigeria\*Corresponding Author Email: [enumahcorp@gmail.com](mailto:enumahcorp@gmail.com)

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## ABSTRACT

Particulate Matter (PM) remain poorly characterized in FCT Abuja and this has led to the examination of the temporal variations and distribution of PM<sub>10</sub> and PM<sub>2.5</sub> in FCT Abuja from January 2024 to January 2025, alongside the influence of meteorological parameters as the aim of the research. Observation Instrument, installed at a height of 1.85m at Centre for Atmospheric Research-National Space Research and Development Agency (CAR NASRDA) Observation Centre (8°59'N, 7°23'E; elevation: 427m) was used to gather hourly PM concentrations and meteorological data for January 2024–January 2025 were acquired from Nigerian Meteorological Agency (NiMet) (9°4'N, 7°29'E; elevation: 345m). The study shows an annual mean concentrations of PM<sub>2.5</sub> and PM<sub>10</sub> in 2024 to be 65.21µg/m<sup>3</sup> and 61.23µg/m<sup>3</sup> respectively. Monthly averages for PM<sub>2.5</sub> ranged from 40.13µg/m<sup>3</sup> to 126.02µg/m<sup>3</sup>, and PM<sub>10</sub> ranged from 38.71µg/m<sup>3</sup> to 114.16µg/m<sup>3</sup> respectively. For PM<sub>2.5</sub>, the highest and lowest levels of PM were 126.1±67.4µg/m<sup>3</sup> in February and 64.7±25.3µg/m<sup>3</sup> in December; respectively, in January (114.2±38.5µg/m<sup>3</sup>) and May (38.7±6.8µg/m<sup>3</sup>). In February and November, the highest and lowest values of PM<sub>2.5</sub>/PM<sub>10</sub> were 1.48 and 0.84, respectively. For the month-to-month fluctuation, the highest and lowest PM<sub>2.5</sub> were in January (harmattan/dry season) and September (rain season) 2024 at 174.6µg/m<sup>3</sup> and 26.3µg/m<sup>3</sup> respectively. For PM<sub>10</sub>, the highest fluctuation 182.33µg/m<sup>3</sup> was in January while 170.23µg/m<sup>3</sup> was in October respectively. The mean daily air temperature varied from 17.2°C during March to a high of 45.8°C in May 2024, relative humidity was between 12.6% and 92.8%, and atmospheric pressure varied from 84.6hPa to 967.4hPa respectively.

## KEYWORDS

Particulate matter, Air Quality, Temporal, Meteorological, Air Pollution

## 1. INTRODUCTION

Particulate Matter (PM) a complex mixture of liquids and solids includes fine (PM<sub>2.5</sub>) and coarse (PM<sub>10</sub>) fractions, emitted from construction, industry, transport, and secondary atmospheric reactions (Brauer et al. 2012). Atmospheric PM is a critical constituent of urban and regional air pollution contributing to visibility degradation and influencing regional and global climate dynamics (Shaddick et al., 2018). High PM values also pose major health and economic growth hazards (Hoffman et al., 2021 ; Southerland et al. 2022). As a major air pollutant in rapidly developing African country such as Nigeria, PM has garnered considerable scientific and policy attention (Urhie et al., 2020). Extensive research has been conducted on the physicochemical characteristics of PM, as well as its interactions with meteorological factors, particularly in Nigeria megacities and economically advanced regions (Komolafe et al., 2014 ; Ogunjobi et al., 2018). While these studies have advanced our understanding of aerosol formation and variability in Nigeria, investigations in FCT Abuja remain limited, especially concerning the spatiotemporal distribution of PM across urban, suburban, and rural areas (Abulude and Abulude 2021). PM diffusion and removal is affected by meteorology (Southerland et al., 2022 ; Wang et al., 2020). PM distribution is influenced by wind speed in northeast China, however regional and seasonal complexity is still unclear (Lee et al., 2023; Yan et al., 2021). Comparable uncertainties exist in Nigeria, where urbanization, industrial emissions, and gas flaring worsen PM

pollution (Adetunji et al., 2020; Abdullahi, 2013). With over 11.8 million vehicles (NBS, 2018) and Nigeria's air quality crisis necessitates quick research especially considering its reliance on satellite-derived data owing to few ground data and widespread biomass burning (Abdullahi et al., 2012 ; Hassan and Abdullahi, 2012). Previous studies have examined correlations between PM<sub>2.5</sub> concentrations and meteorological variables in Abuja and Benin cities (Lala et al., 2023). While identified PM as a key factor for air pollution in Kura and Idiroke (Abulude and Abulude, 2021). However, the seasonal and regional variability of meteorological impacts on PM remains poorly characterized in this FCT Abuja.

Lugbe is located in Federal Capital Territory of Nigeria. Rapid urbanization and industrial growth have led to severe PM pollution (Abulude and Abulude, 2021 ; Lala et al., 2023), driven by anthropogenic emissions (e.g., vehicular exhaust, industrial activity, domestic fuel combustion, and agriculture) as well as natural sources like dust from harmattan wind (Lala et al., 2023). Air quality in FCT Abuja has become a pressing public health concern, particularly following high construction and quarrying activities. This study examines the temporal variations of PM<sub>10</sub> and PM<sub>2.5</sub> in Lugbe, FCT Abuja from January 2024 to January 2025, alongside the influence of meteorological parameters. The analysis of the PM data collected across urban, suburban, and rural sites, were complemented by surface meteorological observations from Centre for Atmospheric Research-National Space Research and Development Agency (CAR-NASRDA).

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## 2. MATERIALS AND METHODOLOGY

The Federal Capital Territory of Nigeria Abuja is located in the centre of Nigeria. It is located in the Heart of the nation and thus is a natural gateway to all other parts of Nigeria. Its location in the middle combined with its modern infrastructure and international airport places Abuja in the position of being a gateway to travel and trade (Albert et al., 2021). Meteorological data for January 2024 – January 2025 including hourly Temperature, pressure, and relative humidity were acquired from Nigerian Meteorological Agency (NiMet) (9°4'N, 7°29'E; elevation: 345 m) (Abulude and Abulude, 2021).

Daily mass concentrations of PM<sub>2.5</sub> and PM<sub>10</sub> over FCT Abuja from January 2024 to January 2025 were acquired from the Data Centre of CAR-NASRDA Nigeria (<https://carnasrda.com/data/>); The date which was captured at 2-minuties intervals were downloaded as a Comma Separated Value (CSV) file. The overall size of dataset were 1,211,810 data points the data were processed into daily and monthly averages for statistical characterization of their temporal trends relationships and for clear visualization using Microsoft Excel 2016 version and Jupyter Notebook within the Anaconda3 distribution (version 2024.10.1). The analysis environment included relevant libraries such as Pandas, NumPy, Matplotlib, seaborn and Sklearn.

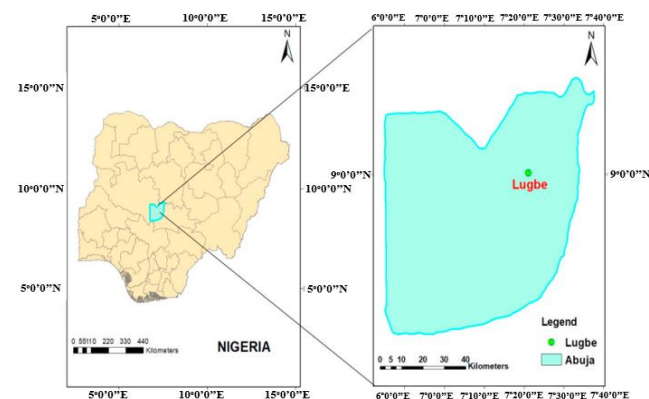


Figure 1: Map of FCT Abuja location of showing monitoring station location (Jimoda, 2012).

## 3. DISCUSSION OF FINDINGS

### 3.1 Assessing the Fluctuations in PM<sub>2.5</sub> and PM<sub>10</sub> Mass Concentrations

The trends of PM<sub>2.5</sub> and PM<sub>10</sub> mass concentrations at Lugbe FCT Abuja between 2021 and January 2025 and the average monthly PM<sub>2.5</sub>/PM<sub>10</sub> ratio are illustrated in figure 2-4. From Figure 2, both PM<sub>2.5</sub> and PM<sub>10</sub> concentrations followed temporal patterns, with mean daily values generally less than 180µg/m<sup>3</sup> for PM<sub>2.5</sub> and 200µg/m<sup>3</sup> for PM<sub>10</sub>.

Eight prominent peaks in daily PM levels were recorded during the month of January in the study period. The first, second, third, fourth, seventh and eighth peaks—each with PM<sub>2.5</sub> concentrations soaring above 180µg/m<sup>3</sup> were linked to the seasonal open burning of crop residues, a longstanding agricultural practice in the study area, particularly common in January and March (Abulude and Abulude, 2021). These burnings, though brief, can trigger extreme pollution episodes under stagnant atmospheric conditions.

The sixth peak, recorded in late October 2024, was characterized by a sharp rise in PM<sub>10</sub> and a significant drop in the PM<sub>2.5</sub>/PM<sub>10</sub> ratio to below 30% hallmarks of a dust intrusion event, consistent with criteria outlined by (Biancofiore, 2017), where PM<sub>10</sub> levels exceed 180µg/m<sup>3</sup>.

The seventh peak registered in early December (PM<sub>2.5</sub> 154.68µg/m<sup>3</sup> and PM<sub>10</sub> 167.53µg/m<sup>3</sup>), resulted from construction activity within to the study site.

Overall, the average annual concentrations of PM<sub>2.5</sub> and PM<sub>10</sub> during 2024 were 65.21µg/m<sup>3</sup> and 61.23µg/m<sup>3</sup>, respectively. While both were still above Nigeria's national annual PM<sub>2.5</sub> standard of 20µg/m<sup>3</sup> and PM<sub>10</sub> 60µg/m<sup>3</sup> (National environmental air quality control regulation–2021 B3345-3377), indicating the persistent air quality problem in FCT Abuja (NEAQCR, 2021).

PM<sub>2.5</sub> had average monthly levels between 40.13µg/m<sup>3</sup> and 126.02µg/m<sup>3</sup>, while PM<sub>10</sub> had levels between 38.71µg/m<sup>3</sup> and 114.16µg/m<sup>3</sup> as illustrated in Figure 3. Both pollutants showed a U-

shaped seasonal pattern, peaking in January and dipping in August—except in January where PM<sub>2.5</sub> (99.96µg/m<sup>3</sup>) deviated slightly from the trend. A similar U-shaped seasonal profile has also been observed in Seoul, South Korea, though with peak levels in January and the lowest in September (Park, 2018). The observed U-shaped trend in particulate matter (PM) concentrations is driven by seasonal variability. High level of PM are usually recorded between November and February, elevated PM<sub>10</sub> and PM<sub>2.5</sub> values are mostly caused by the impact of Harmattan winds, which transfer mineral dust from along the Sahara with more biomass burning and less rainfall (Magaji, 2015). From April to June, the beginning of light rainfall stirs surface dust without adequately eliminating it from the atmosphere, therefore causing PM values to drop gradually. Heavy and persistent rain between July and September results in major wet deposition of aerosols and diminished combustion operations, therefore leading to a noticeable drop in PM. Concentrations usually seen in September. However, in Northern China, (Xiaolan et al., 2017 ; Bia et al., 2018) recorded V-shape.

The peak concentrations of PM<sub>2.5</sub> were 126.1±67.4µg/m<sup>3</sup> in February, followed by January (99.9±28.7µg/m<sup>3</sup>), March (78.3±36.6 µg/m<sup>3</sup>), April (63.1±34.2 µg/m<sup>3</sup>), May (47.6±31.4 µg/m<sup>3</sup>), June (41.0±19.0 µg/m<sup>3</sup>), July (42.3±19.8 µg/m<sup>3</sup>), August (40.4±20.9 µg/m<sup>3</sup>), September (40.1±9.4 µg/m<sup>3</sup>), October (45.1±14.9 µg/m<sup>3</sup>), November (55.6±20.2 µg/m<sup>3</sup>), December (64.7±25.3 µg/m<sup>3</sup>) and January (104.8±40.2 µg/m<sup>3</sup>); PM10 followed the same seasonal trend: January (103.6±25.9 µg/m<sup>3</sup>), February (85.2±24.3 µg/m<sup>3</sup>) March (61.8±19.5 µg/m<sup>3</sup>), April (44.4±10.9 µg/m<sup>3</sup>), May (38.7±6.8 µg/m<sup>3</sup>), June (39.7±7.9 µg/m<sup>3</sup>), July (39.1±6.8 µg/m<sup>3</sup>), August (40.8±6.5 µg/m<sup>3</sup>), September (39.6±4.4 µg/m<sup>3</sup>), October (48.0±5.1 µg/m<sup>3</sup>), November (66.2±10.3 µg/m<sup>3</sup>), December (72.8±17.3 µg/m<sup>3</sup>) and January (114.2±38.5 µg/m<sup>3</sup>). Table 1 summarizes annual average concentration of PM<sub>2.5</sub> and PM<sub>10</sub> observed in different state of Nigeria.

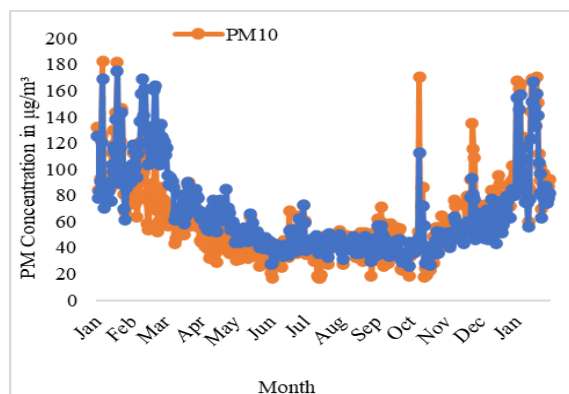


Figure 2: Temporal disparity in daily PM<sub>10</sub> and PM<sub>2.5</sub> level.

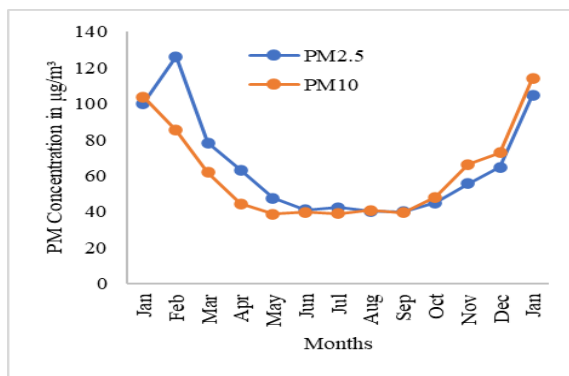


Figure 3 : Temporal variation in monthly PM<sub>2.5</sub> and PM<sub>10</sub> mass levels.

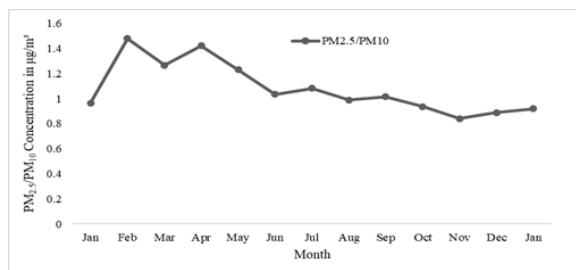


Figure 4: The ratio of PM<sub>2.5</sub>/PM<sub>10</sub> average.

The  $PM_{2.5}/PM_{10}$  ratios were quite high, dry northeasterly winds transport Saharan dust across the area, and widespread biomass burning leads to high fine particulate concentrations. The highest  $PM_{2.5}/PM_{10}$  ratio, at 1.48 in February, indicates the dominance of fine particulate matter.

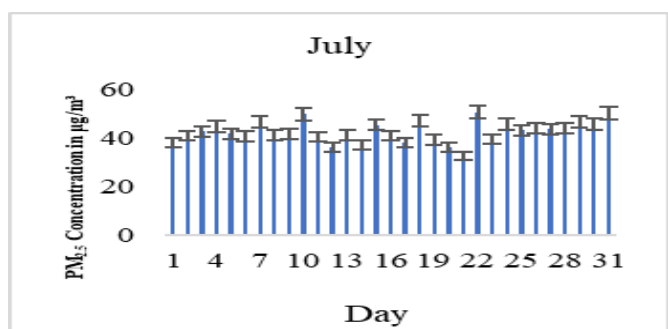
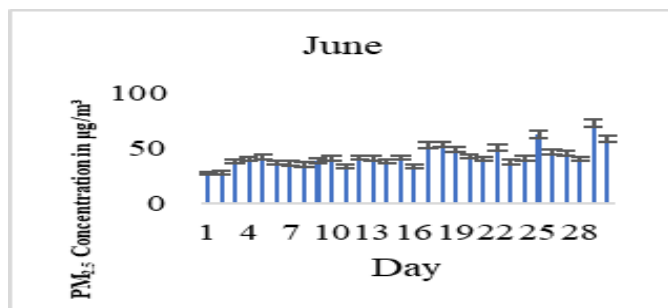
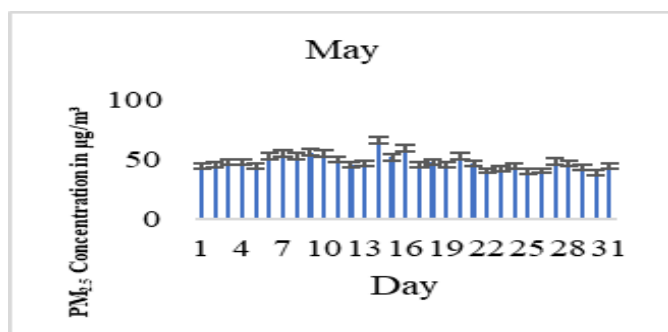
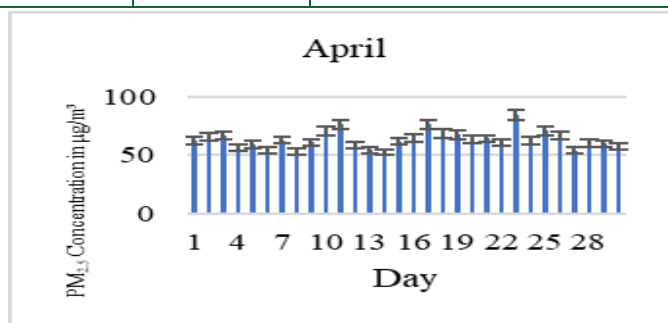
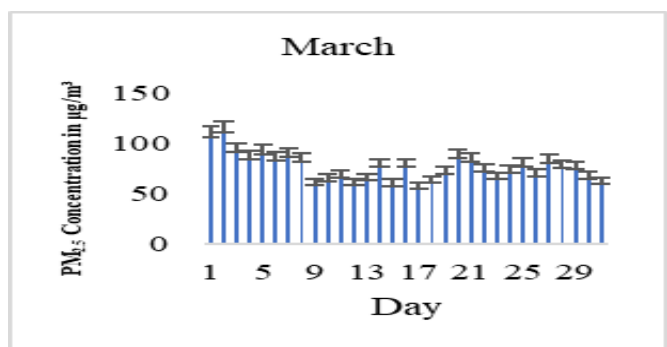
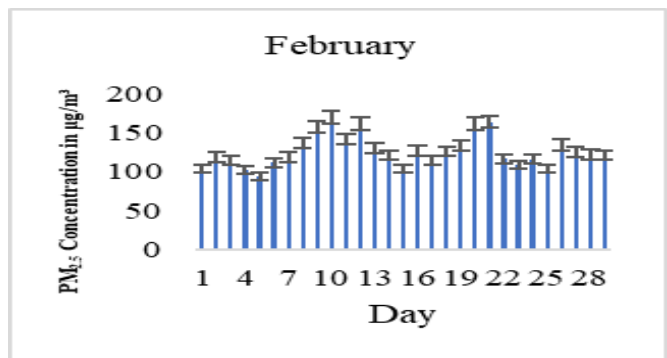
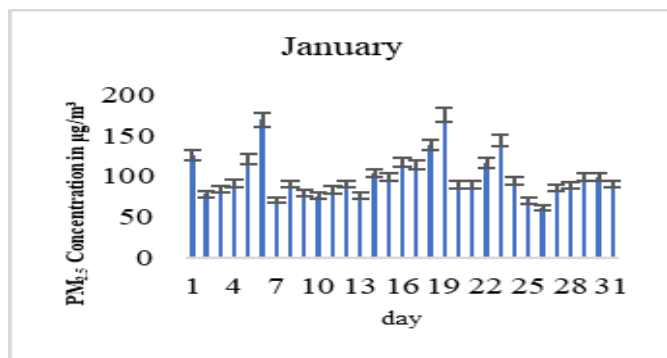
Conversely, the  $PM_{2.5}/PM_{10}$  ratios were lowest in November 0.84. Stronger wind speeds and increased atmospheric turbulence during this period enhanced the resuspension of coarse particles, contributing to a higher proportion of  $PM_{10}$  in ambient air (Ediagbonya et al., 2015).

**Table 1:** List of yearly mean  $PM_{2.5}$  and  $PM_{10}$  concentration in literature

Location	Period	Number of months	$PM_{2.5}(\mu g/m^3)$	$PM_{10}(\mu g/m^3)$	Reference
FCT	2024-01-31 to 2025-01-31	13	62.02	56.68	This paper
FCT	2021-10-01 to 2022-01-31, 2022-04-01 to 2022-07-31	8	49.62	55.75	(Lala et al., 2023)
Edo	2021-10-01 to 2022-01-31, 2022-04-01 to 2022-07-31	8	49.41	60.23	(Lala et al., 2023)
FCT	2020-09-18 to 2021-03-13	7	66.6	74.71	(Abuludu and Abulude, 2021)
Delta	2020-11-14 to 2021-03-12	5	61.98	68.29	(Abuludu and Abulude, 2021)
Osun	2020-11-04 to 2021-03-20	4	63.63	20.54	(Abuludu and Abulude, 2021)
Kebbi	2020-11-12 to 2020-12-17	2	79.1	185.4	(Abuludu and Abulude, 2021)
Lagos	2020-12-22 to 2021-03-12	4	86.25	101.23	(Abuludu and Abulude, 2021)

**3.2 Temporal trends in PM concentration levels**

$PM_{2.5}$  and  $PM_{10}$  concentrations monthly variation were observed from November 2024 to January 2025 illustrated in Figure 5 and 6. High levels of  $PM_{2.5}$  were recorded in the harmattan/dry season months; low levels were recorded in the rainy season months,  $174.6\mu g/m^3$  in January 2024 followed by  $169.3\mu g/m^3$  in February, which were the highest  $PM_{2.5}$  levels. September  $26.3\mu g/m^3$  recorded the lowest  $PM_{2.5}$  level logged.



PM<sub>10</sub> concentrations monthly variation followed a similar temporal trend to that of PM<sub>2.5</sub>. The highest PM<sub>10</sub> concentration, 182.33µg/m<sup>3</sup>, was recorded in January 2024, and the second highest, 170.23µg/m<sup>3</sup>, in October 2024 (figure 6). The January peak can be attributed to increased Harmattan conditions that improve atmospheric dust loading and decrease dispersion due to decreased humidity and wind stagnation (Okedere et al., 2018 ; Wembebe et al., 2020). The elevated October levels are likely to indicate the beginning of the dry season, which has more biomass burning and lower precipitation, both of which influence increases particulate emission and restricts wet deposition (Okedere et al., 2018).

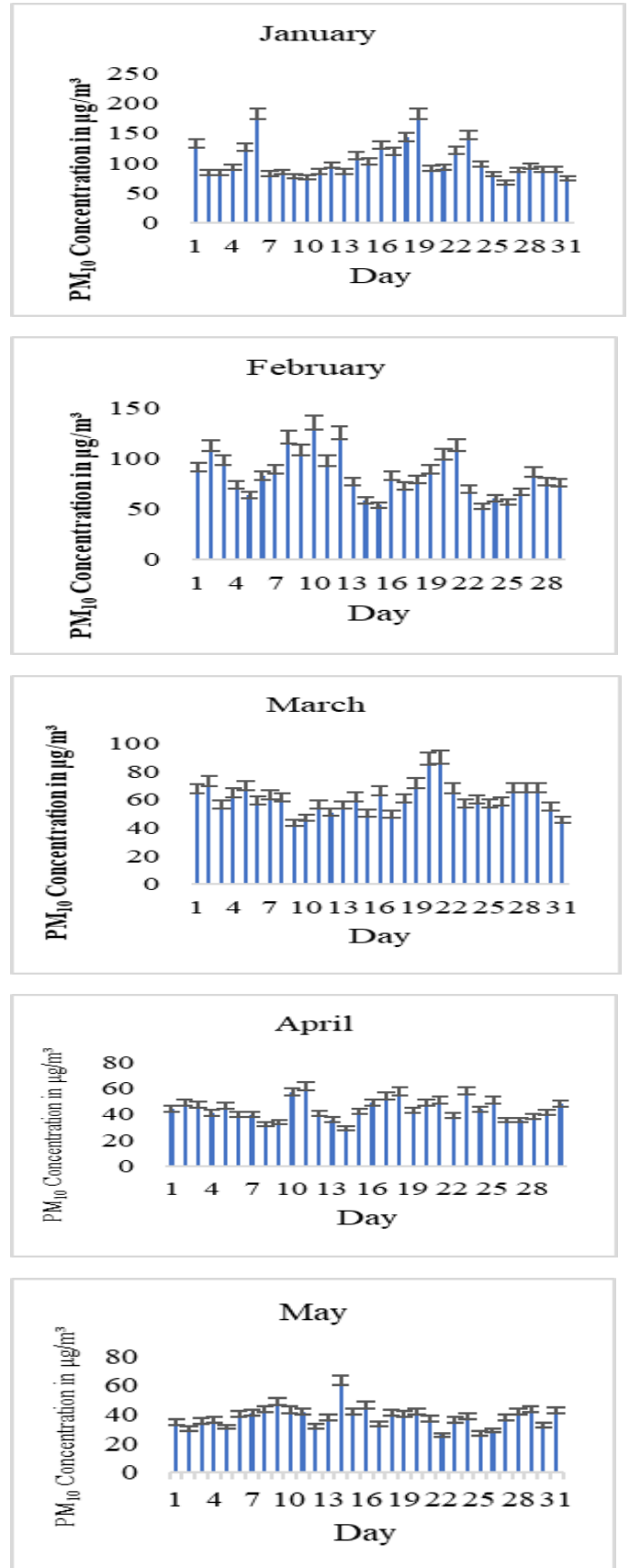
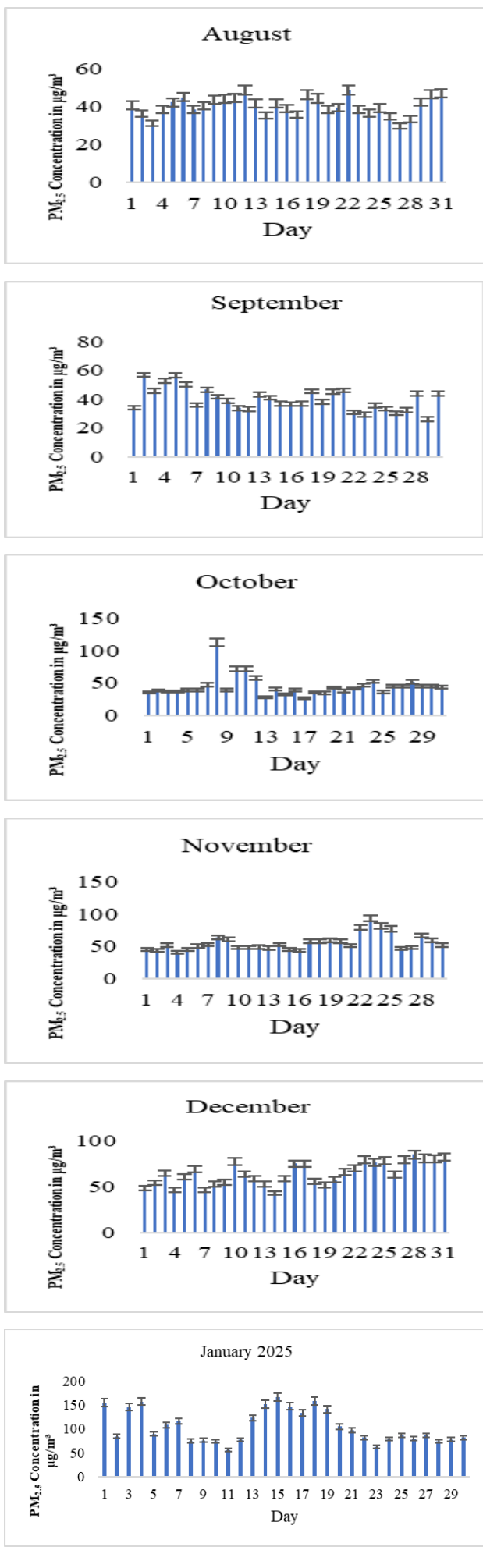


Figure 5: PM<sub>2.5</sub> concentration monthly difference

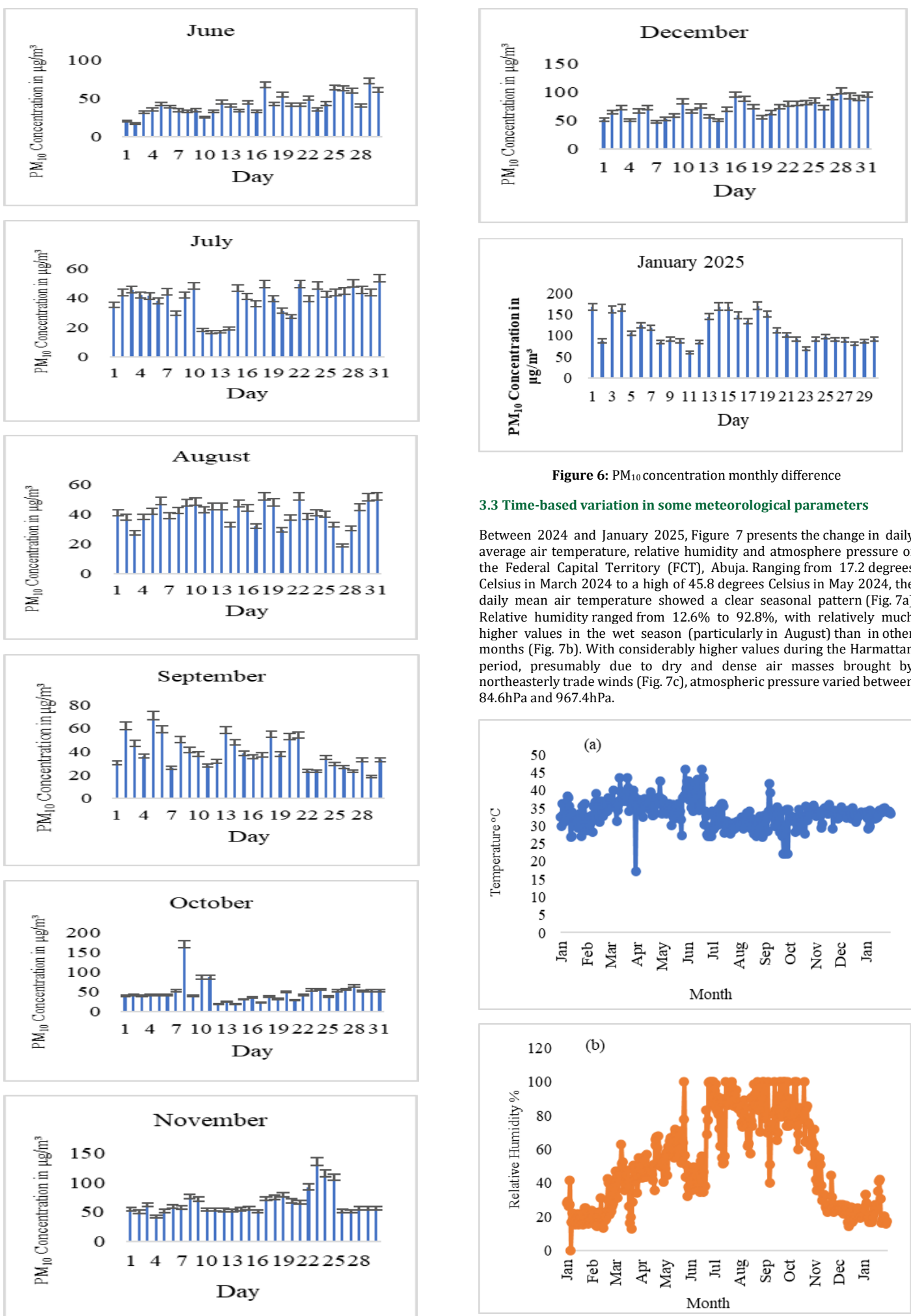
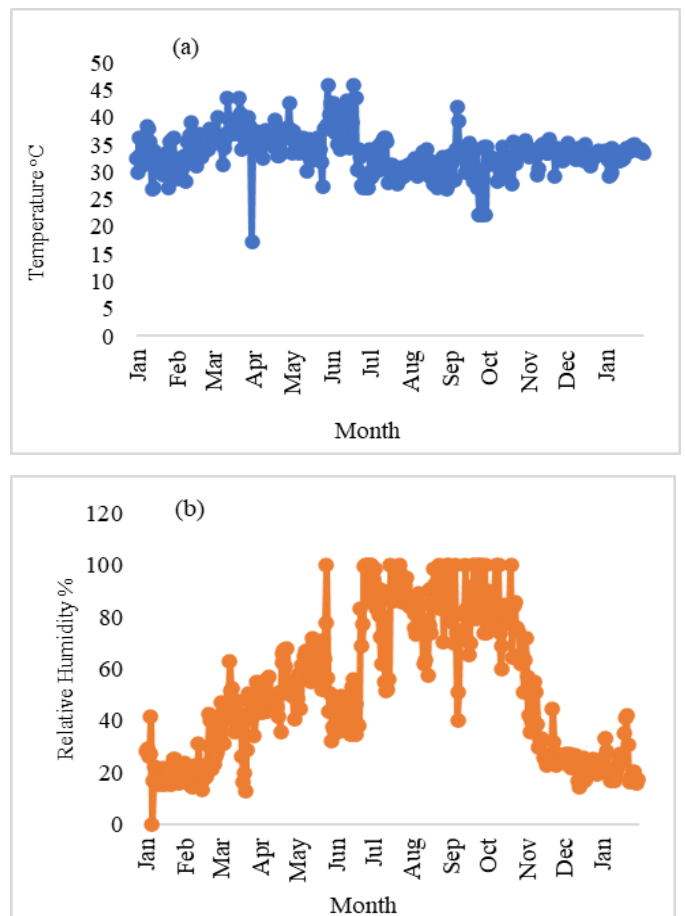
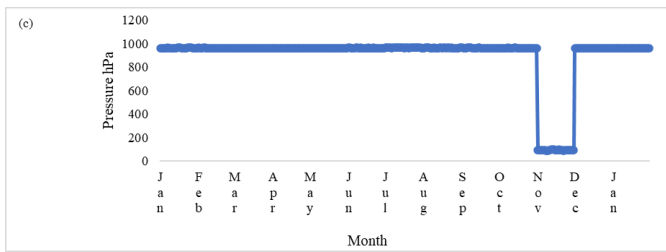


Figure 6: PM<sub>10</sub> concentration monthly difference

3.3 Time-based variation in some meteorological parameters

Between 2024 and January 2025, Figure 7 presents the change in daily average air temperature, relative humidity and atmosphere pressure of the Federal Capital Territory (FCT), Abuja. Ranging from 17.2 degrees Celsius in March 2024 to a high of 45.8 degrees Celsius in May 2024, the daily mean air temperature showed a clear seasonal pattern (Fig. 7a) Relative humidity ranged from 12.6% to 92.8%, with relatively much higher values in the wet season (particularly in August) than in other months (Fig. 7b). With considerably higher values during the Harmattan period, presumably due to dry and dense air masses brought by northeasterly trade winds (Fig. 7c), atmospheric pressure varied between 84.6hPa and 967.4hPa.





**Figure 7:** (a) daily mean air temperature, (b) relative humidity and (c) atmosphere pressure

The drop in atmospheric pressure ( $940 \pm 28$  to  $98 \pm 13.4$ ) experienced in November is mostly attributed to the beginning of the dry season and the resulting impact of the Harmattan winds (Kurnykina et al., 2018; Menares et al. 2021). This period is a shift in the prevailing air mass over the region from the moist tropical maritime air mass to the dry tropical continental air mass (Jimoda et al., 2012). The Harmattan, a hot and dry northeasterly wind blowing from the Sahara Desert, imports enormous quantities of dust and imports dry, stable air into the region (Abulude and Abulude, 2021 ; Jimoda et al., 2012). Such conditions result in the decrease of atmospheric pressure, which suggests the dominance of colder, denser continental air masses during this period (Lala et al., 2018). The same in their research study on atmospheric pressure change (Washington et al., 2006)

**3.4 Influence of Meteorological Conditions on PM Pollution Concentration**

**Table 2:** Correlation coefficients between seasonal PM<sub>2.5</sub> and PM<sub>10</sub> concentrations and meteorological parameters (Coefficient of determination R<sup>2</sup> in brackets)

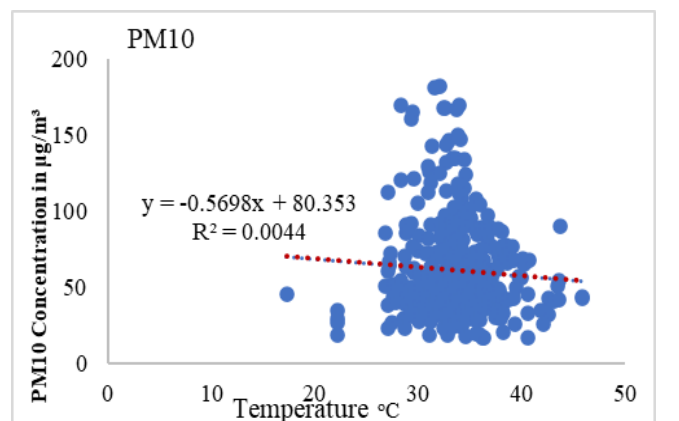
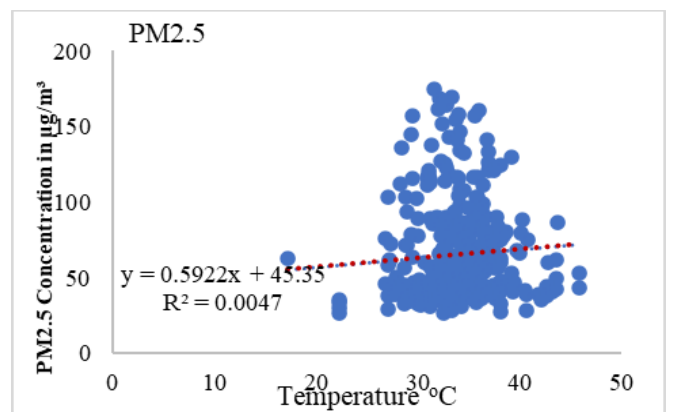
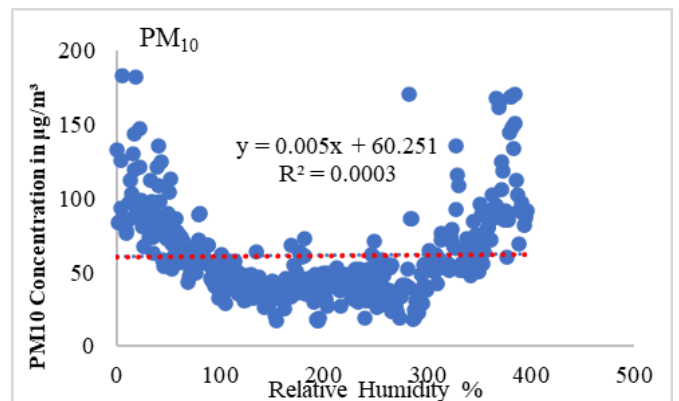
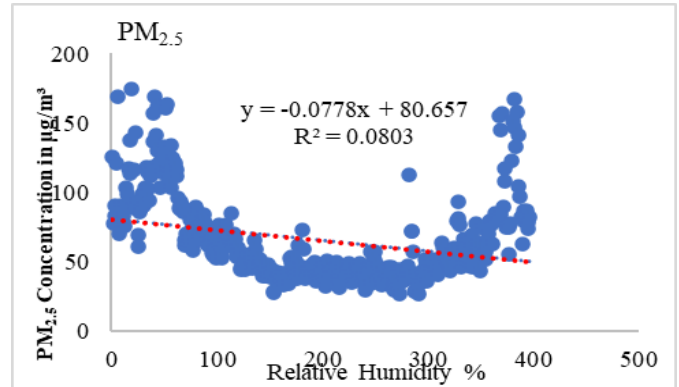
Season	PM <sub>2.5</sub>			PM <sub>10</sub>		
	Pa	T	RH	Pa	T	RH
Dry	0.0351	-0.084	0.3596	0.0087	0.2940	-0.205
Raining	0.6918	0.068	0.0351	0.0316	-0.066	0.2189

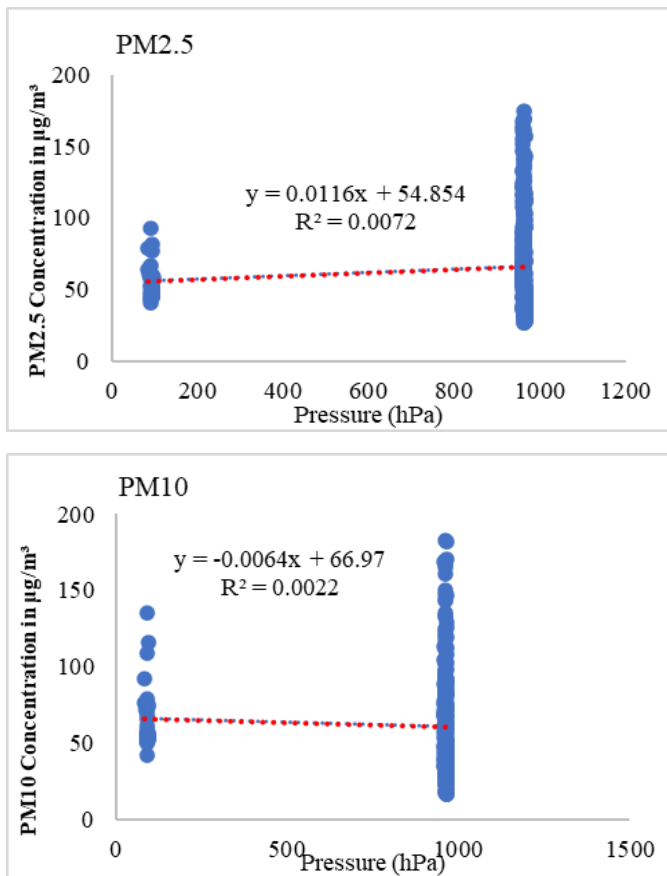
Indices of correlation betwixt some weather-related parameters and seasonal level of PM<sub>2.5</sub> and PM<sub>10</sub> in dry and wet seasons in 2024 are recorded in table 2. PM<sub>2.5</sub> and PM<sub>10</sub> were negatively correlated with relative humidity during both seasons in 2024, which shows that horizontal dispersion significantly influence PM levels reduction, mainly for fine particles. though, PM<sub>10</sub> concentrations show a weak positive correlation between relative humidity (R = 0.071) in raining season, and such positive correlation disappeared in dry season. Essentially, relative humidity values were higher in raining season (92.8%) than those in dry season (12.6%). Recurrent dust episodes and high PM<sub>10</sub> concentration in dry season have a positive relationship with relative humidity (Washington et al., 2006). Our findings also indicate that high relative humidity aid to reduce the carriage of dust. PM levels were weakly positively correlated with air pressure, particularly in dry season (PM<sub>2.5</sub> = 0.035 and PM<sub>10</sub> = 0.0087) which is aligns with some previous studies (Bai et al., 2019 ; Lee et al., 2023 ; Nguyen et al., 2024). High air pressure and downturn repress the vertical movement of Particulate Matters, resulting in particles buildup. relationship between air pressure, PM<sub>2.5</sub> and PM<sub>10</sub> levels was negative for in both seasons.

However, the daily mass concentration (figure 8) of PM<sub>2.5</sub> shows a positive correlation of 0.59, this is as a result of Heat transfer favouring the upward movement of dust particles to a certain extent. Conversely, no such correlation were established for PM<sub>10</sub> levels. PM<sub>10</sub> levels were negatively correlated with temperature (-0.57), indicating that higher temperatures were associated with lower particulate matter levels. The negative association agrees with general atmospheric dynamics, in which higher temperatures enhance vertical mixing of air, reducing the lifespan of near-surface pollutants (Apostolopoulou et al., 2020 ; Zhang et al., 2018). Contrariwise, lower temperatures can promote thermal inversions and stagnant air masses, which would exacerbate PM<sub>10</sub> accumulation (Global Air Pollution and Health, 2021). Factors, such as increased biomass burning for domestic heating during colder months, may well reinforce this trend (EEA, 2020).

Negative correlations of PM<sub>10</sub> and PM<sub>2.5</sub> levels and relative humidity (-

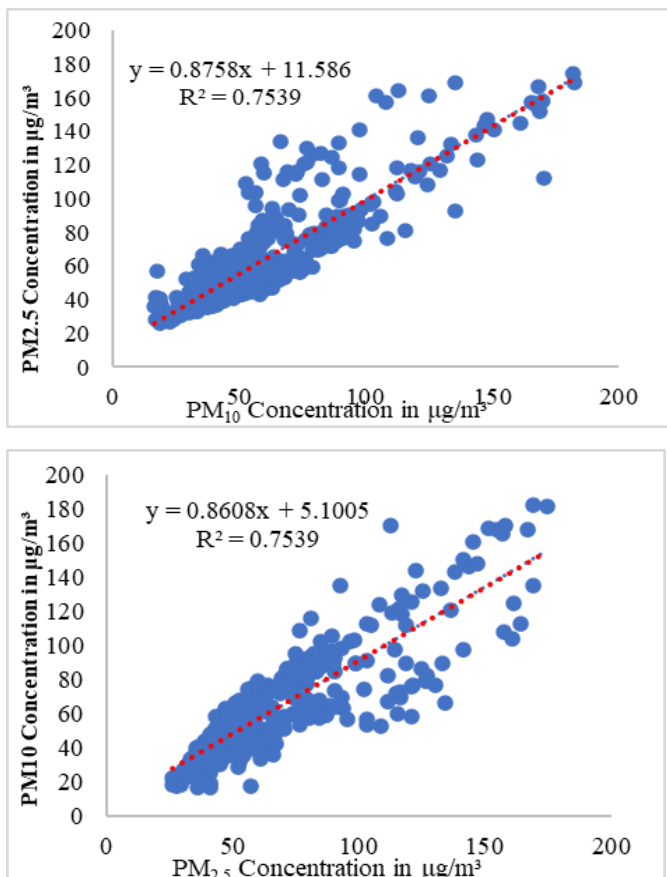
0.5894 and -0.534) obtained were primarily due to the suppression of emissions of dust at high air moisture content in the effects of wet scavenging due to high rainfall abundance. Additionally, rainfall tends to increase the difficulty of emitting dust, as the minimum friction velocity/wind speed for dust uplifting is increased under the condition of wet soil (Adeyemi 2009; Xu et al., 2020). Generally, meteorological conditions and Particulate Matter levels showed seasonality between their relationship and may differ between years. These complex interactions require the contemplation of multiple meteorological drivers, including solar radiation, boundary layer dynamics, relative humidity, air temperature, and wind speed.





**Figure 8:** Scattered plot of daily mean PM<sub>2.5</sub> and PM<sub>10</sub> concentration.

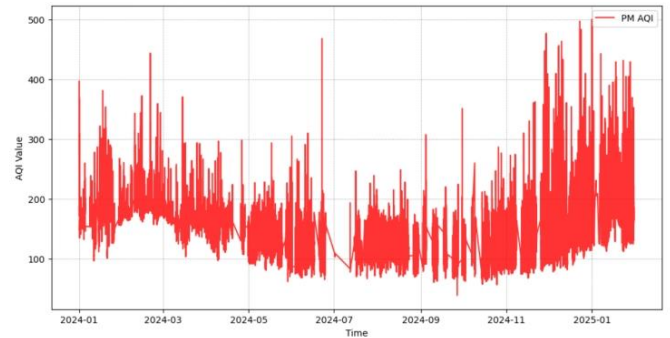
Figure 9 reveals a strong relationship between these pollutants. The most significant correlation is observed between PM<sub>2.5</sub> and PM<sub>10</sub>, with a value of 0.87 which is the PM<sub>10</sub> and PM<sub>2.5</sub>, suggesting that these pollutants likely share a common source and exhibit similar temporal patterns.



**Figure 9:** Scattered plot showing coefficient of determinant for daily mean concentration of PM<sub>10</sub> and PM<sub>2.5</sub>

### 3.5 Air Quality Index (AQI)

Air Quality Index (AQI) shown in figure 10, indicate PM AQI trends from January 2024 to January 2025, illustrating sudden fluctuations in air quality. The AQI levels were very dispersed with frequent spikes indicating routine spikes of pollution which was observe in the study, this might be due to environmental conditions, vehicle emissions, or manufacturing processes (Ni et al., 2017). There were seasonal patterns, with high AQI (usually greater than 300) in early 2024, temporary abatement mid-2024, and abrupt jump late 2024 and early 2025, perhaps related to seasonal patterns like harmattan pollution. There were instances of severe pollution with AQI greater than 400, perhaps due to fire, traffic, or weather. The sharp drop in mid-2024 may be an indication of improved air quality or a data lag.



**Figure 10:** The time-series plot illustrating PM AQI trends

### 4. CONCLUSION

This study investigated the temporal variation of PM<sub>2.5</sub> and PM<sub>10</sub> mass concentrations in Lugbe FCT Abuja, Nigeria from January 2024 to January 2025, alongside their relationships with meteorological parameters. The analysis utilized daily PM data combined with concurrent surface meteorological observations.

Monthly average concentrations of PM<sub>2.5</sub> and PM<sub>10</sub> ranged from 40.13 to 126.02  $\mu\text{g}/\text{m}^3$  and 38.71 to 114.16  $\mu\text{g}/\text{m}^3$ , respectively. PM concentrations peaked in harmattan, followed by dry season, and were lowest in raining season. Annual mean PM levels in FCT Abuja during January 2024 to January 2025 exceeded national regulatory highlighting the severity of air pollution in Nigeria federal capital, Abuja.

Daytime variations exhibited bimodal peaks in dry season with the highest in February 2024 followed by January 2025. A minor spring peak in PM<sub>10</sub> was also observed to have exhibited the same for January 2024 and January 2025.

PM<sub>2.5</sub> and PM<sub>10</sub> concentrations showed a strong positive correlation with each other (0.87). In general, PM levels were negatively correlated with pressure, indicating the role of horizontal dispersion in reducing pollutant concentrations. However, in harmattan, pressure contributed to increased PM<sub>10</sub> by resuspending and transporting coarse particles.

Temperature exhibited negative correlations with PM<sub>2.5</sub> levels in both seasons, PM<sub>2.5</sub> and PM<sub>10</sub> concentrations were generally positively correlated with relative humidity during raining season for PM<sub>10</sub>, whereas in dry season both showed negative correlations, this is as a result of the suppression of dust emissions under moist conditions.

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### AUTHORS CONTRIBUTIONS

Amarachukwu Enumah has developed the paper out of his PhD thesis which is supervised by Prof. Abdullahi Mohammed Evuti and Prof. Karmoru Adio Salam as PhD program at university of Abuja, Yahaya Sayyadi Mohammed also improved the paper he has contributed for also steps of research including supervision and writing steps. Samuel

Shamaye Silas has contributed for the research and writing a paper by means of improvement of the manuscript and also implementation of the methodology.

## ETHICAL APPROVAL

This is not applicable

## DATA AVAILABILITY STATEMENT

The data analysis results generated during this study are available in the PurpleAir repository: <https://carnasrda.com/data/>

Also, the data are available from corresponding author on request.

## REFERENCES

- Abdullahi M. E., 2013. A synopsis on biogenic and anthropogenic volatile organic compound emission: Hazards and control. *International Journal of Engineering Science* 2(5), Pp. 145-153.
- Abdullahi M. E., Okobia E. L. and Hassan S. M., 2012. Assessment of ambient atmospheric concentration of volatile organic compounds in Abuja-Nigeria, *Journal of Chemical Sciences, Biological Sciences and Physical Sciences*, 2(3), Pp. 1637-1647.
- Abulude F. O., and Abulude I. A., 2021. Monitoring air quality in Nigeria: The case of Center for Atmospheric Research-National Space Research and Development Agency (CAR-NASRDA), *Aerosol Science and Engineering*, 5, Pp. 478-498.
- Adetunji J., Oladosu I., and Fuwape I., 2020. Influence of Harmattan dust on meteorological parameters in West Africa. *Environmental Monitoring and Assessment*, 192.
- Adeyemi B., 2009. Empirical Modelling of Layered Integrated Water Vapor Using Surface Mixing Ratio in Nigeria, *Journal of Applied Meteorology and Climatology*, 48, Pp. 369-380,
- Albert I., Shakantu W., and Ibrahim S., 2021. The Effect of Poor Materials Management in the Construction Industry: A Case Study of Abuja Nigeria". *Acta Structilia* 25, Pp. 367-371
- Apostolopoulou N., Koukoulakis P. H., Kyritsis S., Kalavrouziotis I. K., and Varnavas S. P., 2020. The role of meteorological factors in the air particulate matter of the Patras Port atmosphere, Greece, *Water, Air, and Soil Pollution*, 231. <https://doi.org/10.1007/s11270-020-04789-3>
- Bai Y., Zeng B., Li C., and Zhang J., 2019. An ensemble long short-term memory neural network for hourly PM<sub>2.5</sub> concentration forecasting". *Chemosphere* 222, Pp. 286-294
- Bai L., Wang J., Ma X., and Lu H., 2018. Air pollution forecasts: an overview. *International Journal of Environmental Research and Public Health*, 15(4), 780, 2018.
- Biancofiore F., Busilacchio M., Verdecchia M., Tomassetti B., Aruffo E., Bianco S., Di Tommaso S., Colangeli C., Rosatelli G. and Di Carlo P., 2017. Recursive neural network model for analysis and forecast of PM<sub>10</sub> and PM<sub>2.5</sub>. *Atmospheric Pollution Research*, 8(4), Pp. 652-659.
- Brauer M., Amann M., Burnett RT., Cohen A., Dentener F., Ezzati M., Henderson SB., Krzyzanowski M., Martin RV., Van Dingenen R., van Donkelaar A., and Thurston GD., 2012. Exposure assessment for estimation of the global burden of disease attributable to outdoor air pollution, *Environmental Science and Technology*, 46(2), Pp. 652-660. doi:10.1021/es2025752.
- Ediagbonya T., Tobin A., Ukpebor E., and Okiemien E., 2015. Impact of aerosol on respiratory symptoms among adults (above eighteen years) in an urban area of Nigeria. *Scientia Africana*, 14(2), 1-12, ISSN 1118 - 1931.
- Federal Republic on Nigeria Official Gazette, 2021. National environmental air quality control regulation-2021 B3345-3377. <https://archive.gazettes.africa/archive/ng/2021/ng-government-gazette-supplement-dated-2021-02-17-no-161.pdf>
- Global Air Pollution and Health 2021 – Technical Advisory Group, Geneva: World Health Organization, 2021. [https://www.who.int/groups/global-air-pollution-and-health---](https://www.who.int/groups/global-air-pollution-and-health---technical-advisory-group)
- Hassan S. M., and Abdullahi M. E., 2012. Evaluation of pollutants in ambient air: A case study of Abuja-Nigeria, *International Journal of Scientific and Research Publication*, 2(12), Pp. 2250-3153.
- Hoffman B., Boogard H., Nazelle A et al., 2021. WHO Air Quality Guidelines 2021 – Aiming for healthier air for all: A joint statement by medical, public health, scientific societies and patient representative organisations, *International Journal Public Health*, 66,1604465. doi: 10.3389/ijph.2021.1604465.
- Jimoda L. A., Lala M. A., Adeniran J. A., and Sonibare J. A., 2012. Variation of gaseous air pollutants mixing ratio with meteorological data in Ogere transport pool of southwestern Nigeria, *Lautech Journal of Engineering and Technology*.
- Komolafe A., Adegboyega S., Anifowose A., Akinluyi F., and Awoniran D., 2014. Air pollution and climate change in Lagos, Nigeria: Needs for proactive approaches to risk management and adaptation, *American Journal of Environmental Sciences*. 10(4), Pp. 412-423.
- Kurnykina O. V., Popova O. V., Zubkova S. V., Karpukhin D. V., Pavlov V. P., Varenik P. K., Aleshkova I. A., and Novitskaya L. Y., 2018. Air pollution by road traffic and its measurement methods, *EurAsia Journal of BioSciences*, 12, Pp. 181-188.
- Lala M. A., Adesina O. A., Yusuff A. S., Jimoda L. A., and Sonibare J. A., 2018. Air quality index pattern of criteria air pollutants around a haulage truck stop, *Petroleum and Coal*, 60(6), Pp. 1072-1079.
- Lala M. A., Onwunzo C. S., Adesina O. A., and Sonibare J. A., 2023 Particulate matters pollution in selected areas of Nigeria: Spatial analysis and risk assessment, *Case Studies in Chemical and Environmental Engineering*. 7, 100288. <https://doi.org/10.1016/j.cscee.2022.100288>
- Lee J., Miao Y., Chau R. L. T., Hernandez M., and Lee P. K. H., 2023. Artificial intelligence-based prediction of indoor bioaerosol concentrations from indoor air quality sensor data, *Environment International*, 174. 107900, 2023. <https://doi.org/10.1016/j.envint.2023.107900>.
- Liu, Q., Cui B., and Liu Z., 2024. Air Quality Class Prediction Using Machine Learning Methods Based on Monitoring Data and Secondary Modeling. *Atmosphere* 15, 553. <https://doi.org/10.3390/atmos15050553>
- Magaji Y., and Hassan M., 2015. An Assessment of Air Quality in and around Gwagwalada Abattoir, Gwagwalada, Abuja, FCT. *Journal of Environment and Earth Science*, 5(1), 87-92 ISSN 2224-3216 (Paper) ISSN 2225-0948. <https://core.ac.uk/reader/234663970>
- Menares C., Perez P., Parraguez S., and Fleming Z. L., 2021. Forecasting PM<sub>2.5</sub> levels in Santiago de Chile using deep learning neural networks, *Urban Climate*, 38, 100906. <https://doi.org/10.1016/j.uclim.2021.100906>
- Nguyen A. T., Pham D. H., Oo B., Ahn Y., and Lim B., 2024, Predicting air quality index using attention hybrid deep learning and quantum-inspired particle swarm optimization, *Journal of Big Data*, 11. <https://doi.org/10.1186/s40537-024-00926-5>.
- Ni, X.Y., Huang, H., and Du W.P., 2017. Relevance analysis and short-term prediction of PM<sub>2.5</sub> concentrations in Beijing based on multi-source data. *Atmospheric Environment*, 150, Pp. 146-161.
- Nigeria National Bureau of Statistics. 2018a. Petroleum Products Imports and Consumption 2017. <http://www.nigerianstat.gov.ng/>
- Ogunjobi K. O., Ajibola A. A., and Ede P. N., 2018. Characterization of Harmattan dust in southwestern Nigeria, *Atmospheric Pollution Research*, 12(6),1011322. [https://www.researchgate.net/publication/326331397\\_Variability\\_of\\_Harmattan\\_Dust\\_Haze\\_over\\_Northern\\_Nigeria](https://www.researchgate.net/publication/326331397_Variability_of_Harmattan_Dust_Haze_over_Northern_Nigeria)
- Okedere O. B., Fakinle B. S., and Sonibare J. A, 2018. Annual estimates of air pollutants from utilization of diesel as energy source at base transceiver stations, *Environmental Quality Management*, 28, Pp. 129-135.
- Park, S., Kim M., Kim M., Namgung H.G., Kim K.T, Cho K.H., and Kwon S.B., 2018, Predicting PM<sub>10</sub> concentration in Seoul metropolitan subway stations using artificial neural network (ANN). *J. Hazard. Mater.* 341, Pp. 75-82.

- Shaddick G., Thomas M., Green A., Brauer M., Van-Donkelaar A., Burnett R., Cahng H., Cohen A., Dingenen RV., Dora C., Gumy S., Liu Y., Martin R., Waller LA., West J., Zidek JV., and Pruss-Ustun A. 2018. Data integration model for air quality: A hierarchical approach to the global estimation of exposures to ambient air pollution, *Journal of Applied Statistics*, 67(1), Pp. 231–253. <https://pubs.acs.org/doi/10.1021/acs.est.8b02864>.
- Southerland VA, Brauer M., Moheg A., Hammer MS., van Donkelaar A., Martin RV., Apte JS., and Anenberg SC. 2022. Global urban temporal trends in fine particulate matter (PM<sub>2.5</sub>) and attributable health burdens: Estimates from global datasets. *Lancet Planetary Health* 6, Pp. 39–46. DOI: 10.1016/S2542-5196(21)00350-8
- The European Environment — state and outlook 2020: knowledge for transition to a sustainable Europe <https://www.eea.europa.eu/en/analysis/publications/soer-2020>
- Urhie E., Afolabi A., Afolabi A., Matthew O., Osabohien R., and Ewetan O., 2020. Economic growth, air pollution and health outcomes in Nigeria: A moderated mediation model. *Cogent Social Sciences*, 6.
- Wambebe N. M., and Duan X., 2020. Air quality levels and health risk assessment of particulate matters in Abuja municipal area, Nigeria, *Atmosphere*, 11, 817 <https://doi.org/10.3390/atmos11080817>
- Wang W., Wang W., Li L., Li J., Wei L., Chi W., Hong L., Zhao Q., and Jiang J., 2020. Seasonal concentration distribution of PM<sub>1.0</sub> and PM<sub>2.5</sub> and a risk assessment of bound trace metals in Harbin, China: Effect of the species distribution of heavy metals and heat supply. DOI: 10.1038/s41598-020-65187-7
- Washington R., Todd M. C., Middleton N. J., and Goudie A. S., 2006. Dust-storm source areas determined by the Total Ozone Monitoring Spectrometer and surface observations, *Annals of the Association of American Geographers*, 93(2), Pp. 297–313.
- Xiaolan L, Yanjun M, Yangfeng W, Ningwei L, and Ye H., 2017. Temporal and spatial analyses of particulate matter (PM<sub>10</sub> and PM<sub>2.5</sub>) and its relationship with meteorological parameters over an urban city in northeast China, *Atmospheric Research*, S0169-8095(16)30318-0, Pp. 1-32. <https://doi.org/10.1016/j.atmosres.2017.08.023>
- Xu Y., Xue W., Lei Y., Huang Q., Zhao Y., Cheng S., Ren Z., and Wang J., 2020. Spatiotemporal variation in the impact of meteorological conditions on PM<sub>2.5</sub> pollution in China from 2000 to 2017, *Atmospheric Environment*, 223, 117215.
- Yan, D., Kong Y., Ye B. and Xiang H., 2021. Spatio-temporal variation and daily prediction of PM<sub>2.5</sub> concentration in world-class urban agglomerations of China. *Environ. Geochem. Health* 243, Pp. 301–316
- Zhang H., Yuan H., Liu X., Yu J., and Jiao Y., 2018. Impact of synoptic weather patterns on 24 h-average PM<sub>2.5</sub> concentrations in the North China Plain during 2013–2017, *Science of the Total Environment*, 627, Pp. 200–210. <https://doi.org/10.1016/j.scitotenv.2018.01.248>

