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INVESTIGATING THE ANNUAL ATMOSPHERIC POLLUTION AND ITS ANALYSIS

***Hammed A. Lawal & Mukhtar I. Muhammed**

Space Physics /Atmospheric Science Research Group
Department of Physics, Air Force Institute of Technology, Nigeria

*Corresponding authors' email: hadelawal@yahoo.co.uk; h.lawal@afit.edu.ng

ABSTRACT

In the new global health report, air pollution has been regarded as one of the leading causes of deadly diseases in both rural and urban area. The major causes of Air Pollution are the particulate matters (PM). Several researches have been carried out on air quality and concentration of PM in different states of Nigeria. So far, however, there has been little discussion about the annual concentration of particulate matters (PM) in Nigeria. The aim of this paper is to analyze the annual concentration of PM from January2021 – December2021 in some states in Nigeria using real-time air quality data obtained from PurpleAir.com. Results obtained from this study have shown that the annual concentration of $PM_{2.5}$ in the study locations in Abuja, Kogi, Edo and Port Harcourt is greater than 20 µg/m^3 which is beyond the annual Air quality standards regulation while for $PM_{10.0}$, Abuja and Port Harcourt exceeded 40µg/m^3 (recommended value for $PM_{10.0}$) and therefore can be said to be highly polluted.

Keywords: Air Pollution, Concentration, Particulate Matters, PurpleAir

INTRODUCTION

Air pollution is the introduction of harmful gasses in to the atmosphere. Ground-level ozone, Carbon monoxide, Sulfur dioxide, Nitrogen dioxide and Particulate Matter ($PM_{1.0}$, $PM_{2.5}$ and PM_{10}) have been reported as the leading causes of air pollution. A good number of previous researches e.g. (Miller et al., 2007, Bingheng et al., 2008 and Javeria et al., 2018) have shown that long term exposure to polluted air can lead to serious respiratory and cardiovascular diseases e.g. Asthma, Pneumonia, Lung cancer, stroke etc. However, recent development in the study of air pollution have shown that air pollution even at lower concentration can affect health (WHO, 2022). Particulate Matters (PM) mostly exist as solid particles and liquid droplets in the atmosphere. The major components of particulate matters are ash, dust, sea salt, water, organic carbon and elemental carbon metals etc. (Zala & Jure, 2012; David et al., 2014). Airborne suspended PMs can be classified as primary or secondary. Primary particles e.g. Carbon monoxide, sooth, dust etc. are emitted directly into the atmosphere while secondary particles are formed in the atmosphere by the chemical transformation of different gases such as SO_2, NH_3 etc. (Zala & Jure, 2012). Based on the size of their particle diameter, PM are classified in to ultra-fine - $PM_{1.0}$, fine - $PM_{2.5}$ and coarse - $PM_{10.0}$. $PM_{2.5}$ are however regarded as the most dangerous PM due to its composition of fine inhalable particles capable of penetrating deep into the lungs and entering the blood stream (WHO, 2022) and the ability to travel far. In many developing states, there are agencies earmarked for the monitoring of air quality e.g. Environmental Protection Agency (EPA) in the US, California Air Resources Board (CARB), and Center for Atmospheric Research – National Space Research and Development Agency (CAR-NASRDA) in Nigeria etc.

In recent years, there has been an increasing number of researches that focus on air quality in some states in Nigeria e.g. Alani, et al.(2019) in an attempt to find the air quality within University of Lagos (UniLag) and Agege found out that the $PM_{2.5}$ concentrations ranged from 6µg/m^3 – 14µg/m^3 in respectively.

In the same vein, David et al., (2014) focused on assessing the $PM_{2.5}$ concentration in air at different periods of the day at highly trafficked junction of Sango-Ota, Ogun State; Nigeria. Using BR-SMART-126 portable 4-in-1 air quality monitor device, it was found that the concentration of $PM_{2.5}$ at the Sango-Ota intersection has an average hourly concentration between 97 and 370µg/m^3.

Nathaniel & Xiaoli (2020) carried out air quality levels and health risk assessment in Abuja Municipal using the data collected from BR-SMART-126 - a handheld portable smart air quality detector. Results from these findings have revealed that the daily average concentrations of $PM_{2.5}$ varied from 15.30 µg/m^3 to 70.20 µg/m^3. In addition, it was found that most-polluted locations fell under commercial locations, transport and residential areas.

Francis & Ifeoluwa (2021) in an attempt to monitor the air quality in Nigeria for a period of 5 – 7 months using real-time data obtained from NASRDA website found out that $PM_{2.5}$ concentrations for Lagos, Osun, Delta, and FCT are in the range of 23.23 – 847.75 µg/m^3, 9.1 – 236.6 µg/m^3, 12.11 – 487.36 µg/m^3 and 0 -1146.73 µg/m^3 respectively while the concentration of $PM_{10.0}$ in these aforementioned regions are in the range of 25 – 753.8 µg/m^3, 9.95 – 260.68 µg/m^3, 12.96 – 552.51 µg/m^3 and 0 - 831 µg/m^3 respectively.

A recent study by (Lawal & Mukhtar, 2022) on the concentration of PM in some selected areas in Nigeria namely; Lagos, Rivers and Abuja using purpleair real time data which spanned for 12 weeks between November 2021 and January 2022. Results from this study have shown that among the study areas, Port Harcourt has the highest concentration of Atmospheric (ATM) Particulate Matters followed by Abuja with a 12-weekly average $PM_{2.5}$_ATM = 63.15 µg/m^3 respectively while Abuja has an average $PM_{2.5}$_ATM value of 52.07 µg/m^3.

Overall, these studies tend to focus on the concentration of particulate matters within 3 to 7 months. So far, little have been known about the mean annual concentration of PM in Nigeria. This paper seeks to provide an in-depth analysis on the annual air quality in Nigeria through quantitative analysis on the concentration of Particulate Matters and the effect of our climatic season on air pollution. It is noteworthy that the findings in this report are subject to at least two limitations. First; absence of air quality sensors in some states and secondly, due to incessant power disruption and fluctuations in network, some data could not be captured or uploaded to

the real time database (PurpleAir) from where the data for this research was downloaded. Therefore, this study shall only focus on states under the coverage of Purpleair data.

MATERIALS AND METHOD OF DATA COLLECTION

The data used in this paper was obtained from PurpleAir map available at http://www.map.purpleair.com. The daily average data was collected over a period of 365 days (1 year) from January 2021 to December 2021. Using column, we represent the mean monthly PM concentration of $PM_{2.5}$ and PM_{10}. Nigeria has 36 states and out of which Five (5) states and the Federal Capital Territory (FCT Abuja) within certain regions where sensors are installed are selected for this study. The Five (5) states selected are, Lagos, Rivers, Oyo, Edo, Kogi and the FCT, Abuja. The selected study area in this work is shown in Figure 1. The latitude and Longitude of the selected locations are shown in Table 1.

Research Area

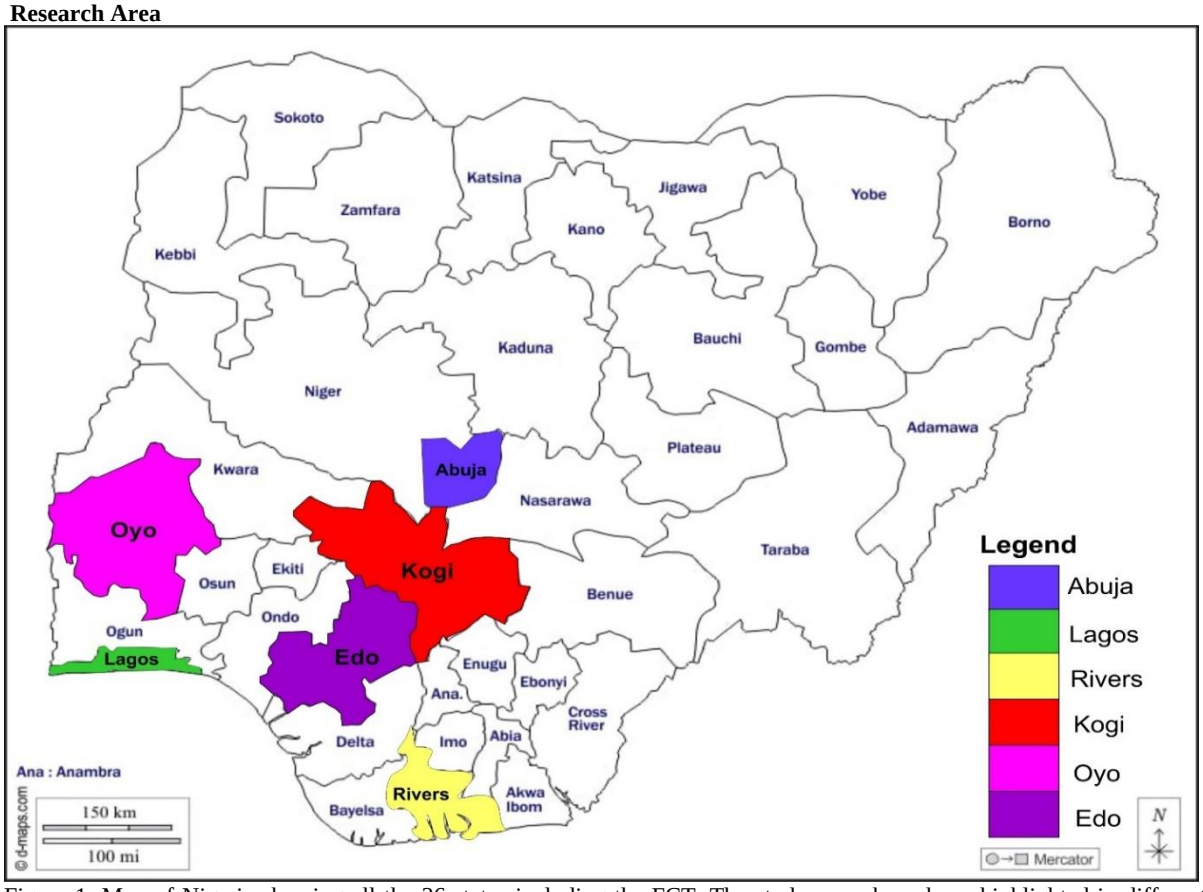

Figure 1: Map of Nigeria showing all the 36 states including the FCT. The study areas have been highlighted in different colours.

Table 1: Location of Air quality sensors

STATE	PURPLEAIR SENSOR LOCATION	LATITUDE	LONGITUDE
Abuja	Space Env. Res. Lab.	$9°4'20.1504''N$ $8.9641°N$	$7°29'28.6872E''E$ $7.3814°E$
Edo	Palm House	$05°04'N$ 6.3350°N	05°44′E 5.67037°E
Kogi	Kogi State Univ.	$7°28'39''N$ $7°28'51.39''N$	$7°11'14.86''E$ $7°11'14.86''E$
Rivers	Port Harcourt	$4°51'29.0772''N$ $4°49'27.0012''$N	$6°55'15.2904E''$ $7°2'0.9996''E$
Lagos	Lekki	$6°27'55.5192''N$ $6.4698°N$	$3°24'23.2128''E$ $3.5852°E$
Oyo	Ibadan	$7°51'9.25''$N $7°22'36.2496''$N	$3°55'52,5''$E $3°56'23.2296''$E

RESULTS AND DISCUSSION

Figure 2– figure 7 show the mean monthly concentration of $PM_{2.5}$ and $PM_{10.0}$ from January 2021 to December 2021 for different locations in Nigeria. The monthly mean Particulate Matter concentration across each state have shown great variation with some having a very high concentration beyond the recommended level.

Figure 2 shows the average monthly concentration of PMs in Lekki, Lagos state. It can be observed from the figure that the concentration of $PM_{2.5}$ and $PM_{10.0}$ was below 8µg/m^3 within the period of January to April. In May, the concentration of $PM_{2.5}$ and $PM_{10.0}$ increased to about 13.3 and 14.2 µg/m^3 respectively while in the month of July, the concentration of $PM_{2.5}$ and $PM_{10.0}$ increased to 15.4 to 16.0 µg/m^3. It is apparent that the highest concentration of PM occurred in the month of December with an average $PM_{2.5}$ = 56.4 µg/m^3 and $PM_{10.0}$ = 64.7 µg/m^3.

The bar graph in Figure 3 shows the monthly concentration of PM in Ibadan, Oyo state. The largest concentration of PM recorded occurred in the month of March. The $PM_{2.5}$ and $PM_{10.0}$ concentration is 11.6 and 16.7 µg/m^3 respectively. What is more interesting is that unlike other months, the difference between the concentration of $PM_{2.5}$ and $PM_{10.0}$ is remarkably high. Between January and February, there was no available data. The concentration of $PM_{2.5}$ and $PM_{10.0}$ within the interval June – July are in the range 8.9 to 5.3 µg/m^3. The level of PM for the month of April, May, September, November and December was very low.

Figure 4 presents the concentration of Particulate Matters in Kogi State. It can be seen that the highest concentration of PM in the year 2021 was recorded in January with $PM_{2.5}$ = 87.6 µg/m^3 and $PM_{10.0}$ = 94.6µg/m^3. The second highest concentration of PM as shown in the bar graph was recorded in December with $PM_{2.5}$ = 60.2 µg/m^3 and $PM_{10.0}$ = 66.5 µg/m^3. These two months in the northern Nigeria are characterized by harsh harmattan weather condition which usually results to dry air and dust haze. Within the interval April – November, the Concentration of PM are in the range 9.4 µg/m^3 – 32.1 µg/m^3 and 9.7 µg/m^3 – 34.7 µg/m^3 for $PM_{2.5}$ and $PM_{10.0}$ respectively.

Figure 5 shows the concentration of $PM_{2.5}$ and $PM_{10.0}$ from January 2021 – December 2021 in FCT. It is apparent from the bar graph that January recorded the highest concentration of PM with $PM_{2.5}$ = 100 µg/m^3 and $PM_{10.0}$ = 111.88 µg/m^3. There is a clear trend of decrease in the concentration of PM from February to June. Within this interval, the PM concentration is in the range 61.4 – 23.5 µg/m^3 and 72.4µg/m^3 - 25.25 µg/m^3 for $PM_{2.5}$ and $PM_{10.0}$ respectively. In July, the concentration of $PM_{2.5}$ = 39.57µg/m^3 and $PM_{10.0}$ = 41.4 µg/m^3 and between October and September, the $PM_{2.5}$ concentration vary between 23.5 µg/m^3 and 24.1 µg/m^3 while $PM_{10.0}$ concentration is in the range 24.5 and 26.95 µg/m^3. In December, the concentration of PM is 37.19 and 43.53 µg/m^3 for $PM_{2.5}$ and $PM_{10.0}$ respectively.

Figure 6 shows the concentration of PM in Edo state. The concentration of PM steadily increased from September to December. The PM value ranges from 12.5 – 114 µg/m^3 and 13.2 – 117 µg/m^3 for $PM_{2.5}$ and $PM_{10.0}$ respectively. There was no data available for the period of January to March. The reason for this shortfall in data was mainly due to the fact that the purpleair data for this location was created later than May as stated in purpleair database. Similarly, Figure 7 provides the monthly concentration of PM in Port Harcourt, River state. As shown in the figure, we can observe based on the available data, that January is the least in PM concentration value. There was no significant data available from February to June. The maximum concentration of PM occurred in August with a corresponding $PM_{2.5}$ and $PM_{10.0}$ values of 213 and 219 µg/m^3 respectively. From the month of September to December, the concentration of $PM_{2.5}$ ranges between 108 – 154 µg/m^3 while $PM_{10.0}$ concentration is in the range 116 – 161 µg/m^3.

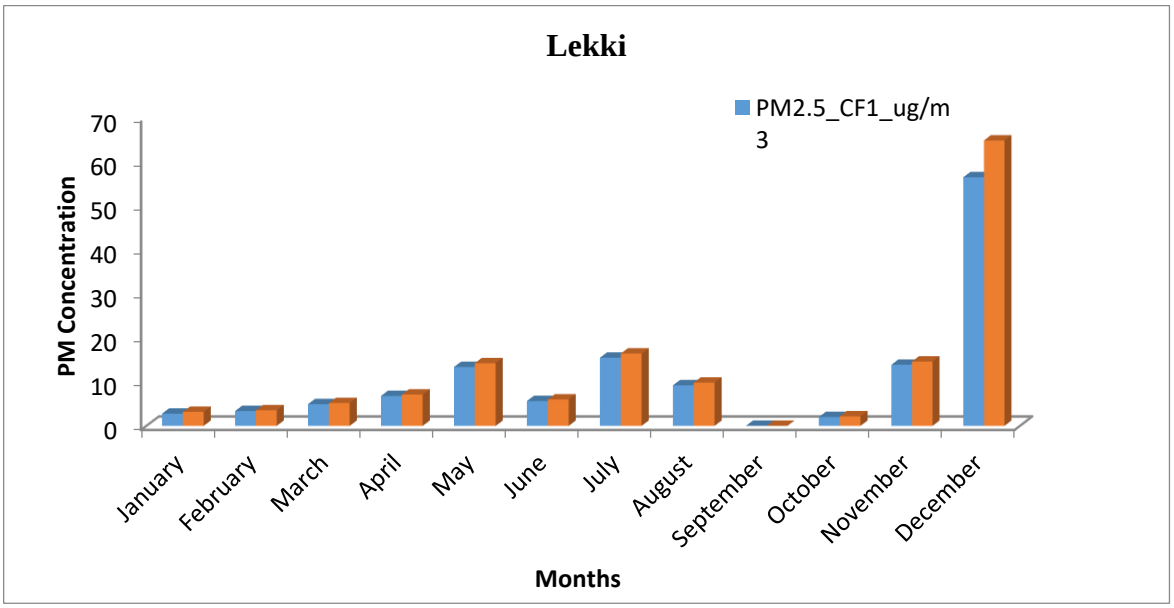

Figure 2: PM Concentration in Lekki, Lagos State

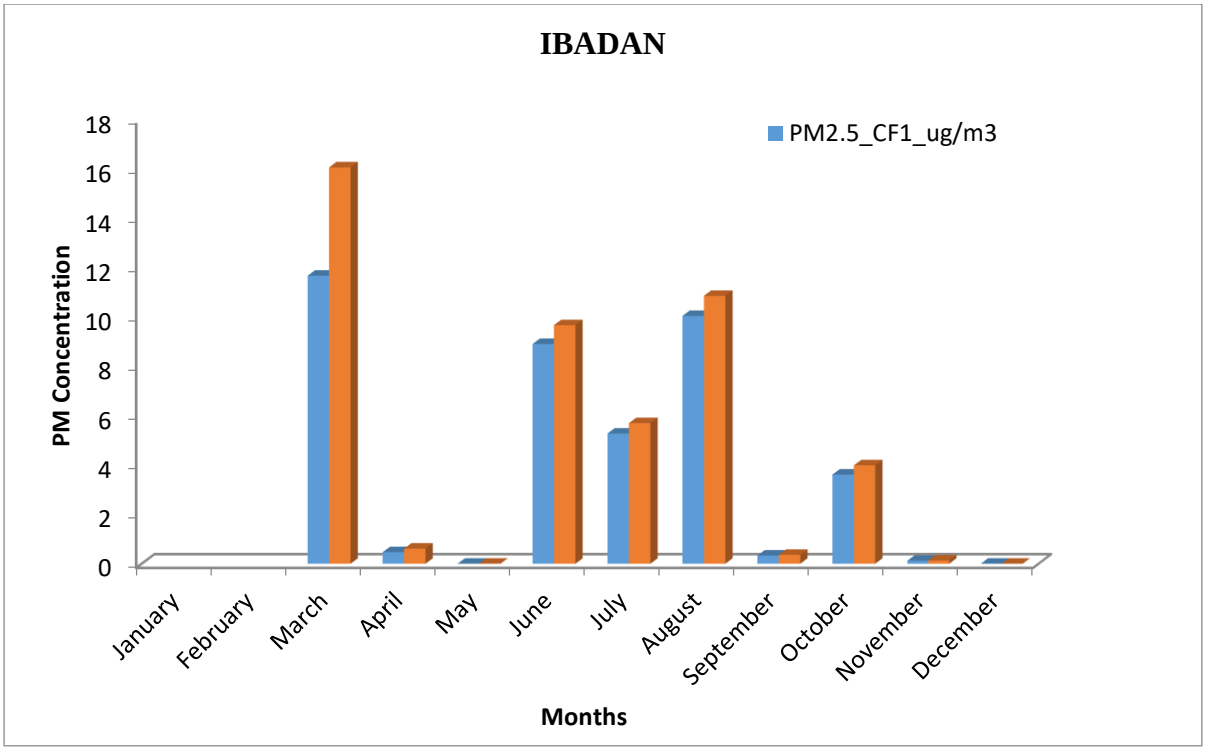

Figure 3: PM Concentration in Ibadan, Oyo State.

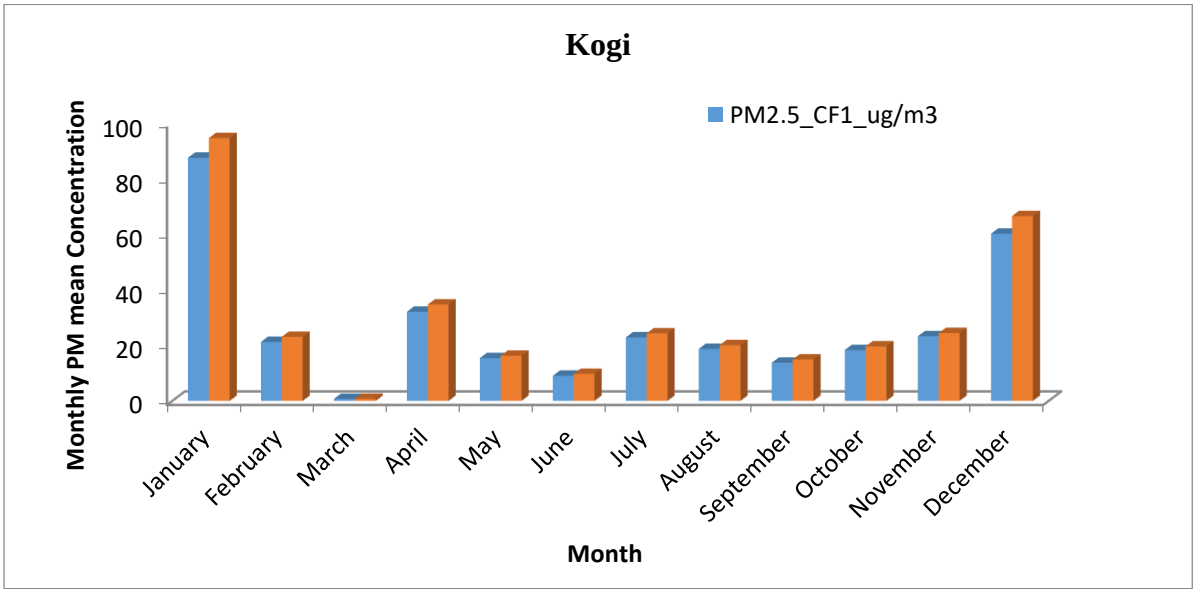

Figure 4: PM concentration in Kogi state.

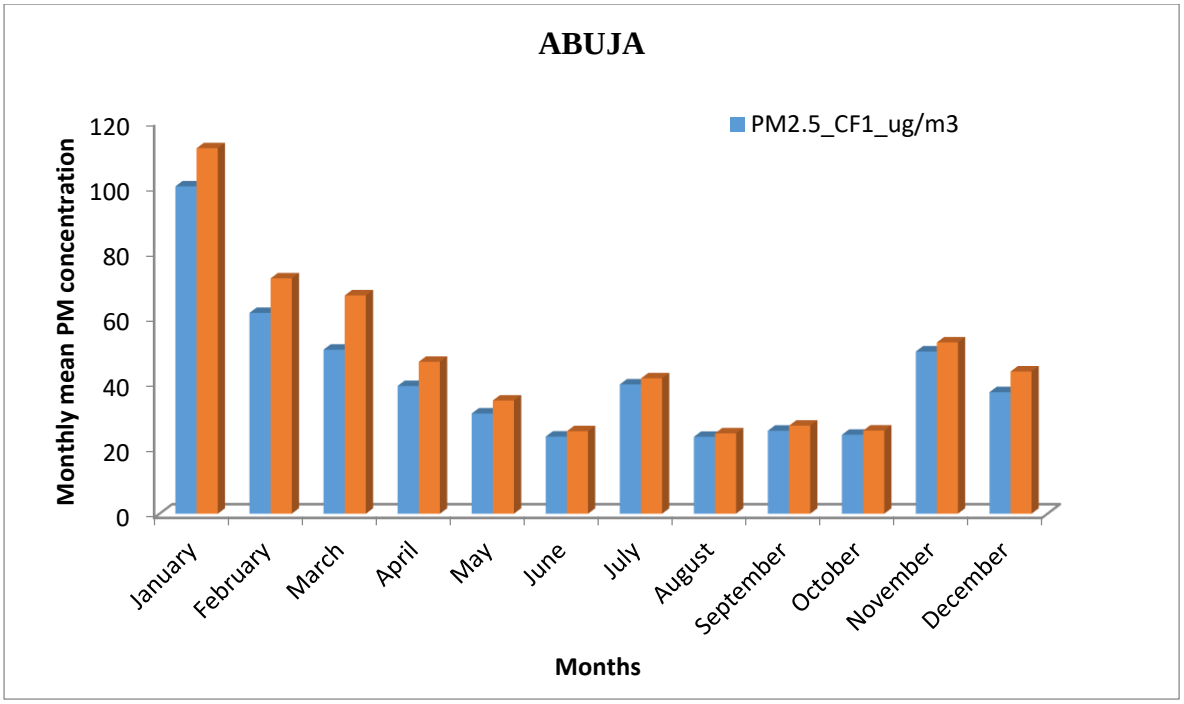

Figure 5: PM concentration in Abuja, FCT.

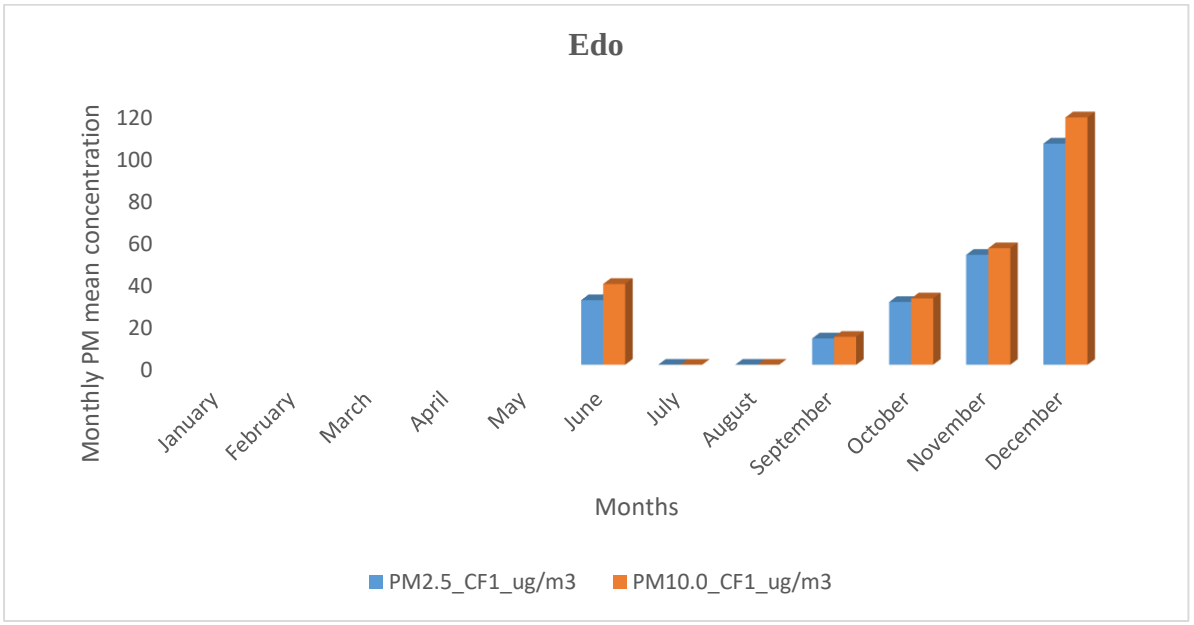

Figure 6: PM concentration in Edo state.

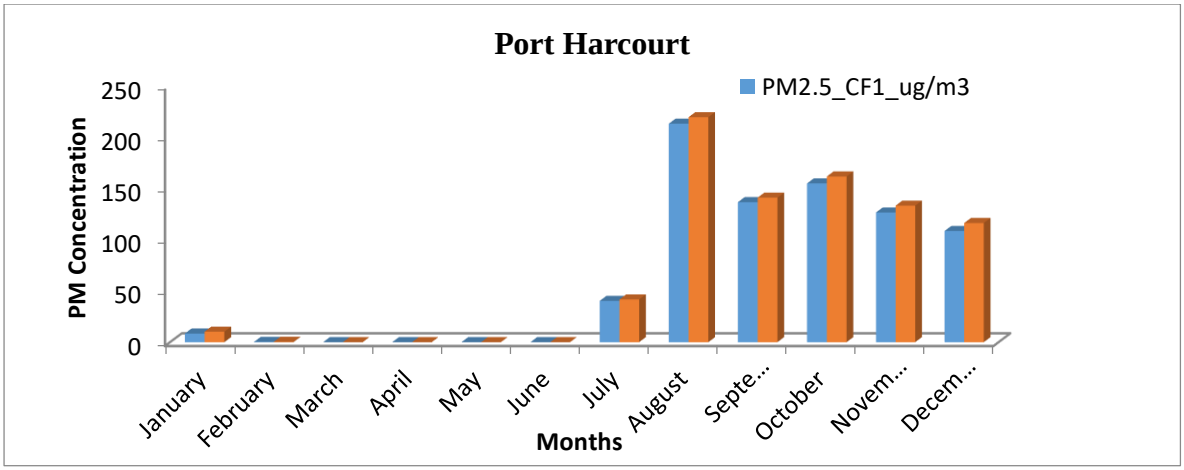

Figure 7: PM Concentration in Port Harcourt, Rivers State.

We can observe in this study that out of the six states, four states recorded the maximum concentration of PM between December and January. A possible explanation for this abrupt increase in the concentration of PM in these two months may be due to the increasing number of automobiles pacing through this location. These four locations namely Lekki, Ibadan, Abuja and Kogi are characterized with large numbers of Diesel-powered machines used in industry, increasing number of automobiles etc. As scientific experiment has revealed, the combustion gas emitted as exhaust fumes contain a large composition of water vapour - H_2O, Carbon dioxide - CO_2, Carbon monoxide - CO and Nitrogen - N_2 (Martin et al., 2012). These gases have been found to participate actively in the pollution of atmosphere. Since there are still ongoing construction in Lekki, where this sensor was placed. It can therefore be assumed that the high concentration of PM recorded could result from dust from construction sites. In view of this, It also is very essential to note that within the perimeter of the location of the air quality sensor in Kogi state university campus, Ayingba; where one of the air quality sensors was located, there has been an ongoing road construction that calls for the excavation of lands in the construction of drainage by heavy machines and the use of stone dust etc. These activities coupled with the incautious pouring of cement from its sack while mixing concrete could possibly contribute to the factors leading to the high concentration of PM in this area. Interestingly, a recent study by (Aleksei & Kirill, 2020) have highlighted that the manufacturing of cement is associated to PM. According to the United States Environmental protection Agency (EPA), "the cement sector is the third largest industrial source of pollution emitting more than 500,000 tons per year of Sulphur dioxide, nitrogen oxide and carbon monoxide", these findings by EPA seems to focus majorly on the cement plants and the process of cement production. Reports have found that cement dust causes cough, lung function impairment, and deterioration in sight, heart, liver and skin diseases. (Sultan, 2004, Jong-Han, 2012 and Ahmed et. al., 2021) . This is due to the inhalable constituent of cement which are approximately 0.05 – 5.0 µm in diameter.

Comparing our results with previous studies, there are similarities in the magnitude of concentration of PM in Lagos and Abuja in this study and the one demonstrated by (Francis & Ifeoluwa, 2021). The maximum concentration of PM in Ibadan are 11 and 16 µg/m^3 for $PM_{2.5}$ and $PM_{10.0}$ respectively while in Port Harcourt, the maximum concentration of $PM_{2.5}$ and $PM_{10.0}$ were recorded in March and August with a corresponding $PM_{2.5}$ and $PM_{10.0}$ concentration of 213 and 219 µg/m^3 respectively. It can be observed from Table2 that the largest concentration of PM across the six states was recorded in Port Harcourt, Rivers state. This abnormal rise in the concentration of PM could be due to the industrial activities in the state. Rivers is one of the state with the highest deposit of crude oil and hence, houses the biggest oil refinnery in Nigeria. Gas flares from refinnery sites emmitted in to the atmosphere can be suggested as one of the leading factor in the rise of the concentration of PM in this area. This can result to large deposits of black sooth spread within the atmosphere of this particular location which when exposed to may lead to serious respiratory diseases.

Table 2: Annual concentration of PM in some states in Nigeria

Location	Particulate Matters	Annual Mean Concentration
Lagos	$PM_{2.5}$	11.14 µg/m^3
	$PM_{10.0}$	12.24 µg/m^3
Oyo	$PM_{2.5}$	4.05 µg/m^3
	$PM_{10.0}$	4.75 µg/m^3
Abuja	$PM_{2.5}$	42.1 µg/m^3
	$PM_{10.0}$	47.6 µg/m^3
Kogi	$PM_{2.5}$	26.95 µg/m^3
	$PM_{10.0}$	29.10 µg/m^3
Edo	$PM_{2.5}$	32.9 µg/m^3
	$PM_{10.0}$	36.6 µg/m^3
Port Harcourt	$PM_{2.5}$	65.66 µg/m^3
	$PM_{10.0}$	68.6 µg/m^3

CONCLUSION

This study sets out to determine the annual concentration of Particulate Matters in Lagos, Oyo, Kogi, FCT, Edo and Rivers state. The results of this investigation have revealed that the highest concentration of Particulate Matter in the year 2021 was recorded in Port Harcourt with an annual PM concentration of 65.66 and 68.6μg/m^3 for $PM_{2.5}$ and $PM_{10.0}$ respectively. The least annual concentration of PM was recorded in Oyo with a corresponding PM value of 4.05 and 4.75 μg/m^3 for $PM_{2.5}$ and $PM_{10.0}$ respectively. The annual concentration of $PM_{2.5}$ in Abuja, Kogi, Edo and Port Harcourt is beyond the EPA annaul Air quality standards regulation While for $PM_{10.0}$, Abuja and Port Harcourt exceeded 40μg/m^3 (recommended value for $PM_{10.0}$) and therefore can be said to be highly polluted. On this basis, the overall air quality in these study locations except Oyo is unhealthy for the people over there.

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