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EVALUATION OF SOME GASEOUS POLLUTANTS AT SELECTED LOCATIONS IN NIGERIA: A CASE STUDY OF BENUE STATE UNIVERSITY, MAKURDI

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A B S T R A C T

This research work assessed the concentration of some gases (CO, SO_2 and NO_2) at selected locations in Benue State University, Makurdi. The study highlighted the major sources of gases within the school environment and its potential health effects when exposed to them at a concentration above threshold. The concentration of pollutants at the various sampling points within the campus varied significantly. The equipment (Crowcon Gasman monitors) used were properly calibrated before each usage. The analysis of the gases was carried out twice each day with the interval of six (6) hours to the next analysis and was repeated for five (5) days. All the gases investigated were present at the monitored locations and were recorded in mean and standard deviation. Findings of the study showed that most concentration levels of CO (1.50 – 18.17 ppm) and SO_2 (0.00 - 0.12 ppm) and NO_2 (0.02 – 0.13 ppm) for all the respective study locations (CHS, FC and SC) were below the regulating limits (0.1, 0.04 – 0.06 and 10 ppm) set by NESREA except for few values that were slightly above the permissible limit at certain points per time. The concentration levels of the control site (UZA) had all values below the NESREA standard for all the monitored gases. The study concludes that the air in Benue State University, Makurdi has not been polluted yet, even though some of the assessed gases were present in the air. The study therefore recommends that strict and appropriate vehicular emission management, regular waste collection coupled with close burning management of waste should be considered in the study locations to prevent the hazards associated with these pollutants.

Keywords: Carbon (II) Oxide, Environmental Pollution, Health, Pollutants, Nitrogen (IV) Oxide, Sulphur (IV) Oxide

1. Introduction

Air is one of the most important constituents of man's environment. An average human being requires about 12 dm^3 of air each day, which is nearly 12-15 times greater than the amount of food consumed (Abaje et al., 2020). Clean dry air is very essential for human health and survival. Any change in the natural and normal composition of air that adversely affects the living system; particularly the human life invariably causes air pollution (Abaje et al., 2020).

Air pollution is one of the environmental problems confronting growing cities and is currently the challenge faced by many developed and developing countries. It is an invisible murderer and foremost cause of some of the most common human health challenges. Statistically, WHO reported that of the outdoor air pollution-related premature deaths, 80 % were due to asthmatic heart disease and strokes, 14 % due to chronic obstructive pulmonary disease or acute lower respiratory infections, and 6 % due to lung cancer (Hegerl et al., 2007). The World Health Organization (WHO) defines air pollution as limited to situations in which the outer ambient atmosphere contains materials in concentrations which are harmful to man and his environment. A

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substance in the air that can cause harm to humans and the environment is known as an air pollutant (Abaje et al., 2020; Suleiman, 2013). Such pollutants include fumes, dust, gases, mist, odour, smoke, smog and these pollutants can be caused by natural or anthropogenic activities and such activities include the use of gasoline generators, use of fuel wood, industrial emissions, domestic waste and industrial waste and vehicular exhausts (Ameh et al., 2015).

Air pollutants are classified into harmful solid, liquid or gaseous substances. However, this study is targeted on gaseous air pollutants; this is because their effects on human lives are enormous as it causes disease and can result in acute and chronic illnesses (Wong, 2008). Also, pollutants emitted during the combustion of fossil fuels are responsible for smog, acid rain, and global warming and climate change. Some of the major gaseous air pollutants of the atmosphere that pose the greatest threat to environment include Carbon (ii) oxide (CO), Nitrogen (IV) oxide (NO_2), Ammonia (NH_3), Sulphur (IV) oxide (SO_2), Carbon (IV) oxide (CO_2), Ozone (O_3) (Abaje et al., 2020; Ameh et al., 2015).

Makurdi, like any other urban city elsewhere in developing countries, is faced with air pollution caused by the aforementioned anthropogenic activities. The major sources of air pollution are from industrial and transportation activities. On the empirical balance, transportation is identified as a highly significant culprit accounting for well over 50 % to 80 % of the total air pollutants in developing countries (Fu et al., 2001; Goyal et al., 2006; Raheem et al., 2019). However, this situation is alarming and is predicated on the poor economic disposition of developing countries, poor vehicle maintenance culture and importation of old vehicles, which culminates in an automobile fleet dominated by a class of vehicles known as “super emitters” with high emission of harmful pollutants (Emodi et al., 2017). The increase in this traffic-related pollution is not based on the above factors only, but also on low quality fuel which may be due to the increase in illegal refineries in Nigeria, poor traffic regulation and lack of air quality implementation force among others (Okunola et al., 2012; Garba et al., 2016). Although other sources like refuse and poor waste management has been known to have constituted air pollution in Makurdi.

The impact and complexity of traffic-related air pollution in Nigeria today, alongside concurrent emissions from industrial and domestic sources therefore necessitates a new and well defined approach to the mitigation and management of air pollution. An assessment of the potential for increased vehicular and fossil pollution requires some basic and regular information relating to traffic volume and the intensity of pollutant emissions on road corridors (Ojo and Awokola, 2012). This work aims to determine the emission levels of CO, SO_2 and NO_2, compare the emission levels with Nigerian ambient air quality standard and also identify the influence factors of pollution in Benue State University, Makurdi.

2. Experimental

2.1 *Sample Location*

Makurdi the Benue State capital is located along the Benue River bank on latitude 7.44N and longitude 8.32E with an estimated population of 365,000. Benue State university situated in Makurdi metropolis is near the southern bridgehead of the Benue River on sandy alluvial formation. It occupies 6 square kilometres piece of land between Gboko Road and River Benue approximately 1.5 km wide and 4 km long.

Through careful observations, sampling locations or stations in Benue State University were identified prior to the dates of field work. Vehicular movement along these locations and other anthropogenic activities were a considerable factor in the collection of air samples so as to determine the concentration of pollutants being inhaled by residents and non-residents of the vicinity.

A total of Four (4) locations were selected in the study area. These locations included College of Health Science (CHS), First Campus (FC) and Second Campus (SC). The University Zoo Area (UZA) in the Benue State University of Makurdi was used as control point (where there are no vehicular movements or commercial activities going on). For each of the study locations, three (3) sample points were earmarked for the study.

For CHS, the sample points were CHS Entrance opposite the University General Library, CHS Medical Hostels A & B and CHS Entrance Opposite Gboko-Road. The First point (CHS Entrance opposite the University General Library) and third point (CHS Entrance Opposite Gboko-Road) represent areas observed to have moderate rates of traffic congestion and less vegetation cover, while the second point (CHS Medical Hostel A and B) represent an area with congestion of students, poor sanitary conditions and high-level gas cylinder usage with less traffic congestion and less vegetation cover. The selected sample points for FC included the School Main Gate (vehicular movement), the First Campus Labour Market (use of generators and other combustion activities) and around Auditorium 1 lecture hall (student activities). Sample points for SC were, SC main entrance gate (vehicular movements), student’s hostel (cooking fuels such as gas and kerosene) and mini labour market (commercial services).

2.2 *Methods*

The raw data obtained at each site was recorded accordingly for morning and evening. Mean values were calculated for repeated measurements to obtain representative discrete values; statistical analysis of the data was carried out using statistical software programme (SPSS version 18.0). To start measuring the gases (CO, SO_2 and NO_2), the switch is first turned to TEST position. Red LED with flash, sounder will operate, display will indicate battery condition (100 = fully charged). After which the switch is turned to Gas position. Unit is then in normal operation. The Green LED will flash and operational sounder will operate once every three seconds to confirm normal operation. The specification for gas and range for CO gas meter is 0 - 500 ppm, SO_2 gas meter is 0 - 10 ppm and NO_2 gas meter is 0 - 10 ppm respectively. While the temperature range is −10 ˚C to +50 ˚C and humidity range is 0 % - 90 % RH, non-condensing.

Sample Collection and quantification: The measurement of the concentration of the pollutants (CO, SO_2 and NO_2) over time (5 minutes' interval) for 1 hr 30 minutes were made during different phases (Morning—7:30 am to 9:00 am and Evening—4:00 pm to 5:30 pm) for each site. The parameters were measured simultaneously using the different meters.

Plate 1. Crowcon Gasman Monitors used in the Study (Photo by Jenny & Natty W, 2022)

3. Results and Discussion

The mean with standard deviation of the daily concentration of carbon monoxide (CO), sulphur dioxide (SO_2) and nitrogen dioxide (NO_2) obtained at CHS, FC and SC is shown in table 1 – 3. The University Zoo Area (UZA) which was used as the control site in the study had very low concentration level of pollutants ranging from 0.00 - 0.67 ppm. The low concentration level of pollutants in this study location maybe attributed to less vehicular movements and none commercial activity at the sampled site. It may also be due to the trees planted around the sampled location, since trees serves as sink to some of the investigated gases.

The instrument for measuring the emission was taken from one site to another for measurement in October, 2022.

Table 1: Concentration levels (ppm) of Air pollutants in CHS (College of Health Science)

Day	Point 1	Point 2	Point 3
Carbon (II) oxide (CO) [NESREA standard: 10 ppm]			
1	2.50 ± 1.38	3.50 ± 1.76	2.67 ± 1.21
2	2.50 ± 0.84	2.33 ± 0.52	2.67 ± 0.52
3	1.83 ± 0.75	2.17 ± 1.17	1.50 ± 1.05
4	2.00 ± 1.09	1.83 ± 0.98	2.00 ± 1.26
5	1.67 ± 1.37	1.83 ± 0.75	2.50 ± 0.55
Sulphur (IV) oxide (SO_2) [NESREA standard: 0.1 ppm]			
1	0.10 ± 0.06	0.10 ± 0.06	0.07 ± 0.05
2	0.08 ± 0.04	0.08 ± 0.04	0.12 ± 0.04
3	0.08 ± 0.04	0.08 ± 0.04	0.12 ± 0.04
4	0.10 ± 0.05	0.11 ± 0.08	0.00 ± 0.00
5	0.12 ± 0.04	0.10 ± 0.06	0.10 ± 0.06
Nitrogen (IV) oxide (NO_2) [NESREA standard: 0.04 – 0.06 ppm]			
1	0.13 ± 0.15	0.13 ± 0.05	0.08 ± 0.04
2	0.07 ± 0.08	0.10 ± 0.06	0.40 ± 0.05
3	0.08 ± 0.04	0.11 ± 0.04	0.02 ± 0.04
4	0.08 ± 0.04	0.10 ± 0.08	0.10 ± 0.06
5	0.10 ± 0.06	0.08 ±0.04	0.10 ± 0.06

The mean level of CO observed in CHS was found to range between 1.67 - 2.50 ppm (point 1), 1.83 - 3.50 ppm (point 2) and 1.50 - 2.67 ppm (point 3). The highest level of CO (3.50 ppm) was recorded at point 2 (CHS Hostel A and B) on day 1, while the lowest level of CO was 1.50 ppm at point 3 (CHS entrance opposite Gboko-Makurdi Road).

The result of SO_2 is also presented in table 1. The mean concentration of SO_2 observed in CHS ranges between 0.10 - 0.12 ppm at point 1, 0.08 - 0.11 ppm at point 2, 0.00 - 0.12 ppm at point 3. The highest concentration level of 0.12 ppm was recorded at point 1 on the fifth day and point 3 on the second and third day while the lowest level of 0.00 pm was recorded at point 3 on the fourth day.

The mean concentration level of NO_2 as recorded in table 1 was found to range between 0.07 - 0.13 ppm at point 1, 0.08 - 0.13 ppm at point 2 and 0.02 - 0.40 ppm at point 3. The highest value of the gas of 0.40 ppm was observed at point 3 on day 2, while the lowest level of the gas (0.02 ppm) was observed at point 3 on day 3.

Hence, it is deduced from the results in table 1 that, concentration levels of almost all the monitored pollutants fall within the permissible limit of NESREA

Table 2: Concentration levels (ppm) of Air pollutants in FC (Faculty of Science)

DAY	School Gate	School Market	School Auditorium
Carbon (II) oxide (CO) [NESREA standard: 10 ppm]			
1	3.67 ± 1.63	4.50± 2.07	2.17 ± 0.41
2	4.83 ± 1.47	8.67 ± 6.09	2.83 ± 0.41
3	4.83 ± 3.25	2.33 ± 0.51	3.00 ± 1.10
4	5.00 ± 3.29	18.17 ± 2.23	2.00 ± 0.00
5	3.50 ± 1.52	4.33 ± 3.89	2.17 ± 0.75
Sulphur (IV) oxide (SO2) [NESREA standard: 0.1 ppm]			
1	0.07 ± 0.05	0.07 ± 0.05	0.10 ± 0.00
2	0.10 ± 0.00	0.10 ± 0.00	0.10 ± 0.00
3	0.05 ± 0.05	0.12 ± 0.04	0.10 ± 0.00
4	0.07 ± 0.05	0.08 ± 0.04	0.08 ± 0.04
5	0.04 ± 0.05	0.08 ± 0.09	0.05 ± 0.05
Nitrogen (IV) oxide (NO_2) [NESREA standard: 0.04 – 0.06 ppm]			
1	0.08 ± 0.04	0.10 ± 0.06	0.08 ± 0.04
2	0.07 ± 0.05	0.08 ± 0.04	0.05 ± 0.05
3	0.08 ± 0.07	0.10 ± 0.09	0.06 ± 0.05
4	0.12 ± 0.04	0.12 ± 0.04	0.10 ± 0.00
5	0.10 ± 0.00	0.13 ± 0.12	0.10 ± 0.00

Investigated CO, SO_2 and NO_2 concentration levels for all sample points at FC are shown in table 2 respectively. The concentration of CO recorded its highest value (18.17 ppm) at the school market on day 4 while the least value (2.00 ppm) was recorded on day 4 at the School Auditorium.

For SO_2 concentration levels across all the sampled points, the school labour market had the highest value (0.12 ppm) at day 3 while the least value (0.04 ppm) was obtained at the school gate on day 5. The highest concentration (0.13 ppm) for NO_2 was observed on day 5 at the school market while the least (0.05 ppm) was recorded at the School Auditorium.

From the result presented in table 2, the concentration of CO recorded indicates that all the values were below the standard set by NESREA (10 ppm) except the value at the labour market on day 4 which had an elevated value of 18.17 ppm. This may be attributed to the use of generators and other activities involving combustion of fuels at the labour market by business owners. All recorded mean values for SO_2 were below the standard set by NESREA (0.1 ppm) except for day 3 (0.12 ppm) values at the labour market which were slightly above the standard value. The recorded values of NO_2 were slightly above the standard set by NESREA (0.04 – 0.06 ppm). This is because of the emission of NO_2 at the sampling points through combustion of fuels and other commercial activities.

From the result in table 2, it is observed that for all the sampled gases (CO, SO_2 and NO_2), the school labour market had the highest mean concentration values followed by the school gate. This is traceable to the use of fuels that emit these gases at the market and also the movement of vehicles in and out of the school premises through the school gate.

Table 3: Concentration levels (ppm) of Air pollutants in SC (Second Campus)

DAY	Entrance gate	Hostel	Labour market
Carbon (II) oxide (CO) [NESREA standard: 10 ppm]			
1	10.50 ± 1.47	1.67 ± 0.87	8.83 ± 1.22
2	2.67 ± 0.75	2.00 ± 0.82	13.67 ±2.23
3	2.83 ± 0.69	3.33 ± 1.80	3.33 ± 1.80
4	3.00 ± 1.00	1.50 ± 0.50	6.17 ± 5.74
5	2.50 ± 1.60	1.67 ± 0.87	2.33 ± 1.11
Sulphur (IV) oxide (SO2) [NESREA standard: 0.1 ppm]			
1	0.08 ± 0.04	0.10 ± 0.00	0.10 ± 0.00
2	0.08 ± 0.04	0.10 ± 0.00	0.08 ± 0.04
3	0.08 ± 0.04	0.10 ± 0.00	0.08 ± 0.04
4	0.05 ± 0.05	0.10 ± 0.00	0.10 ± 0.00
5	0.07 ± 0.05	0.08 ± 0.04	0.02 ± 0.04
Nitrogen (IV) oxide (NO_2) [NESREA standard: 0.04 – 0.06 ppm]			
1	0.10 ± 0.00	0.12 ± 0.04	0.10 ± 0.00
2	0.08 ± 0.04	0.10 ± 0.06	0.07 ± 0.05
3	0.10 ± 0.06	0.08 ± 0.04	0.03 ± 0.05
4	0.07 ± 0.05	0.10 ± 0.00	0.13 ± 0.05
5	0.10 ± 0.00	0.12 ± 0.04	0.10 ± 0.00

The monitored concentration values of CO, SO_2 and NO_2 within SC (Second Campus) are shown in table 3. CO values ranged between 0.33 - 13.67 ppm. The highest value (13.67 ppm) recorded at labour market on day two (2) of monitoring may be due to the continuous use of generator as source of electricity, which releases high amount of CO into the atmosphere. Investigation at the entrance gate also recorded elevated values, especially on day one (1) (10.50 ppm) probably due to vehicular movement round the entrance gate. The lowest values were observed at the hostel, especially on day 4 (1.50 ppm) probably due to the absence of substances and less activities that emit CO. The result, when compared to standard values (NESREA) show that the study location has not yet been polluted by CO, even though elevated levels (13. 67 ppm and 10.50 ppm) of the gas was noticed in the location.

Table 3 also shows that the highest value of SO_2 (0.10 ppm) was more frequent at student's hostel. This could be traced to the use of cooking gas by students. However, these values are not above the standard values set by regulatory bodies (eg NESREA), Implying that the air around the selected location is not yet polluted by SO_2.

The highest concentration level of NO_2 (0.13 ppm) recorded at labour market on day four (4) could be due to the combustion of fuel by generators. Investigation at the Hostel also recorded elevated values (0.12 ppm) on day one (1) of monitoring which may have come from cooking gas because burning of fossil fuel and use of cooking gas and kerosene are major sources of NO_2. The results are above standards set by NESREA, implying that the study site was slightly contaminated.

4. Conclusion

Air pollution is something that we cannot really ignore now. It is one of the most widespread forms of pollution globally. There is great evidence linking air pollution with mortality in the general population, both in developed and developing countries. This study assesses the concentration of CO, SO_2 and NO_2 in the atmosphere at CHS, FC and SC, Benue State University, Makurdi. The study also revealed the natural and anthropogenic sources of pollutants that affect air quality in the school, and also their effects on human health. The result of the study indicates that the air in Benue State University, Makurdi has not yet been polluted, even though some of the assessed gases were present in the air at the time of investigation. Hence, if adequate actions are not taken by regulatory bodies to check the excesses, continuous emission of these gases both from point sources and non-point sources may have cumulative effect on the health and wellbeing of the residence and non-residence in future.

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