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Evaluation of Selected Ambient Air Concentrations in Major Roundabout and Solid Waste Dump Site in Katsina Metropolis, Katsina State, Nigeria

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Abstract
This current study is aimed at investigating the ambient air concentration of major roundabouts and waste dump sites within the Katsina metropolis. This was carried out concerning four air pollutants which include Nitrogen dioxide (NO_2), sulfur (IV) oxide (SO_2), carbon monoxide (CO), and Ammonia (NH_3), with the sole objective of determining their atmospheric concentrations to evaluate their ambient air level in Katsina metropolis. Six locations and one control were studied from November 2021 to February 2022. Measurements were carried out three times daily (7 – 9 am, 12 – 3 pm, and 4 – 7 pm) by using a Gasman air monitor. Descriptive statistics and multivariate analysis were used in analyzing the data set generated. Results of the air pollutants showed that the KTSTA roundabout had the highest CO (10.61±14.54 ppm), the KT roundabout exhibited the highest pollutant concentration in NH_3 (2.056 ± 1.71 ppm), and the GRA roundabout was the lowest. Both Kofar Kaura and KTSTA roundabouts have the highest pollutants of NO_2 (0.69 ± 0.90 ppm) and (0.69 ± 0.78 ppm). Kofar Kaura, Liyafa Roundabout, and Behind ATC dumpsite had the same and highest SO_2 concentrations (0.10± 0.15 ppm), (0.10± 0.15 ppm) and (0.10 0.014 ppm). CO was found to be highest in concentration in the morning period (10.39±11.00 ppm). The findings of this study show that there are lots of commercial and vehicular activities in the vicinity from 7 to 9 am, which are responsible for the observed elevated ambient air level. However, the ambient air pollutant concentration at the control site was all-time low compared to the studied sites. According to the Nigerian Ambient Air Quality Standard, elevated ambient air pollutants are responsible for many respiratory-related diseases. Regular and strict monitoring of the levels of ambient air pollutants in the studied area is therefore recommended because of the adverse health implications of elevated ambient air pollutants on humans.

Keywords: Ambient air Concentration, Air Pollutants, Air Quality, Dumpsite, and Katsina Metropolis

Introduction
Environmental pollution is defined by the Basic Law for Environmental Pollution Control as any collective or individual activity that endangers the health and/or environment of other people in a specific location. In another standpoint, it refers to the degradation of the natural environment or the release of physio-chemical or biological components into the atmosphere that inconvenience both people and other living organisms (Bhola *et al.,* 2010). The ambient and indoor air composition has significant effects on living things, systems, and the environment as a whole. It hurts human health as well as that of other living things in the environment and has a wider impact on environmental and climatic changes (Abaje *et al.,* 2020). Primary and secondary sources are the two main categories into which air pollution can be separated. Those substances or materials that are directly discharged from a natural or ethical organic process, such as volcanic ash, carbon monoxide (CO) gas from automobile exhaust, and sulfur dioxide (SO_2) generated from factories or industries, are considered to be the main sources of air pollution (Yousefian *et al.,* 2020). Many of the negative impacts of air pollution are not, however, caused by primary pollutants alone.

The main contaminants and elements of the atmosphere may react chemically with one another. Secondary air pollutants are those that are generated in the air rather than directly emitted, and they are very much to blame for many negative impacts of air pollution, including smog, and haze, which causes eye discomfort, and damage to vegetation and materials (Agay *et al*., 2013). The first stage in the process of putting a measure in place to combat air pollution is to get comprehensive data on the pollution status through an assessment of the level of air pollution. A very strong scientific foundation for managing air quality and controlling pollution sources is provided by measuring air quality and comprehending its environmental effects (Verhoeven, 2021).

The high rate of insecurity in the country and Katsina in particular, with nine (9) Local Government Areas, out of thirty-four (34) Local Government Areas, experiencing banditry and kidnapping, this negative situation in the State has led to serious drift of displaced people from the affected rural communities to the urban areas. This situation leads to rising economic activities in the cities, with high growth in private and public car ownership, and the use of tricycles as a means of public transport, resulting in traffic congestion and air pollution. Thus, rapid population growth and increased energy demand are the major primary factors causing large quantities of harmful pollution and greenhouse gases to be emitted into the atmosphere, which result in serious human health and environmental degradation (Asubiojo, 2016). This study therefore evaluates ambient air concentration in major roundabouts and solid waste dump sites in the Katsina metropolis.

Materials and Methods

The air pollutants SO_2, CO, NO_2, and NH_3, were identified in the air quality index (AQI) assessment between November 2021 and February 2022. The study was conducted in the metropolitan area of five roundabouts and one dump site in Katsina metropolis, Nigeria. The fact that Katsina is experiencing some mini-industrialization and population growth made this research necessary. The area's rising level of urbanization is linked to numerous businesses, commercial, and industrial activities, such as the use of power generators, a large number of vehicles, and traffic involving tricycles and motorcycles, all of which are known for their incomplete combustion of fossil fuels, which typically results in the emission of these air pollutants.

The Study Area

Katsina State is located in Nigeria's Sudan Savannah zone, between 12°15'N and 7°30E, and has hot and dry weather for most of the year (Nkromah, 2007). March to May are the hottest months, with temperatures ranging from 23°C to 42°C. The yearly rainfall ranges from 700mm to 1000mm, with the rainy season lasting from June through September. Katsina State's population is primarily farmers, an insignificant number of traders, and civil servants (Katsina State Diary, 2002). According to the 2006 census, the city has a population of 5,792,578 people. It is bounded to the South by Kaduna State, to the East by Jigawa and Kano State, to the West by Zamfara State and to the North by the Niger Republic. The State capital is located between latitudes 12^0 45^1N and 13^0 15^1N and longitudes 7^0 30^1 and 8^0 0^0E. The location is in Northern Nigeria, around 30 kilometers from the Nigeria-Niger border. Urban Katsina is made up of two local government areas: Katsina and a portion of Batagarawa (Zayyana, 2010). The samples were collected from six locations in the Katsina metropolis as follows: Kofar Kaura Roundabout, G.R.A Roundabout, Liyafa Roundabout, KTSTA Roundabout, Old Park Roundabout, and Waste dump site behind A.T.C Katsina. These are areas where various economic activities and high vehicular movements are significant.

Sampling Procedure

The study was conducted from November 2021 to February 2022, across the six locations from morning (7 – 9 am), afternoon (12 – 3 pm), and evening (4 - 6:30 pm) with the measurement of the concentrations of air gaseous pollutants data, SO_2, CO, NO_2 and NH_3, by using mobile gas sensors manufactured by crown detection Gasman instrument Ltd, England, coupled with in-out door thermometer (Elehinafe, 2016).

Statistical Analysis

The data generated in the field was analyzed using descriptive statistics and multivariate analysis with the means and standard deviation of the air pollutant concentrations measured in the morning (7 - 9 am), afternoon (12:00 - 3 pm), and evening (4 - 6:30 pm) hours. The standard deviation SD, variance, and correlation were determined which were used to assess the variation in the concentration level of the air pollutant monitored in the research.

Result

Table 1: Air Quality Monitoring Location of Katsina Metropolitan, North West Nigeria

S/No	Location	Characteristics
1.	Kofar Kaura Round About	High vehicular, motorcycle, tricycle, and many commercial activities including roadside meat/fish roasters
2.	G.R.A Round About	High vehicular, motorcycle, tricycle, and many commercial activities including roadside meat/fish roasters
3.	KTSTA Round About	High vehicular, motorcycle, tricycle, and many commercial activities including roadside meat/fish roasters and fruit seller
4.	Liyafa Round About	Low human activities
5.	Behind ATC Dump Site	Many residential buildings

Table 2: Air Pollutant Concentration of Various Locations

Location	CO	NH_3	NO_2	SO_2
Kofar Kaura Round About	10.42 ± 12.54^{ab}	1.94 ± 1.84^{ab}	0.069 ± 0.090^{a}	0.10 ± 0.15^{a}
GRA Round About	7.66 ± 9.42^{bc}	1.40 ± 1.092^{c}	0.064 ± 0.077^{a}	0.092 ± 0.15^{a}
Old Park Round About	10.12 ± 13.62^{ab}	2.01 ± 2.14^{ab}	0.059 ± 0.11^{a}	0.092 ± 0.11^{a}
Liyafa Round About	6.083 ± 6.054^{c}	1.58 ± 1.67^{bc}	0.049 ± 0.060^{a}	0.10 ± 0.11^{a}
KTSTA Round About	10.61 ± 14.54^{a}	2.056 ± 1.71^{a}	0.069 ± 0.078^{a}	0.085 ± 0.11^{a}
Behind ATC Dump Site	6.78 ± 11.23^{c}	1.69 ± 1.82^{abc}	0.056 ± 0.075^{a}	0.10 ± 0.14^{a}

Mean values with the same superscript are statistically significant at $\alpha = 0.05$

Table 3: Air Pollutant Concentration for the Period

Period	CO	NH_3	NO_2	SO_2
7 – 9 am	10.39 ± 11.00^{a}	2.32 ± 2.14^{a}	0.065 ± 0.079^{a}	0.037 ± 0.056^{b}
12 – 3 pm	7.60 ± 8.94^{b}	1.71 ± 1.58^{b}	0.071 ± 0.075^{a}	0.21 ± 0.15^{a}
4 - 6:30 pm	7.82 ± 14.36^{b}	1.30 ± 1.26^{c}	0.046 ± 0.090^{b}	0.041 ± 0.071^{b}

Mean values with the same superscript are statistically significant at $\alpha = 0.05$

Table 4: Results of Correlations among Air Pollutants Concentrations

Correlations				
	CO	NH_3	NO_2	SO_2
	1			
CO	0.610**	1		
NH_3	0.000			
NO_2	0.389**	0.269**	1	
	0.000	0.000		
SO_2	0.186**	0.191**	0.266**	1
	0.000	0.000	0.000	

***Correlation is significant at 0.05 level (2 tailed)**
****Correlation is significant at 0.01 level (2 tailed)**

Table 5: Results of Correlations of Air Pollutant Concentrations with Temperature

Correlations				
	Co	NH_3	NO_2	SO_2
	0.073*	0.008	0.142**	0.462**
Temperature	0.032	0.809	0.000	0.000

***Correlation is significant at 0.05 level (2-tailed)**
****Correlation is significant at 0.01 level (2-tailed)**

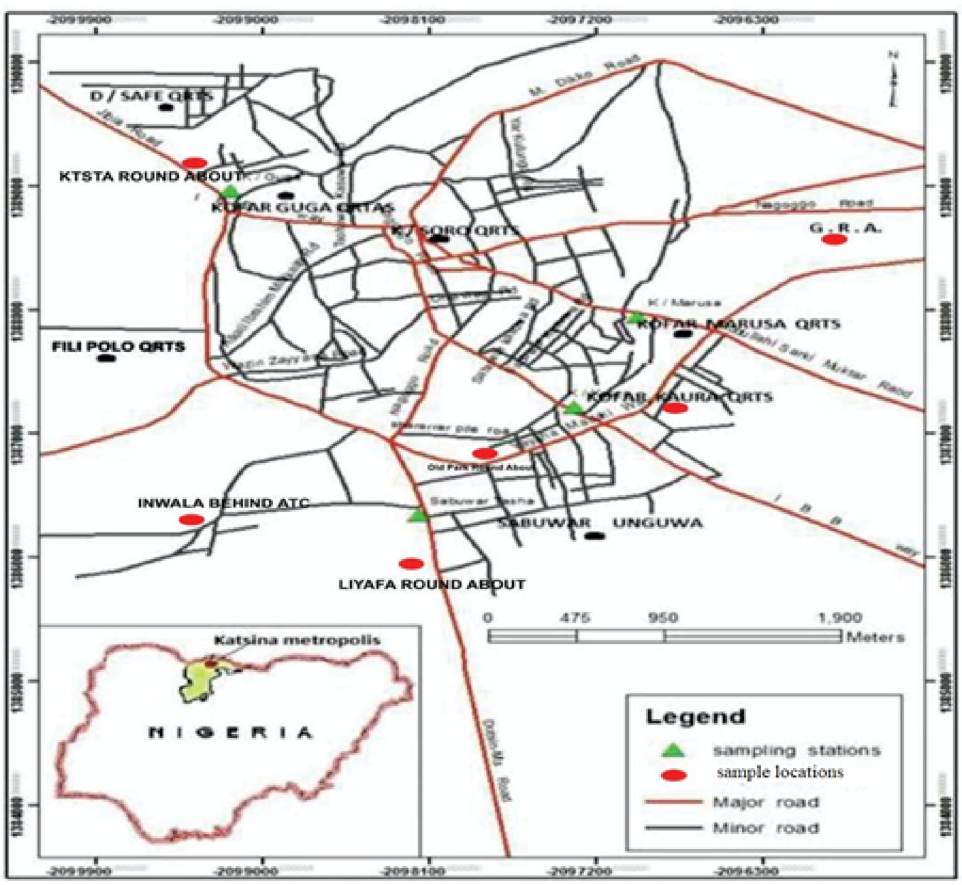

Fig 1: Map of Katsina State shows the sampling locations

Discussion

Table 2 showed that KTSTA roundabout had the highest concentrations and variability (standard deviation) of CO, which indicated the traffic congestion due to a high number of vehicular, motorcycle, and tricycle movements since this site is located at the park for Katsina State Transport Authority (KTSTA). Similarly Liyafa roundabout had the lowest concentration and variability (standard deviation) of CO which indicated low traffic congestion. Analysis of variance revealed that the concentration of CO is statistically different among the locations at a 5% level of significance. Locations with the same superscripts for example Liyafa roundabout and behind the ATC dump site had statistically the same concentration of CO at a 5% level of significance while locations with different superscripts have statistically different concentrations of CO for example Kofar Kaura roundabout and GRA roundabout as shown by Duncan multiple comparison test.

KTSTA roundabout had the highest concentrations of NH_3 and Old Park roundabout had the highest variability (standard deviation) of NH_3, which indicates the emission source of high traffic congestion of lorries and tricycle movements. GRA roundabout had the lowest concentrations and variability (standard deviation) of NH_3. Analysis of variance revealed that the locations with the same superscripts for example Kofar Kaura roundabout and Old Park roundabout have statistically the same concentration of NH_3 at a 5% level of significance while locations with different superscripts have statistically different concentrations of NH_3 for example Kofar Kaura roundabout and GRA roundabout as shown by Duncan multiple comparison test.

Kofar Kaura roundabout and KTSTA roundabout have the highest concentrations of NO_2 and Old Park roundabout had the highest variability (standard deviation) of NO_2, which also indicates the presence of trucks, power plants, and so many off-road equipment. Liyafa roundabout has the lowest variability (standard deviation) of NO_2. Analysis of variance revealed that the concentration of NO_2 is statistically the same for all the locations at a 5% level of significance. This means all the locations have the same superscripts indicating that they have statistically the same concentration of NO_2 at a 5% level of significance as shown by the Duncan multiple comparison test.

Kofar Kaura roundabout, Liyafa roundabout, and Behind ATC Dump site had the highest concentrations of SO_2, and Kofar Kaura roundabout and GRA roundabout had the highest variability (standard deviation) of SO_2, which shows that there is lots of burning of refuse dump and of low burning activities in Old Park, Liyafa roundabout and KTSTA roundabout with lowest variability (standard deviation) of SO_2. Analysis of variance revealed that the concentration of SO_2 is statistically the same for all the locations at a 5% level of significance. This means all the locations have the same superscripts indicating that they have statistically the same concentration of SO_2 at a 5% level of significance as shown by the Duncan multiple comparison test.

Table 3 Indicates that the morning period (7 - 9 am) has the highest concentration of CO due to the flux of traffic from the State Transport Authority moving to different destinations, high vehicular, tricycles and motorcycles comprising of people going to workplaces and students going to schools (on-peak traffic) and afternoon period (12 - 3 pm) had the lowest concentration and variability (standard deviation) of CO. This may be attributed to low vehicular movement of motorist (off-peak traffic). Analysis of variance revealed that the periods with the same superscripts namely afternoon (12 - 3 pm) and evening (4 - 6:30 pm) hours have statistically the same concentration of CO at a 5% level of significance while periods with different superscripts have statistically different concentration of CO namely 7 – 9 am versus 12 -3 pm and 7 - 9 am versus 4 - 6:30 pm as shown by Duncan multiple comparison test. 7

– 9 am had the highest concentration and variability (standard deviation) of NH_3 and 4 - 6:30 pm had the lowest concentration and variability (standard deviation) of NH_3. Analysis of variance revealed that the periods with the same superscripts have statistically the same concentration of NH_3 at a 5% level of significance while periods with different superscripts have statistically different concentrations of NH_3. Therefore, in this research, 7 – 9 am, 12 – 3 pm and 4 - 6:30 pm hours have statistically different concentrations of NH_3 as shown by Duncan's multiple comparison test. 12 -3 pm had the highest concentration of NO_2 and lowest variability (standard deviation) of NO_2. The 4 - 6:30 pm period had the lowest concentration but the highest variability (standard deviation) of NO_2. Analysis of variance revealed that the periods with the same superscripts have statistically the same concentration of NO_2 at a 5% level of significance, namely 7 - 9 am and 12 - 3 pm hours while periods with different superscripts have statistically different concentrations of NO_2 namely 7 - 9 am, 12 -3 pm and 4 - 6:30 pm hours versus 4 -6:30pm as shown by Duncan multiple comparison test. The afternoon period (12 -3 pm) had the highest concentration of SO_2 and highest variability (standard deviation) of SO_2, while higher concentrations of SO_2 and NO_2 were maximal in the afternoon and minimal during the morning period. 7 – 9 am had the lowest concentration and lowest variability (standard deviation) of SO_2. The variation of these parameters may be attributed to the robustness of the atmospheric boundary layer and associated convective turbulence, which extensively mixed and redistributed pollutants to a greater vertical extent. Analysis of variance revealed that the periods with the same superscripts have statistically the same concentration of SO_2 at a 5% level of significance, namely 7 – 9 am and 4 – 7 pm hours while periods with different superscripts have statistically different concentrations of SO_2 namely 7 - 9 am versus 12 - 3 pm and 12 - 3 pm versus 4 - 6:30 pm as shown by Duncan multiple comparison test. The high values of pollutants recorded in this study can be attributed to traffic congestion and the time at which the *data* were collected. Table 4 indicates that CO has a significant positive correlation with NH_3, NO_2, and SO_2 for locations and periods. This means the higher the concentration of CO the higher the concentrations of NH_3, NO_2, and SO_2 for locations/periods and vice versa. It also indicates that NH_3 has a significant positive correlation with NO_2 and SO_4 which means the higher concentration of NH_3 results in higher concentrations of NO_2 and SO_4 for locations/periods and vice versa. It also indicates that NO_2 has a significant positive correlation with SO_4 which means the higher concentration of NO_2 results in higher concentrations of SO_4 for locations/periods and vice versa. Table 5: indicates that temperature has a significant positive correlation with CO, NO_2, and SO_2 for locations. The considerable positive connection shows that the emission sources are somewhat similar, that is; the concentration of pollutants is influenced by traffic density and is therefore affected by vehicle, tricycle, and motorcycle exhaust. This means the higher temperature gives the higher concentrations of CO, NO_2, and SO_2 for locations. Similarly, it indicates that there is no significant correlation between temperature and NH_3. This means that the temperature of the location does not significantly determine the concentration of NH_3, because the sources of NH_3 in the atmosphere are caused by animal waste, and ammonification of humus, then the emissions will take place from the soil. Low concentrations of NH_3 from this study happened due to the unavailability of these sources which was attributed to the nature of the sample locations which are mainly comprised of roadside rather than waste dump sites.

Conclusion

The air pollutants recorded in this study varied from one location to the other and the time of the day, morning (7 – 9 am), afternoon (12 - 3 pm) and evening (4 - 6:30 pm) hours. This observation reflects the level of population growth, urbanization, commercial activities, and traffic flow. The observed pollutant concentration of the gases for locations showed that KTSTA roundabout had the highest concentrations and variability (SD) of CO (10.61$\pm$14.54 ppm). Similarly, the Liyafa roundabout recorded the lowest level of CO, while the KofarKaura roundabout had the highest concentration of NO_2 and variability (SD) of (6.083$\pm$6.054ppm). The same KTSTA roundabout had the highest concentrations of NH_3 (2.056$\pm$1.71) while the Old Park roundabout had the highest variability (SD) of (2.01+2.14ppm). Also G.R.A roundabout had the lowest concentration and variability (SD) of (1.40$\pm$1.092ppm). The NO_2 gas showed the highest concentration of (0.069$\pm$0.078ppm) for the KTSTA roundabout and (0.069$\pm$0.090ppm) for Kofar Kaura roundabout while the Old Park roundabout had the highest variability (SD) of (0.059$\pm$0.11ppm), liyafa roundabout shows the lowest variability (SD) of (0.049$\pm$0.069ppm). Kofar Kaura roundabout, Liyafa roundabout and behind ATC dump site had the highest concentration of SO_2 of (0.10$\pm$0.15ppm), (0.10$\pm$0.11ppm) and (0.10$\pm$0.14ppm), in which the same Kofar Kaura roundabout and G.R.A roundabout had the highest variability (SD) while Old Park, Liyafa and KTSTA roundabout had the lowest variability (SD) of (0.092$\pm$0.15ppm), (0.10$\pm$0.11ppm) and (0.085$\pm$0.11ppm).

The air pollutants concentration for periods showed that the morning period (7 - 9 am) had the highest concentration of CO (10.39$\pm$11.00 ppm) and the afternoon period (12 – 3 pm) had the lowest level and variability (SD) of (7.60$\pm$8.94 ppm), NH_3 gas had the highest level concentration and variability of (SD) at morning (7 - 9 am) while the lowest in the evening (4 - 6:30 pm) (1.30$\pm$1.26 ppm). Afternoon (12 - 3 pm) periods showed the highest level concentration of NO_2 with the lowest variability of (SD) (0.071$\pm$0.075 ppm), but the evening (4 - 6:30 pm) had the lowest with highest variability (SD) of 0.046$\pm$0.090ppm). The SO_2 shows the highest concentration during the afternoon periods (12 – 3 pm) and the lowest variability (SD) of (0.21$\pm$0.15 ppm) while the morning (7 – 9 am) had both the lowest level of concentration and variability (SD) of (0.037$\pm$0.056 ppm). The observed level of the concentrations showed that there are strong correlation among gases in both periods and locations. The higher the concentration of CO the higher the concentration of NH_3, NO_2, and SO_2, and vice-versa. NH_3 too has a significant positive correlation with NO_2 and SO_2, which implies that the higher the concentration of NH_3 the higher concentration of NO_2 and SO_2 and vice-versa. Despite the differences in the level of ambient air concentration of all the locations and periods, it can be concluded that the highest values in KTSTA and Kofar Kaura roundabouts could be as a result of vehicular, tricycles and motorcycles of both private and commercial movements, especially during the morning (7 – 9 am) and afternoon (12 – 3 pm) as the on peak hours while evening (4 - 6:30 pm) as off-peak hours. Strict legislation on the effects and control of air pollution and regular air quality assessment of Katsina State is advocated.

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