Nigerian Research Journal of Chemical Sciences **(ISSN: 2682-6054)**
Volume 8, Issue 2, 2020

ASSESSMENT OF LEVEL OF AIR POLLUTANTS AND PARTICULATE MATTER WITHIN ABUJA METROPOLIS, NIGERIA

* [1]M. O. Otse, [1]E. B. Agbaji, [1]N. C. Nwokem and [2]A. M. Funtua
[1]Department of Chemistry, Ahmadu Bello University, Zaria, Kaduna State, Nigeria
[2]Department of Chemistry, Kaduna State University, Kaduna, Nigeria.
*Corresponding author: michaelotse@gmail.com

ABSTRACT

This research work assessed the levels of air pollutants in the ambient air of Abuja metropolis, Nigeria. These pollutants were measured in-situ during morning, afternoon and evening periods using air quality monitors in 16 locations within the months of March and August, 2018. The results showed that the mean concentrations (ppm) of the air pollutants ranged as follows: CO, 0.00 – 24.05, SO_2, 0.00 – 0.49, NO_2, 0.00 – 0.71, H_2S, 0.00 – 0.53, $PM_{2.5}$, 0.00 – 0.04, and PM_{10}, 0.00 – 0.15. The results revealed that the concentration of CO was higher than other pollutants across the sites and were above the Nigerian National Ambient Air Quality Standards (Nigerian NAAQS) and WHO recommended safe limits especially during evening periods. Also the air quality index (AQI) analysis revealed that CO is the main gaseous pollutant in the study area. This calls for urgent measures, to protect lives, improve fuel quality and control emission.

Keywords: Abuja, Air pollutants, Human health, Vehicular emissions.

INTRODUCTION

Atmosphere is a gaseous layer surrounding the earth [1]. Health impact of air pollution depends on the pollutant type, its concentration in the air, length of exposure, other pollutants in the air, and individual susceptibility [2]. Air pollution and especially urban air pollution is an alarming phenomenon. The presence of high concentrations of air pollutants could pose serious environmental and health concerns [3, 4, 9 – 11]. Clean air is considered to be a basic requirement of human health and well-being [5, 6]. Smog caused by air pollutants has a significant adverse impact on the health of Nigerians, the Nigerian economy, and the environment. Smog is a noxious mixture of gases and particles [7, 8]. The emission of pollutants by vehicles into the atmosphere as a result of traffic density emanating from high fleet growth, increased population, increased urbanization and economic improvement have caused serious damage to the environment. These pollutants affect plants, animals and man and by extension crops cultivated on places exposed to these emissions especially those areas close to road sides [12]. Vehicular emissions are one of the leading causes of air pollution. The operation of motor vehicles is a major source of air pollutants. Traffic congestion increases vehicle emissions and degrades ambient air quality [5].

Motor vehicle emissions are a result of combustion and evaporation of fuel. The most common types of transport fuels are gasoline and diesel. When the fuel in a vehicle is burned, pollutants such as CO, SO_2, NO_2 and PM are emitted [7]. Diesel exhaust emissions comprise significantly high amounts of particulate matter and its precursors, which can cause respiratory and cardiovascular problems and premature death [8]. The main products of the combustion of motor fuels are carbon dioxide and water, but inefficiencies and high temperature inherent in engine operation encourages the production of many other pollutants of varying effect [12]. Due to urbanization, with increase in the influx of vehicles, Abuja experiences major traffic congestions. These occur early in the morning and sometimes in the evening, when people are returning from their work places.

In this study, the concentrations of CO, SO_2, NO_2, H_2S and PM were monitored in selected traffic sites in Abuja metropolis in the morning (6:45 am-8:45 am), afternoon (12:45-2:45 pm) and evening (4:45-6:45 pm).

The aim of this work was to assess the level of ambient air pollutants in Abuja metropolis. This aim was designed to be achieved through the following objectives: Determination of the levels of these pollutants (CO, SO_2, NO_2, H_2S. PM 2.5, PM 10) in the morning, afternoon and evening. Comparing the concentration recorded with standard limits (WHO and NAAQS) to identify potential risks to human and the environment and determination of the variation of the pollutants within high traffic and low traffic areas of the city.

MATERIALS AND METHODS

Study Area

Sixteen sample sites were chosen within the Abuja metropolis for the study. The sites were: M1-(Kabusa junction, Apo), M2-(AP junction, Gudu district), M3-(Apo under bridge, Garki), M4-(Old CBN junction, Ahmadu Bello way, Central District area), M5-(FCDA bus stop, Central Business area), M6-(Area 3 junction, Garki), M7-(Old Federal Secretariat junction ,Garki), M8-(Wuse bus stop, Area 1), M9- (Area 2 shopping mall junction, Garki), M10-

(UTC bus stop), M11-(Ship house, Bolingo hotel junction, Wuse), M12-(Ali brothers junction, Wuse zone 1), M13-(National Hospital roundabout, Wuye), M14-(Games village junction, Kukwaba district), M15-(Galadimawa junction, Lokogoma) and M16-(National stadium as control) which is devoid of high vehicular traffic, mini parks and refuse dump site. The 15 sampling sites were randomly selected as shown in the map below and labelled (M1-M15) with an average distance of 500 metres from one another. These sites are characterized as follows: M1-, close local motor park, commercial vehicles activities; M2-Near filling station; M3- high volume of commercial vehicles especially taxis; M4-High traffic; M5-many commercial vehicles; M6- many commercial motorcycles, tricycles and activities, usage of generators and heavy traffic; M7- Near filling station; M8- Refuse dump, vehicles especially taxicab, mainly commercial; M9- commercial vehicles, refuse dump; M10- Near filling station, local motor park, 30m from main motor park, commercial vehicles and trucks; M11 and M12-moderate traffic; M13- High traffic; M14- moderate traffic; M15-Many commercial motorcycles, tricycles and commercial activities, usage of generators and heavy traffic.

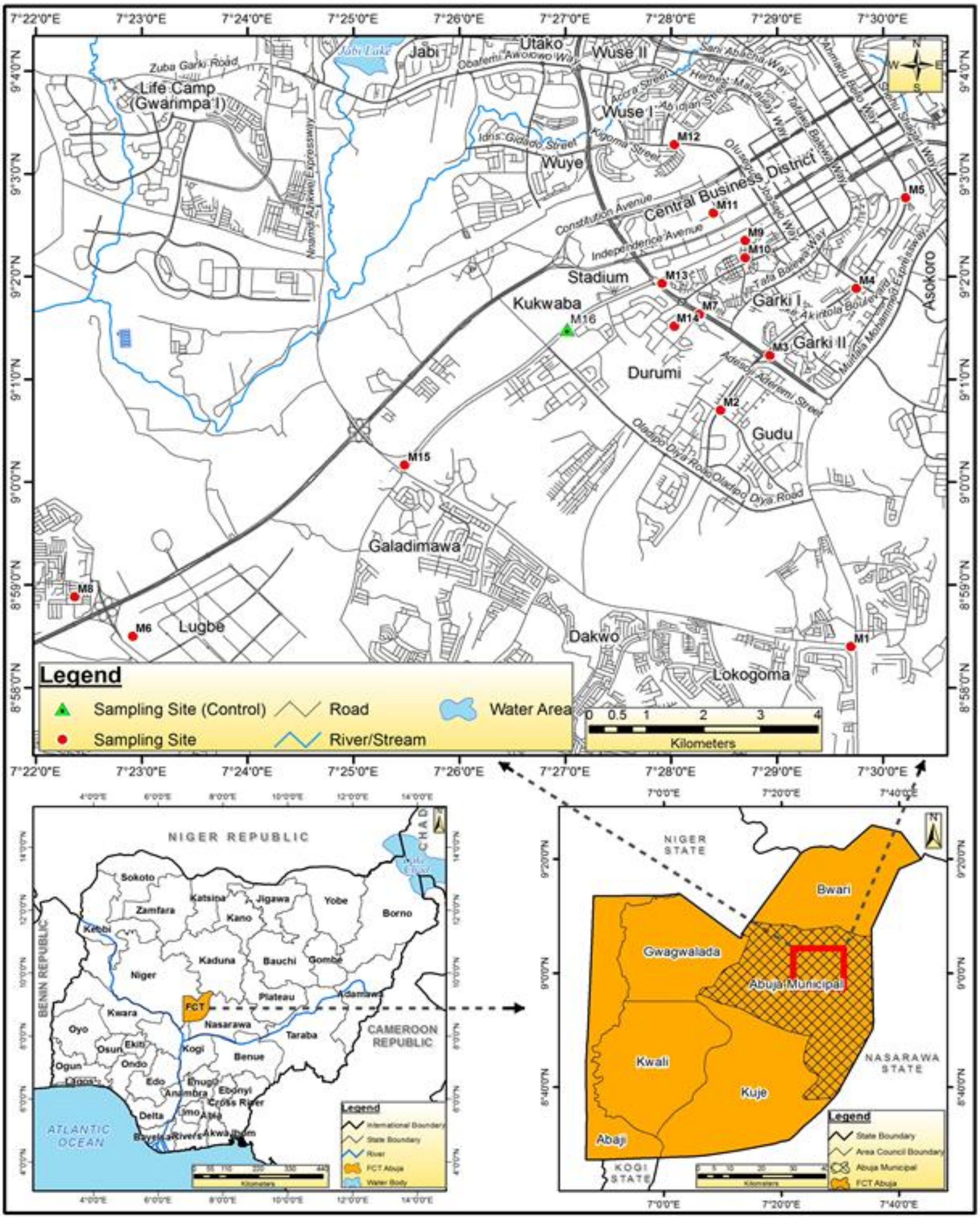

Figure 1: Map of Abuja Municipal showing sampling Sites (Source: Map Gallery, Geography Department, ABU, Zaria).

MATERIALS

ALTAIR 5X (Manufactured by Mine Safety Appliances Company, USA)-Multigas detector to detect for Carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen dioxide (NO2), and hydrogen sulphide (H_2S). CW-HAT200 (M&A INSTRUMENTS INC, USA) dust particle counter air quality monitor to detect for particulate matter (PM 10 and PM 2.5).

ALTAIR 5X Multigas detector was operated according to the manufacturer's instructions. The instrument was put ON with the button, after which the instrument performed self-tests. During the self-test, the instrument checked alarm LEDs, audible alarm, vibrating alarm, and installed sensors. After this a bump test was done to quickly confirm that the gas sensors were functioning. The Fresh Air Setup (FAS) was then performed for instrument ZERO adjustment before the measure page appeared. The equipment was moved to the study areas and positioned in the direction of the prevailing wind by holding at about 2m above the ground. It was allowed for a moment until the censor detected the concentrations of the pollutants CO, SO_2, NO_2 and H_2S which was signalled by a 'peep' sound. The digital reading was recorded in parts per million (ppm) as soon as it stabilized [13].

CW-HAT200 PM 2.5 and PM 10 dust particle counter air quality monitor was operated according to the manufacturer's instructions. The equipment was pressed and held the power button for 3 seconds to boot, and afterwards, the sampling port on the dust cover is removed, taking note of the temperature and humidity (insert aligned with gap) of the area. The run/stop button was pressed to start the test. Each test process takes 60 seconds to ensure that the sample is representative, as close as possible the average value of the surrounding air. After testing, the results were displayed automatically [14]. Samples of the air pollutants was monitored in the selected traffic sites and assessed for morning rush hour (6:45 am-8:45 am) and off-peak hour (12:45 am-2:45 pm) and close of work periods (4 pm - 6 pm) and also, compared to the National and international Ambient Air Quality Standards. The samples were taken for a period of six months for two seasons (rainy and dry) from March 2018 to August 2018.

RESULTS AND DISCUSSION

The mean concentrations of CO, SO_2, NO_2, H_2S, PM 2.5 and PM 10 are in Table 1. The result is the average of the data collected in the morning, afternoon and evening respectively from all the locations monitored during wet and dry seasons. Each column represents six months air quality data result. It shows the variation pattern for each pollutant measured across the study areas. The variation of carbon monoxide across the areas is as shown in Fig. 1. Its concentrations ranged from 9.30–27.55 ppm in the morning, 6.44-26.52 ppm in the afternoon and 10.83–30.00 ppm in the evening.

In some of the areas, the values were above the Nigerian Air quality standard which stipulates a range of 10 ppm for a 24-hour range time [15]. The values obtained for SO_2 ranged from 0.27 – 0.51 ppm, 0.25 –0.50 and 0.327 – 0.51 for morning, afternoon and evening hours respectively, while the concentration of NO_2 ranged from 0.49 – 0.72, 0.51 – 0.71 and 0.55 – 0.74 for morning, afternoon and evening respectively. The concentration of H_2S ranged from 0.00 – 0.27, 0.05 – 0.70 and 0.06 – 0.62 for morning, afternoon and evening respectively. Concentration of PM 2.5 ranged from 0.00 – 0.09, 0.00 – 0.02 and 0.00 – 0.03 respectively for morning, afternoon and evening and concentration of PM_{10} as shown in Table1 indicates that the values ranges from 0.00 – 0.37 ppm, 0.00 - 0.03 ppm and 0.00 – 0.04 ppm for morning, afternoon and evening respectively

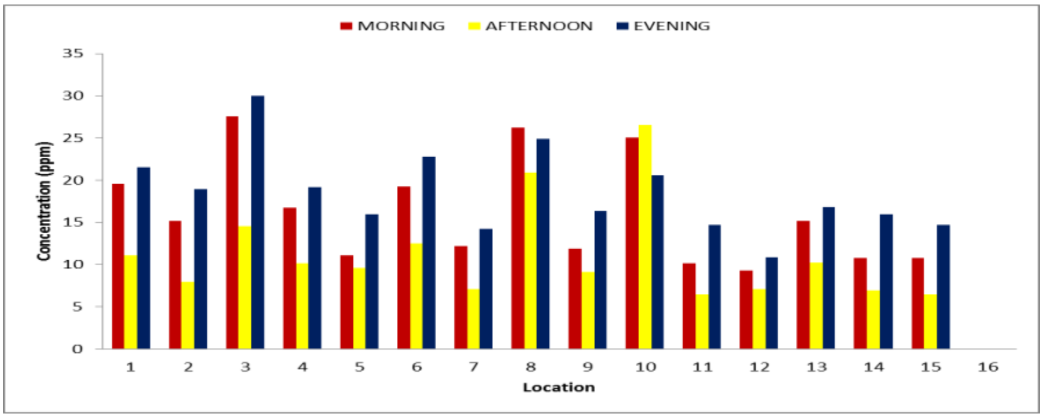

Figure 2: Variations in the levels of CO among sampling sites in Abuja metropolis.

Figure 2 shows the distribution of CO across the sample sites. The level of CO was generally higher in the evening than in the morning and afternoon (off peak) periods across the sites. Similar results were obtained for sulphur (IV) oxide, nitrogen (IV) oxide and hydrogen sulphide across the sites as shown in Figures 3-7. It is significant to note that the level of CO is higher at sites M3, M8, and M10. Similarly SO_2, NO_2 are higher in sites M1, M3, M8, and M10, while H_2S was highest at sites M1, M6 or site M10. The level of H_2S was generally higher in the afternoon (off peak) than in the morning and evening period across the sites.

Figures 5 and 6, however, show higher level of PM (PM 2.5 and PM 10) at sites M1, M2, M4 and M10 in the morning than in the evening periods. All the other pollutants were higher in the evening than in the morning and afternoon across the sites except for H_2S.

Table 1: Mean air pollutants concentration (ppm) in the study areas.

Study area	POLLUTANTS																	
	CO			SO_2			NO_2			H_2S			$PM_{2.5}$			PM_{10}		
	M	A	E	M	A	E	M	A	E	M	A	E	M	A	E	M	A	E
M1	19.58	11.11	21.52	0.44	0.40	0.51	0.68	0.63	0.74	0.14	0.65	0.50	0.02	0.01	0.03	0.39	0.03	0.03
M2	15.14	7.94	18.94	0.42	0.34	0.51	0.63	0.57	0.71	0.10	0.54	0.45	0.01	0.01	0.01	0.21	0.02	0.03
M3	27.55	14.58	30.00	0.51	0.37	0.53	0.72	0.59	0.74	0.21	0.53	0.47	0.02	0.01	0.01	0.03	0.03	0.03
M4	16.77	10.15	19.15	0.38	0.38	0.44	0.62	0.61	0.65	0.04	0.13	0.09	0.01	0.02	0.01	0.21	0.02	0.02
M5	11.10	9.63	15.98	0.32	0.39	0.43	0.58	0.62	0.65	0.02	0.10	0.11	0.01	0.01	0.01	0.02	0.02	0.02
M6	19.26	12.50	22.80	0.39	0.42	0.44	0.66	0.62	0.70	0.10	0.47	0.56	0.01	0.01	0.01	0.03	0.03	0.03
M7	12.18	7.10	14.27	0.31	0.33	0.46	0.56	0.54	0.70	0.10	0.47	0.23	0.01	0.01	0.01	0.02	0.01	0.02
M8	26.26	20.92	24.90	0.49	0.48	0.49	0.71	0.71	0.70	0.26	0.50	0.39	0.09	0.01	0.02	0.03	0.03	0.04
M9	11.89	9.11	16.33	0.27	0.37	0.43	0.49	0.60	0.64	0.27	0.35	0.35	0.01	0.01	0.01	0.01	0.01	0.02
M10	25.07	26.52	20.57	0.47	0.50	0.49	0.69	0.70	0.72	0.26	0.70	0.62	0.01	0.02	0.02	0.03	0.03	0.03
M11	10.18	6.44	14.67	0.31	0.25	0.37	0.51	0.47	0.59	0.00	0.10	0.06	0.01	0.01	0.01	0.01	0.01	0.02
M12	9.30	7.06	10.83	0.31	0.30	0.37	0.52	0.53	0.58	0.08	0.05	0.06	0.01	0.01	0.01	0.01	0.01	0.02
M13	15.21	10.21	16.82	0.41	0.36	0.47	0.64	0.53	0.70	0.20	0.35	0.23	0.01	0.01	0.02	0.02	0.02	0.03
M14	10.82	6.91	16.00	0.31	0.31	0.42	0.56	0.54	0.64	0.03	0.10	0.13	0.01	0.01	0.01	0.02	0.01	0.02
M15	10.82	6.44	14.67	0.31	0.24	0.37	0.51	0.47	0.59	0.00	0.10	0.06	0.01	0.01	0.01	0.01	0.01	0.03
M16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

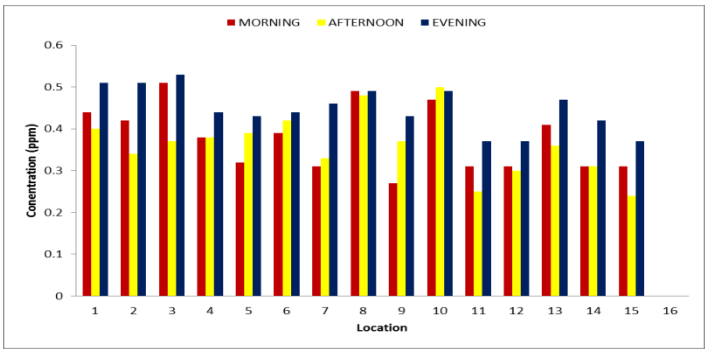

Figure 2: Variations in the levels of SO_2 among sampling sites in Abuja metropolis.

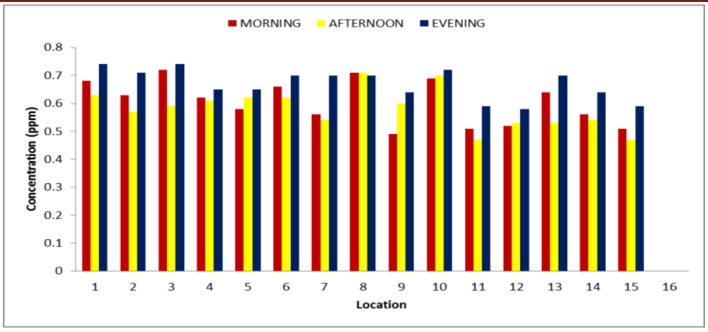

Figure 3: Variations in the levels of NO_2 among sampling sites in Abuja metropolis

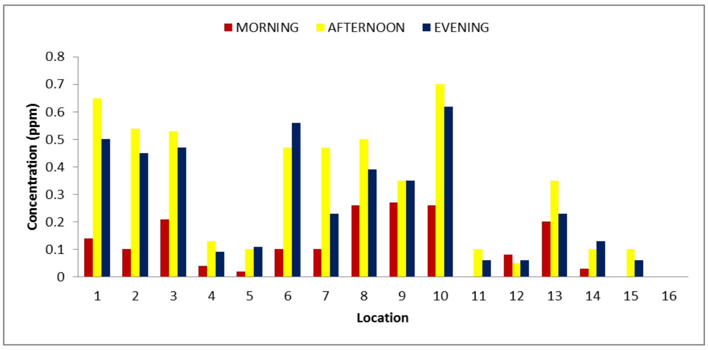

Figure 4: Variations in the levels of H_2S among sampling sites in Abuja metropolis.

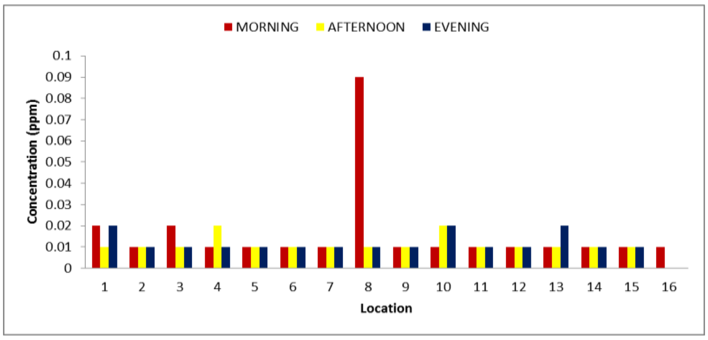

Figure 5: Variations in the levels of PM 2.5 among sampling sites in Abuja metropolis.

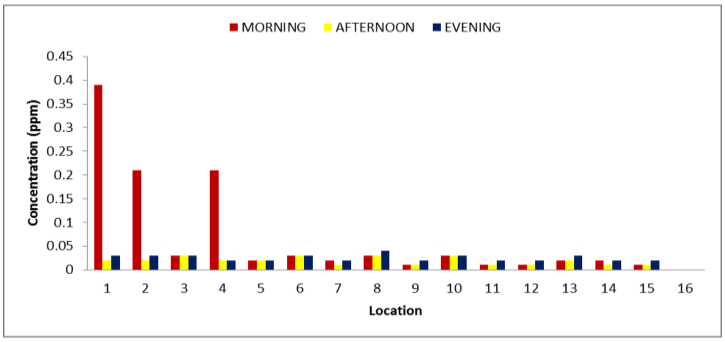

Figure 6: Variations in the levels of PM10 among sampling sites in Abuja metropolis.

Generally, the distribution pattern of the pollutants studied across the areas as shown in figs 2-7 are suggestive that the concentrations are mostly from the same source and mostly in the evening. The highest concentration was found in location where automobile exhaust emissions were higher and in high traffic hold up areas.

The high concentration of CO could be attributed to heavy traffic congestion and slow movement of vehicles. Other sources of pollutions at these sampling locations such as burning of refuse dumps, fossil fuel combustion, especially from vehicles, are the major primary sources of CO [16].

The concentration of SO_2 could be attributed to the combustion of sulphur containing fuel vehicles and power generators along the residential area. Also burning wood and refuse as energy source may contribute. The primary source for the anthropogenic emission of SO_2 into the atmosphere is a combination of the burning of fossil fuels, biomass, and emissions from cars, trucks, buses, power plants, and off-road equipment [17].

In December 2016, Nigeria and four other West African countries agreed to ban the importation of Europe's dirty fuels and limit sulphur in fuels from 3000 ppm to 50 ppm. But more than two years after the ban, which was supposed to come into effect on July 1, 2017 in Nigeria, the Federal government of Nigeria has yet to start its enforcement [18]. The concentration of NO_2 could be due to higher emission from automobiles exhaust [3]. H_2S is a greenhouse gas emitted as a result of the decay of organic matter, decay of food stuff, waste and refuse generated as reported by Adamu et al. [19]. The concentration of PM could also be attributed to road vehicles which are one of the principal emitters of gaseous and particulate air pollutants and are major contributors to urban air pollution [9].

The concentrations of the air pollutant observed in this study were compared with permissible limits recommended by Nigeria NAAQS and WHO [20]. The result indicates that the mean concentration of, CO SO2, NO2, H2S, PM2.5and PM10 in all the air quality monitoring locations exceeded both the annual and 24- hour limit of Nigerian NAAQS and WHO, (9 ppm and 35 ppm) for CO, (0.06 and 0.11ppm) for SO_2 and 0.1 ppm for NO_2, and (0.01 ppm and 7.00 ppm), (0.075 ppm and 0.025 ppm) for PM 2.5, and (0.15 ppm and 0.05 ppm) for PM 10 in most of the locations but some of the locations are within the permissible limit for this air pollutants. This study also indicated motor vehicles and tricycles as major contributors to air pollution in the Abuja metropolis.

CONCLUSIONS

The results of the monitoring and analyses revealed that ambient air samples in Abuja metropolis were polluted by CO, SO_2, NO_2, H_2S and PM. Continuous pollution may have cumulative impact on the health and wellbeing of the residents in future. This study has shown that vehicles contribute greatly to air pollution. All the air pollutants were either above or within the NAAQS/WHO limit, implying that vehicular emissions have reached the level that can really cause negative impact on the air quality of Abuja metropolis. Proper legislative frame work to regulate, control emissions and implementation with enforcement of these control measures be encouraged.

REFERENCES

1. Adeoye, B. K., Popoola, L. T. & Adebanjo,S. A.. (2018). Assessment of atmospheric particulate matter and heavy metals. *International Journal of Environmental Science and Technology*, 15(5), 935–948.
2. 2. Anhwange, B. A., Kagbu, J. A., Agbaji, E. B. & Gimba, C. E. (2012). Analysis of Some Common Air Pollutants in Makurdi Metropolis, Benue State Nigeria *International Journal of Environment and Bioenergy*, 1(1), 47-59.
3. Paraschiv, S. & Paraschiv, L. S. (2019). Analysis of traffic and industrial source contributions to ambient air pollution with nitrogen dioxide in two urban areas in Romania. *Energy Procedia*, 157(9), 1553–1560.
4. Salonen, H., Salthammer, T. & Morawska, L. (2019). Human exposure to NO_2 in school and office indoor environments. *Environment International*, 130 (3), 104887.
5. Ude, I.U., & Anjorin, F. O. (2016). Assessment of Carbon (II) Oxide and Sulphur (IV) Oxide Emissions at Some Selected Traffic Areas in Jos Metropolis, North Central Nigeria. *International Journal of Advanced and Innovative Research*, 5(12), 2278-7844.
6. Garba, M. D. & Yunusa, M. S. (2016). Assessing gaseous pollutants and air quality in some areas of Kano metropolis, Kano, Nigeria, *International Journal of Environmental Impacts*, 203, 125-134.
7. Adeyanju, A. A. & Manohar, K. (2017). Effects of Vehicular Emission on Environmental Pollution in Lagos, *Journal of Scientific Issues, Research and Essays* 5(4), 034-051.

8. Pan, S., Roy, A., Choi, Y., Sun, S. & Gao, H. O. (2019). The air quality and health impacts of projected long-haul truck and rail freight transportation in the United States in 2050. *Environment International*, 130(1), 104922.
9. Taiwo, A. M. (2017). Characteristics of particulate matter collected at an urban background site and a roadside site in Birmingham, United Kingdom, *Atmósfera*, 30(4), 323–335.
10. Omenikolo, A. I., Uduma, C. I., Chinekeokwu, T. & Abara, J. C. (2017). Assessment of air pollution generated by transport inOwerri, South East, Nigeria, *Merit Research Journal of Environmental Science and Toxicology*, 5(1), 9–17.
11. Ugwu, K. E. (2020). A Review of Environmental Issues in Coal Processing and Utilization, and the Mitigation of the Environmental Impacts, *Nigerian Research Journal of Chemical Sciences*, 8(1), 82–91.
12. Okon, I. E. (2015). Assessment of Vehicular Emissions on Air Quality and Proximate Composition of Amaranthus Hybrdus and Mangifera Indica in Zaria, Nigeria. Ph.D Thesis. Ahmadu Bello University, Zaria, Kaduna State, Nigeria
13. Tyovenda, A. A., Ugwuanyi, J. U., Sombo, T. & Anjorin, F. O. (2017). Dispersion and Modeling of Gaseous Pollutants Released from 12 Hp Diesel Engines at Some Selected Sites in North Central Nigeria, *Journal of Environmental Science, Toxicology and Food Technology*, 11(2), 24–36.
14. Ugwuanyi, J. U., Tyovenda, A. A., Sombo, T. & Anjorin, F. O. (2016). Measurements and Modeling of Emissions from Biomass Combustion Sources in North-central Nigeria, *Journal of Environmental Science, Toxicology and Food Technology* 10(10), 4–13
15. Adeyanju, A.A. & Manohar K. (2017). Biodiesel Production and Exhaust Emission Analysis for Environmental Pollution Control in Nigeria, *American Journal of Engineering Research*, 6(4), 80-94.
16. Shan, C., Wang, W., Liu, C., Sun, Y., Hu, Q., Xu, X. & Velazco, V. A. (2019). Regional CO emission estimated from ground-based remote sensing at Hefei site, China. *Atmospheric Research*, 222(2), 25–35.
17. Rahman, A., Luo, C., Khan, M. H. R., Ke, J., Thilakanayaka, V. & Kumar, S. (2019). Influence of atmospheric PM2.5, PM10, O3, CO, NO2, SO2, and meteorological factors on the concentration of airborne pollen in Guangzhou, China. *Atmospheric Environment*, 212(2), 290–304.

18. Femi, A. (2019): Nigeria cuts fuel sulphur level, undershoot target, https://punchng.com/nigeria-cuts-fuel-sulphur-level-undershoots-target/ accessed June 2020.
19. Adamu, Y. R., Gimba, C. E., Abechi, S. E. & Omenesa, H. (2015). Evaluation of Greenhouse Gases Levels in Ambient Air at Selected Roads Intersections in Kano Metropolis, Nigeria. Ph.D Thesis. Ahmadu Bello University, Zaria, Kaduna State, Nigeria
20. World Health Organisation (WHO). (2000). Air Quality Guidelines - (2nd Ed.). Copenhagen, Denmark. ISBN 92 890 1082 7.