VOL 8, NO 1, JUNE 2022.
ISSN: 2276-7924
www.ijssyabatech.com

$PM_{2.5}$ VARIATIONS AND AIR QUALITY ASSESSMENTS IN THREE LOCATIONS.

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ABSTRACT

Air Quality is a major concern of most civilized world; this has a serious effect on human health and the environment. Air pollution threatens the quality of air in our planet. It creates smog and acid rain, causes cancer, respiratory diseases, reduces the ozone layer atmosphere and contributes to global warming. This study aimed at assessing the level of Particulate Matters ($PM_{2.5}$) in Lagos, Abuja and Beijing for a routine measuring device at the US embassy situated in the mentioned stations. General Air Index Acquisition (GAIA) instrument uses a high-tech laser particle sensor to measure air indices in real-time. It only requires a Wi-Fi access point and a USB power supply, once connected; air quality levels of $PM_{2.5}$ are monitored continuously. Measured results showed that daily $PM_{2.5}$ values for 2021,varies from 38 to 370μg/m^3, 51-376μg/m^3 and 15-265μg/m^3 at Lagos, Abuja and Beijing respectively, while the monthly averages showed variations of 93.9 to 160.2μg/m^3, 76.0 to 179.9μg/m^3 and 74.1 to 147.03μg/m^3 respectively for Lagos, Abuja and Beijing. The implications of this monitored values in the colour ranges is a shift from "Moderate" to "Unhealthy" conditions for the three locations. Lagos had the highest in the observed values of the daily variation ranges of $PM_{2.5}$ in the air. This may be adduced to the commercial and industrial activities in Lagos.

KEYWORDS: Air pollution; Air quality index; Particulate Matter ($PM_{2.5}$), health condition and Sensitive groups.

INTRODUCTION.

The earth is enveloped by a thick blanket of gases. This gaseous cover of the earth is known as the atmosphere, and it is held to the earth by the force of gravity. It consist of 78% nitrogen and 21% oxygen, with the remaining consisting of argon, carbon (IV) Oxide (CO_2), ozone (O_3) and water vapor. Other gases such Neon, Krypton, Helium, Methane, Hydrogen etc. occur in very small proportions. The atmosphere also contains suspended liquid and particulate matters (PM), collectively called aerosols, extending several thousands of kilometers above the earth's surface. Studies have revealed that these atmospheric particles can lead to the reduction of biodiversity and the quality of goods and services offered by ecosystem. Air pollution is one of the environmental problems confronting growing cities and is currently the challenge faced by many developed and developing countries (Amos *et al*, 2015). Air pollution is defined as the presence of one or more substance in the atmospheric air at concentration and duration above the natural limits and cause damage to the natural environment (Tawari and Abowei, 2012).

Particulate matter (PM) is divided into two main categories according to type and size. Gas contaminants include PM in aerial masses. Particulate contaminants include contaminant such as Smog, Soot, Tobacco smoke, Oil smoke, Fly ash and cement dust. Life on earth is supported by layer of air, solar energy, our planet magnetic field and the quality of air is very essential to it sustenance (Adesuyi *et al*, 2016). Air Quality is a measure of how clean or polluted the air is.

Monitoring air quality is important because polluted air can be bad for our health – and the health of the environment. In addition to land and water, air is the prime resource for sustenance of life (Hiren and Jagruti, 2017). Exposure to air pollution is associated with a wide range of diseases including Chronic Obstructive Pulmonary Diseases (COPD), asthma, lung cancer, heart disease, stroke, arterial thrombosis and hypertension (Babatunde *et al*, 2020). When we breathe polluted air, pollutants get into our lungs; they can enter the bloodstream and be carried to our internal organs such as the brain. Air pollution has been common health concern not only for humans but also for animals, plants, oceans, aquatic life worldwide (Pradeep and Harne, 2018).Particulate matter is one of the most important parameter having significant contribution to increase in air pollution (Ramik, 2019). These substances are mainly concentrated in metropolitan area and their amounts are frequently higher than the threshold values imposed by local regulations. The possible causes lied in the vehicular traffic, the industrial plants emissions and heating of buildings. People are worried about the effects on human health of possible atmospheric pollution caused by the gaseous emissions of combustion plants (Sofia *et al*, 2018). Air pollution, therefore, is a serious threat to environmental health in many cities of the world today. It is very pertinent to note that this condition is not unconnected to the fact that one of the basic requirements of human health and existence is clean air (Ibe *et al*, 2017).Rapid, accurate and high-throughput sizing and quantification of particulate matter (PM) in air is crucial for monitoring and improving air quality. In fact, particles in air with a diameter of ≤2.5μm have been classified as carcinogenic by the World Health Organization (Wu *et al*, 2017).

Airborne particulate matter has a harmful impact and is estimated to cause between 3 and 7 million deaths per year, mostly due to the creation or worsening of cardio-respiratory disease (Hoek *et al*, 2013). This study is aimed at measuring and assessing the level of $PM_{2.5}$ in the atmosphere, for a routine measuring device situated in the US embassies at Lagos, Abuja and Beijing. In the process, the daily and monthly averages of $PM_{2.5}$ from the measured hourly values at Lagos were calculated. The trends of variation of $PM_{2.5}$ during 2021 were explained, and simultaneously compared with the trends at Abuja and Beijing.

MATERIALS AND METHODS

Fig1, shows picture of a routine GAIA (General Air Index Acquisition), air quality monitoring instrument with mounted sensors. Inside the metal box, the system consists of a micro controller with three sensors extending outwardly to the air, namely carbon monoxide sensor, particulate matter sensor, and smoke sensor. This system is also equipped with a data. Logger to store measured data and LCD to display the level of air quality. The air quality $PM_{2.5}$ measurements were carried out simultaneously in three geographical locations of; Lagos and Abuja in Nigeria, together with Beijing in China all at the US embassies located in the stated countries. The $PM_{2.5}$ measurement were carried out using the GAIA, air quality monitoring meters, which uses a high-tech laser particle sensor to measure in real-time $PM_{2.5}$ pollution. With the help of a WIFI access point and a USB power supply, once connected, air pollution levels are reported instantaneously and in real-time. The $PM_{2.5}$ measurements were monitored in real-time for the entire year 2021 except for December, after which the mean measurement for different months were calculated. The entire measurements in the three locations were pulled together with the help of the internet.

Fig.1: Picture of the routine GAIA Air Quality Monitoring Instrument with mounted sensors.

RESULTS AND DISCUSSION

Fig2, shows the daily trend of variation of $PM_{2.5}$ at Lagos, Abuja, and Beijing for January and February during year 2021.

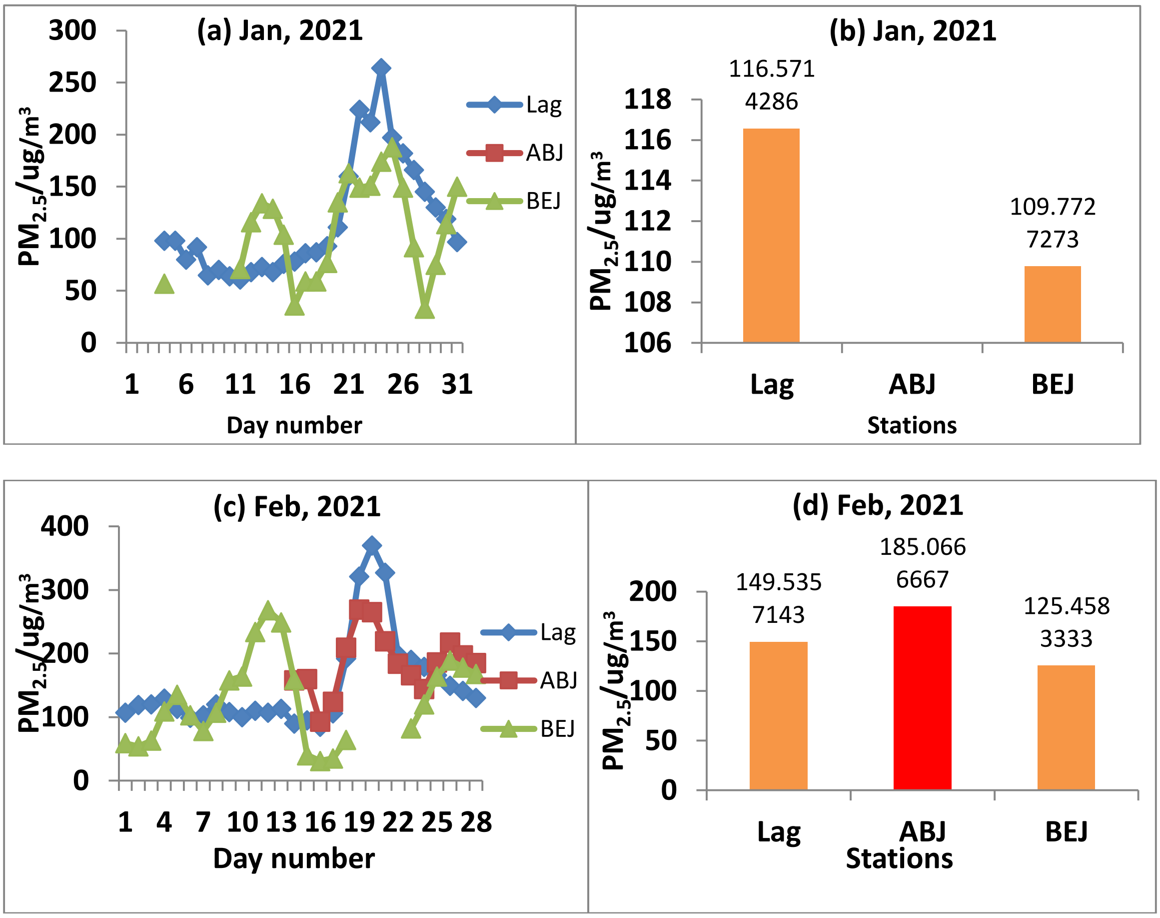

Fig 2: $PM_{2.5}$ Daily Variation (a & c) and monthly averages (b & d) at Lagos, Abuja and Beijing during January and February, 2021.

The variations of $PM_{2.5}$ depicted in Fig 2 (a & c) were 98µg/m^3 for January to 370µg/m^3 during February at Lagos, 57 to 268µg/m^3 at Abuja and 93 to 265µg/m^3 at Beijing. The monthly averages of 116.6 to 149.5µg/m^3 at Lagos, from zero record at Abuja in January to 185.1µg/m^3 in February and 109.8µg/m^3 in January to 125.5µg/m^3 in February at Beijing as indicated in Fig 2(b & d). The implications of this $PM_{2.5}$ values according to USA Environmental Protection Agency, USEPA, (2021) are for the health details of the locations which ranges from unhealthy for sensitive groups at Lagos and Beijing to unhealthy at Abuja. When is unhealthy, everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects. Active children and adults, and people with respiratory disease, such as asthma, should avoid prolonged outdoor exertion; everyone else, especially children, should limit prolonged outdoor exertion.

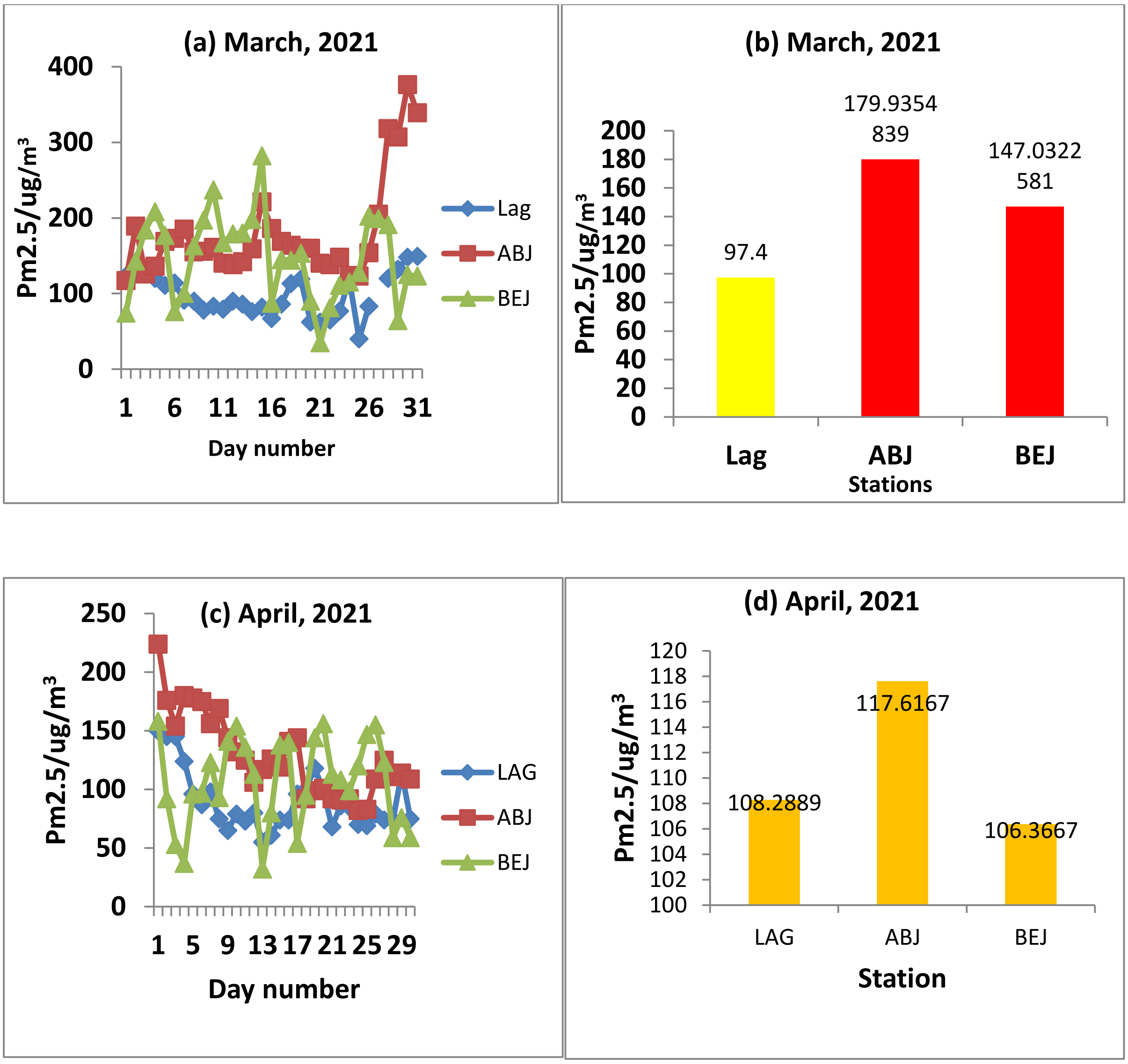

Fig 3: $PM_{2.5}$ Daily Variation (a & c) and monthly averages (b & d) at Lagos, Abuja and Beijing during March and April, 2021.

In Fig 3(a & c), the trend in the daily variation of $PM_{2.5}$ from March to April is from 40 to 145µg/m^3 at Lagos, 83 to 376µg/m^3 at Abuja and 32 to 282µg/m^3 at Beijing. The monthly averages (depicted in Fig 3(b & d)) were 97.4 (Yellow) to 108.3µg/m^3 (Orange), 179.9(Red) to 117.6µg/m^3 (Orange) and 147.03 (Red) to 106.4µg/m^3 (Orange) for Lagos, Abuja and Beijing respectively. The colours indicated shifts from moderate to unhealthy for sensitive groups at Lagos and unhealthy to unhealthy for sensitive groups both at Abuja and Beijing. During moderate condition, air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution. Active children and adults, and people with respiratory disease, such as asthma, should limit prolonged outdoor exertion. (USEPA, 2021)

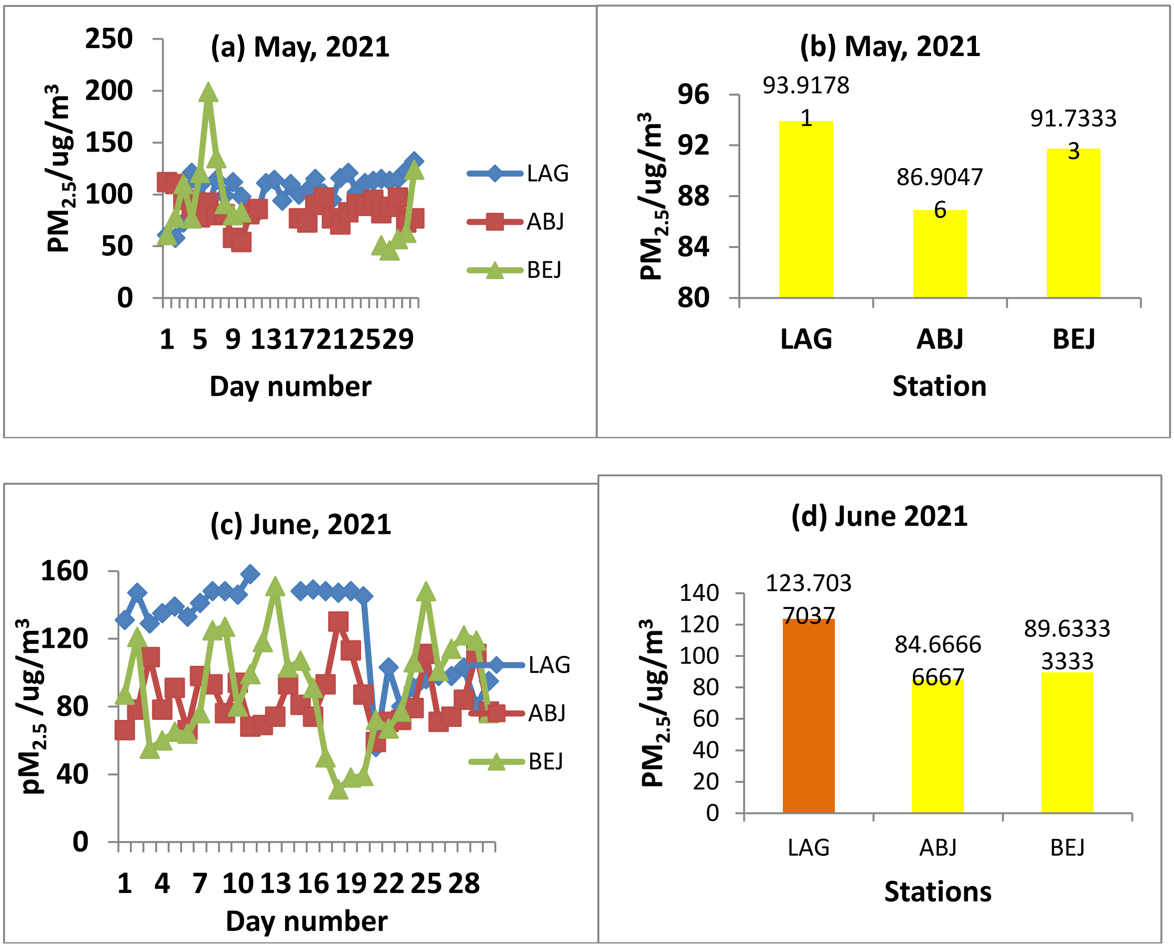

Fig 4: $PM_{2.5}$ Daily Variation (a & c) and monthly averages (b & d) at Lagos, Abuja and Beijing during May and June, 2021.

Fig 4 shows the variations and monthly averages of $PM_{2.5}$ for the months of May and June, 2021. The trend for Lagos, Abuja and Beijing, depicted in Fig 4(a & c) were 61 to 158µg//m^3, 54 to 130µg//m^3 and 51 to 151µg//m^3 respectively. The monthly averages are depicted in Fig4 (b & d) as 93.9 (Yellow) to 123.7µg/m^3 (Red), 86.9 (Yellow) to 84.7µg/m^3 (Yellow) and 91.7 (Yellow) to 89.6µg/m^3 (Yellow) for Lagos, Abuja and Beijing respectively. The variation is more at Lagos, a shift from Yellow (Moderate health condition) to Red (Unhealthy condition), while a moderate health condition were sustained at Abuja and Beijing for these two months. The result obtained in Lagos for these months could be adduced to dust entering the country, urban traffic and industries in the area (Mirhosseini *et al*, 2012).

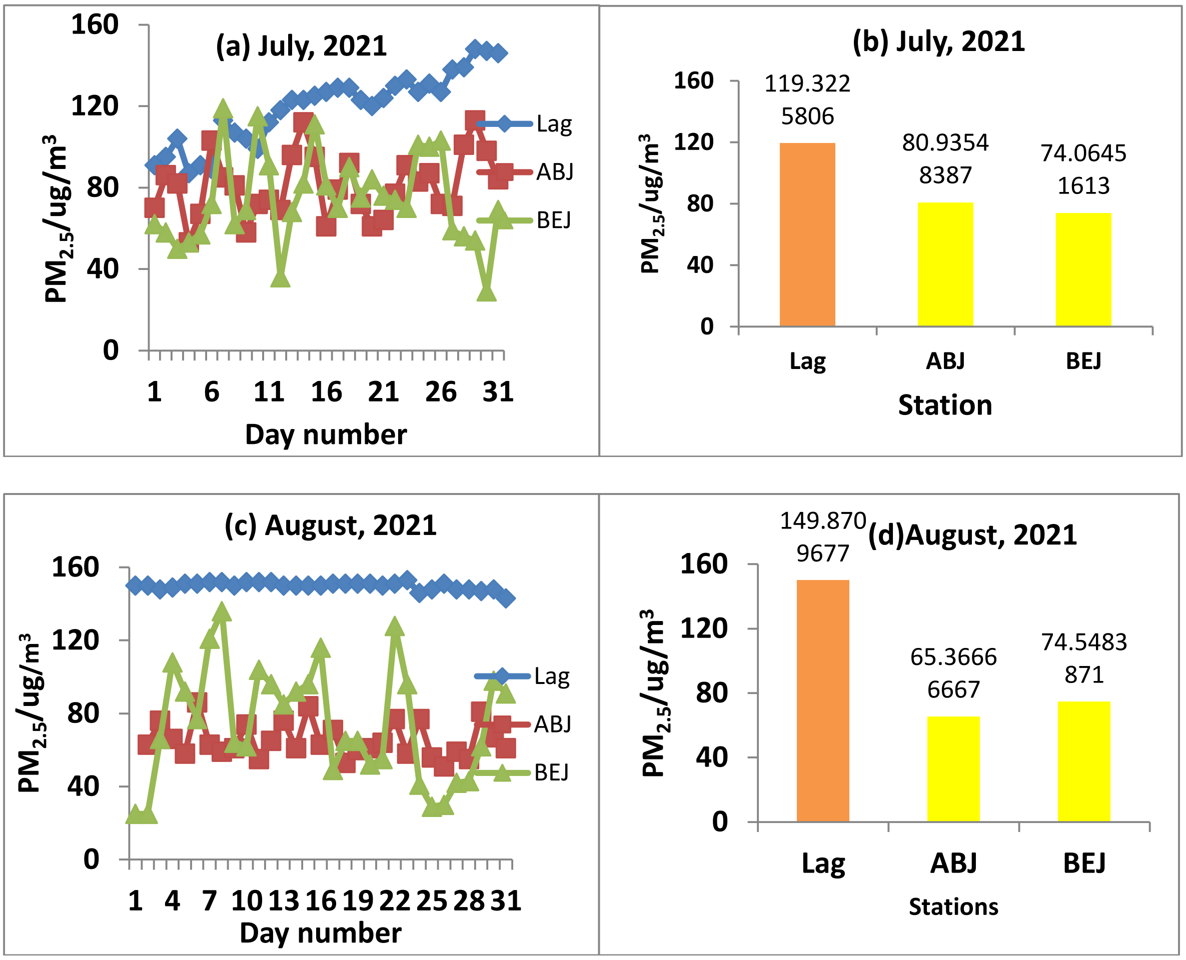

Fig 5: $PM_{2.5}$ Daily Variation (a & c) and monthly averages (b & d) at Lagos, Abuja and Beijing during July and August, 2021.

Furthermore, the trend of variations and monthly averages for July and August, 2021 are presented in Fig 5. In Fig 5(a & c), daily variation trends of 86 to 153µg/m^3, 51 to 113µg/m^3 and 29 to 136µg/m^3 are presented respectively for Lagos, Abuja and Beijing locations. The monthly averages are 119.3 (Red) to 149.8µg/m^3 (Yellow) and 74.1 (Yellow) to 74.5µg/m^3 (Yellow) for Lagos, Abuja and Beijing respectively in Fig 5(b & d). The health conditions of the locations for the two months were sustained as: Unhealthy for Lagos and Moderate for both Abuja and Beijing. The Unhealthy condition presented at Lagos for these two months in the values of $PM_{2.5}$ could not be far fetch from vehicular and industrial emissions.

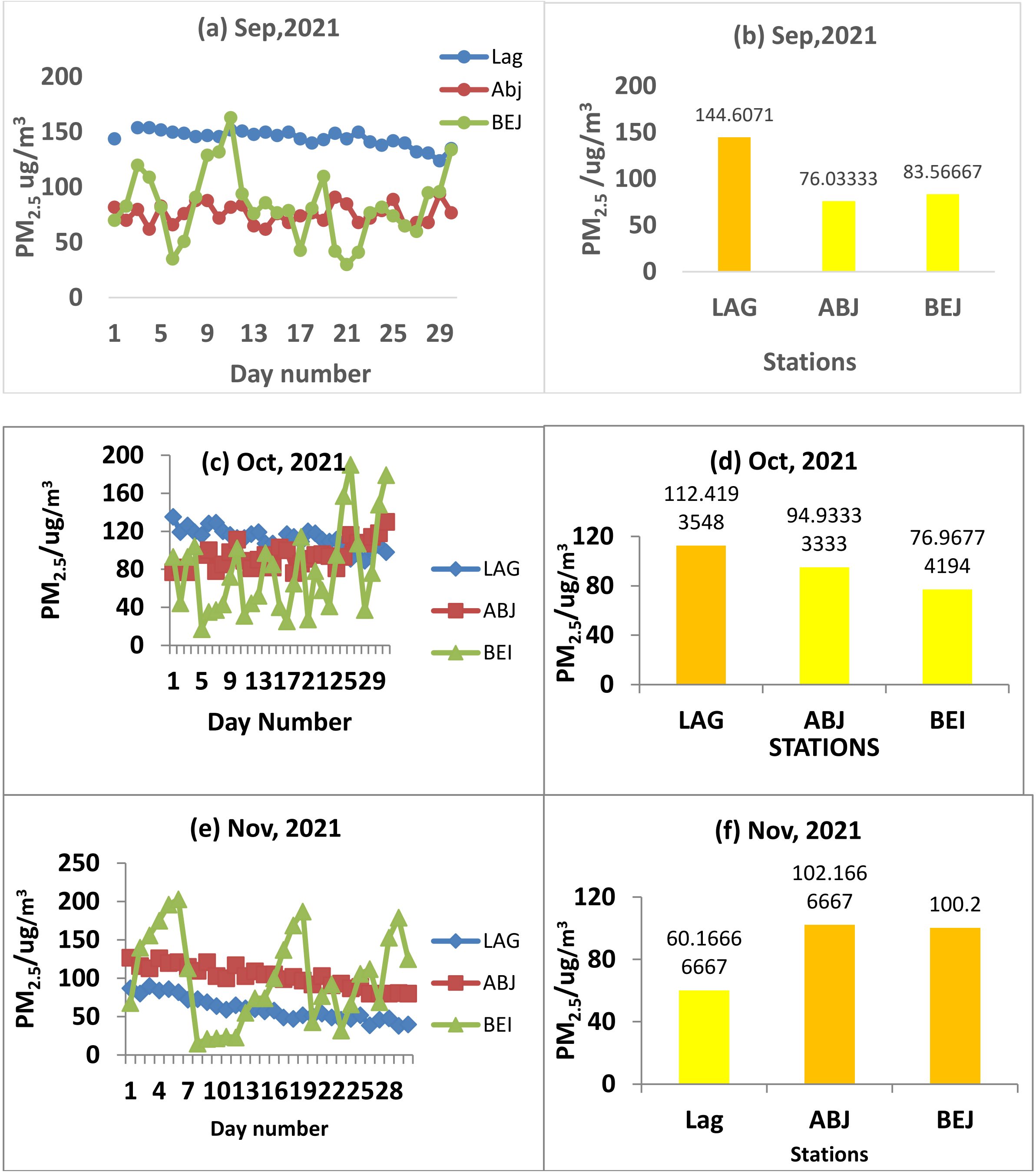

Fig 6: $PM_{2.5}$ Daily Variation (a, c & e) and monthly averages (b, d & f) at Lagos, Abuja and Beijing during Sep, Oct and Nov, 2021.

Further still, Fig 6 shows the trend in the daily variations and monthly averages of monitored $PM_{2.5}$ values for the months of September, October, and November, 2021. Considering Fig 6 (a, c & e), the observed variations are 38 to 154µg/m^3, 62 to 131µg/m^3 and 15 to 196µg/m^3 at Lagos, Abuja and Beijing respectively. The column charts in Fig 6 (b, d and f) for the three months, showed a colour shift from Orange (144.6µg/m^3) to Yellow (160.20µg/m^3), Yellow (76.0µg/m$^{3)}$ to Orange (102.2µg/m^3) and Yellow (77.0µg/m^3) to Orange (100.2µg/m^3) for Lagos, Abuja and Beijing respectively. These indicate a shift from unhealthy for sensitive groups to moderate at Lagos and Moderate health condition to Unhealthy to sensitive groups at Abuja and Beijing.

Following the daily trend depicted in the graphs, the implications of the different values are further discussed as follows:

0 – 50 (Good): Air quality is considered satisfactory, and air pollution poses little or no risk.

51 – 100 (Moderate): Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution. Active children and adults, and people with respiratory disease, such as asthma, should limit prolonged outdoor exertion.

101 – 150 (Unhealthy for Sensitive Groups)
Members of sensitive groups may experience health effects. The general public is not likely to be affected. Active children and adults, and people with respiratory disease, such as asthma, should limit prolonged outdoor exertion.

151 – 200 (Unhealthy)
Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects. Active children and adults, and people with respiratory disease, such as asthma, should avoid prolonged outdoor exertion; everyone else, especially children, should limit prolonged outdoor exertion.

201 – 300 (Very Unhealthy)
Health warnings of emergency conditions. The entire population is more likely to be affected.
Active children and adults, and people with respiratory disease, such as asthma, should avoid all prolonged outdoor exertion; everyone else, especially children, should limit prolonged outdoor exertion.

300+ (Hazardous)
Health alert: everyone may experience more serious health effects. Everyone should avoid all outdoor exertion. (USEPA, 2021)
Overall results obtained from the study in the three stations showed some shifts in the Air quality index $PM_{2.5}$ switching from healthy, moderate, unhealthy and at some time hazardous health conditions as depicted in the daily values. Seasonal trend was depicted in the variations $PM_{2.5}$ across the various months. The Air Quality Index (AQI) values obtained from Lagos in this study was high at some times, then decreases along the line, this result depicted 'unhealthy' to 'moderate' health conditions, while that of Abuja and Beijing were increasing and decreasing i.e ranging from 'moderate' to 'unhealthy'. In the analysis, most of the $PM_{2.5}$ values were above the National Ambient Air Quality Standards, (NAAQS) limits of 35ug/m^3, (Osimobi *et al*, 2019) and the recommended air quality index of the federal ministry of environment (FMEnv) limits of .0.5ug/m^3, (Abulude *et al*, 2020).. Hence national standards to reduce the $PM_{2.5}$ in the air at these three locations are urgently required.

CONCLUSION

The findings of this work and its implications could be summarised as follows:

1. $PM_{2.5}$ daily variations at the three stations are 38-370µg/m^3, 51 - 376µg/m^3 and 15-265µg/m^3 at Lagos, Abuja and Beijing respectively. Lagos had the highest range of 332µg/m^3 in the daily variation.

2. $PM_{2.5}$ monthly averages for the entire year obtained were 93.9-160.2 µg/m^3, 76-179.9µg/m^{3}and 74.1-147.02µg/m^3 at Lagos, Abuja and Beijing respectively. Abuja depicted the highest range of 103.9µg/m^3 in the monthly averages.

3. Seasonal variations are depicted across the months. This is seen as different health conditions across months.

4. Most of the $PM_{2.5}$ values were above the National Ambient Air Quality Standards, (NAAQS) limits of 35ug/m^3. Hence national measures to reduce the $PM_{2.5}$ in the air at these three locations are urgently required.

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ACKNOWLEDGMENT

The authors are very grateful to the US Embassies in the three study locations, for granting us access to their facilities and data via the internet.