
Assessment of Gaseous Pollutants along High Traffic Roads in Kano, Nigeria

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Abstract

This study was aimed at assessing the air quality along some busy roads in Kano metropolis. The study was conducted from December 2009 to September 2010; air pollutants such as: CO, H₂S, NO₂, SO₂, FL and NH₃ were included in this study. The results indicated that the concentrations of CO, H₂S, NO₂ and SO₂ measured, with few exceptions, at some sites were above the air quality index AQI stipulated by USEPA, especially during the afternoon periods. This implies that traffic emission within Kano metropolis is not within the safe limits, revealing that transport-related pollution in Kano metropolis can be potentially hazardous to health. In addition, the results also indicated that the total level of pollutants in all sites was noted across the seasons.. Increases during the Warm and Wet Season provide strong evidence that rainfall impacts the pollutants concentrations at all sites.

Keywords: *Gaseous Pollutants, Quality, Kano, Metropolis, Nigeria*

1. Introduction

Recently, in developing countries, enormous environmental problems due to inadequate environmental planning and monitoring have emanated. This situation is being further complicated in many areas of certain developing countries by environmental problems, which are often associated with development (Oluwande, 1977; Alo, 2008). In such places, environmental problems, like, air pollution in urban centers due to increased volume of traffic on ill-planned roads, are aggravating the already serious problems caused by poor, absent or inadequate sanitary facilities (Arokodare, 1976; Alo *et al.*, 2007).

In most developing countries of the world vehicular growth has not been checked properly by environmental regulating authorities leading to increased levels of pollution (Han, and Naeher, 2006). Traffic emissions contribute about 50-80% of NO₂ and CO concentration in developing countries (Fu,

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2001; Goyal, 2006). 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, has raised high this figure of emission concentration (Ibrahim, 2009). The increase in this traffic-related pollution is not based on the aforementioned factor only, but also on low quality fuel, poor traffic regulation and lack of air quality implementation force. These are clear indices to high levels of traffic-related pollution in developing countries.

In Nigeria as well as in other developing countries, which are not yet fully industrialized, majority of the air pollution problems result from automobile exhaust. In the major towns of some developing countries, because of tropical nature of the climatic conditions, many activities are performed outdoors. People stay along the busy roads every day either to do their work or to sell their wares. Therefore, the ill effects on health due to air pollution resulting from automobile exhaust emission must be very serious indeed (Ayodele and Bayero, 2009). Like any other city of the world, Kano metropolis developed over the years resulting in a steady progress in industrialization and increase in population and traffic density (Ministry of Information, Kano State, 2005). Industrially, it is one of the most developed cities in Northern Nigeria with tannery and textile as some of its dominating industries (Faboya, 1997). From 1991 the population of 2,166,554 grew to be now 3,127,894 people (TWG, 2010). The presence of raw materials, markets, transportation networks, capital and labor makes Kano a major industrial centre in Nigeria. All these factors resulted in a rapid population growth especially through migrations (Malumfashi *et al.*, 2011). With the growth in population, economic activities increased leading to more automobiles averaging 24,857 motorcycles, 19,262 vehicles and 1,209 trucks per day (Okunola *et al.*, 2011). Urban canopy pollution resulting from urbanization is one of the microclimatic problems faced in many urban centers (Akanni, 2010), to which Kano metropolis cannot be an exception. The air along traffic corridors where majority of residents in the formal and informal sectors subsist daily to conduct their daily activities could hardly be regarded as fresh. This is due to automobile emissions from various activities on the roads.

In Nigeria much attention is given to general industrial pollution and pollution in oil industries, with little reference to damage or pollution caused by mobile transportation sources of air pollution (Faboya, 1997; Iyoha, 2002; Magbagbeola, 2001). Pollution from mobile transportation is on the rise due to increase in per capital vehicle ownership, thus resulting in high congestion on Nigeria city roads and increase in the concentration of pollutants in the air, consequently, increasing health risks for human population. In addition compared with the large volume and varieties of studies carried out in the developed world,

exposure studies carried in Nigeria are relatively scarce. So as a first step in focusing attention on these problems, it is necessary to know the types of air pollutants present along with the level of each.

2. Materials and Methods

2.1 The Study Area

Kano Metropolis is located at the central western part of Kano State between latitude $11^{\circ}59'59.57'' - 12^{\circ}02'39.57''\text{N}$ of the equator and between longitudes $8^{\circ}33'19.69'' - 8^{\circ}31'59.69''\text{E}$. It lies in the northern central boundary of Nigeria and is located some 840km away from the edge of the Sahara desert and 1,140km from the Atlantic Ocean (Oseiki, 2009). Its metropolis population is the second largest in Nigeria after Lagos. The Kano Urban area covers 137 sq.km and comprises six Local Government Areas (LGAs) - Kano Municipal, Fagge, Dala, Gwale, Tarauni and Nassarawa.

Ten sites situated along busy roads originating from the city centre covering the six LGAs. were selected, as shown in Figure 1. Specifically, the sites selected for the study included the following: Dan Agundi (Site 1), Kofar Nassarawa (Site 2), Court/France (Site 3), Zoo (Site 4), Sani Abacha (Site 5), Ibo Road (Site 6), Aminu Kano (Site 7), Kofar Mazugal (Site 8), Zungeru/Airport (Site 9) and Rimi Market (Site 10). The criteria for selection of sampling sites included the following: presence of a household near a major road; traffic density and area of population exposure and wind direction. One site, farm center was used as control (Site C). A small garden within a residential buildup area of farm center was used as control site, which was neither close to any secondary nor any main road (Figure 1).

The traffic density was determined by directly observing and counting the traffic during the usual peak traffic periods 8:00 a.m. - 10.00 a.m, 12:00 p.m - 2.00 p.m, 4:00 p.m – 6:00 p.m each day for three days. The average number of traffic at each site per hour was calculated as shown in Table 1.

2.2 Sampling

This study was conducted from December 2009 to September 2010 that is, across the four main seasons: December, cold and dry; March, hot and dry; June, warm and wet; September warm and dry. Concentrations of gaseous pollutants data, CO, H₂S, SO₂, NO₂, FL (flammable gases) and NH₃ were determined using mobile gas sensors manufactured by Crown Detection Instrument Ltd. Oxon OX14DY England and metrological data: sound level and temperature were determined using NL-21 Sound Level Meter and In-Out Door Thermometer.

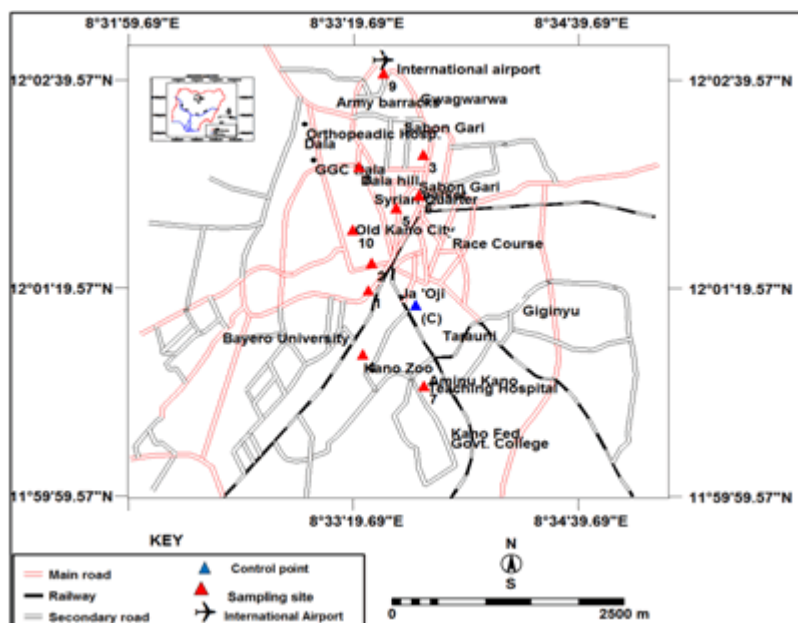


Figure 1. Kano metropolis showing the sampling sites (Adapted and Modified from Google Map Data, 2010)

Table 1. Average traffic volume per hour on high traffic roads in Kano metropolis

Sampling Site Code	Sampling Site	Average Traffic Volume Per hr			
		Number of Motorcycles	Number of Vehicles	Number of Trucks/Lorries	Total
1	Aminu Kano	1902±12	2634±10	196±2	4732
2	Zoo	2011±20	1504±8	121±5	3636
3	Dan Agundi	1206±15	1935±12	216±2	2831
4	Kofar Nassarawa	1323±13	1801±19	46±2	3170
5	Rimi Market	3005±10	2008±14	25±2	5038
6	Sani Abacha	6857±23	1292±13	207±2	8357
7	Ibo Road	2464±19	1845±19	35±5	4344
8	Court/France	2651±18	1041±9	16±2	3708
9	Kofar Mazugal	1995±21	2836±12	149±2	4180
10	Zungeru/Airport	1443±11	2366±17	198±3	4007
C	Farm Center	Nil	Nil	Nil	Nil

2.3 Statistical Analysis

For the interpretation of data the following statistics were used: the raw data obtained was analyzed using descriptive statistic (mean) and was used to create the multi-bar charts; t-test was performed to compare means for seasons and Pearson's correlation was used to determined correlation between pollutants, meteorological and traffic data. Statistics were performed using the comprehensive statistical software (SPSS Version 17).

3. Results

The average seasonal variations of CO, H₂S, NO₂, SO₂, FL and NH₃ concentrations across the sites are illustrated from Figures 2 to 7. The results showed highest concentration for CO, H₂S, SO₂ and NH₃ in dry seasons (cool and dry, hot and dry, and warm and dry seasons) and NO₂ and FL in warm and wet season. The t-test has been applied for comparing mean-values of pollutants obtained at different season per site. The p-value for CO at all sites (except Sites 2, 7 and 9) was < 0.05, p-value for H₂S at all sites (except Sites 1 and 6) was < 0.05, for NO₂, p-value was < 0.05 at all sites except sites 2, 3, 6 and 10, p-value for SO₂ at all sites (except Sites 4, 5, 8 and 9) was > 0.05, p-value for NH₃ at all sites was < 0.05, and for FL, p-value was > 0.05 at all sites except Site 10. P-value less than 0.05 (<0.05) signifies 95% difference in their mean values across the season per site.

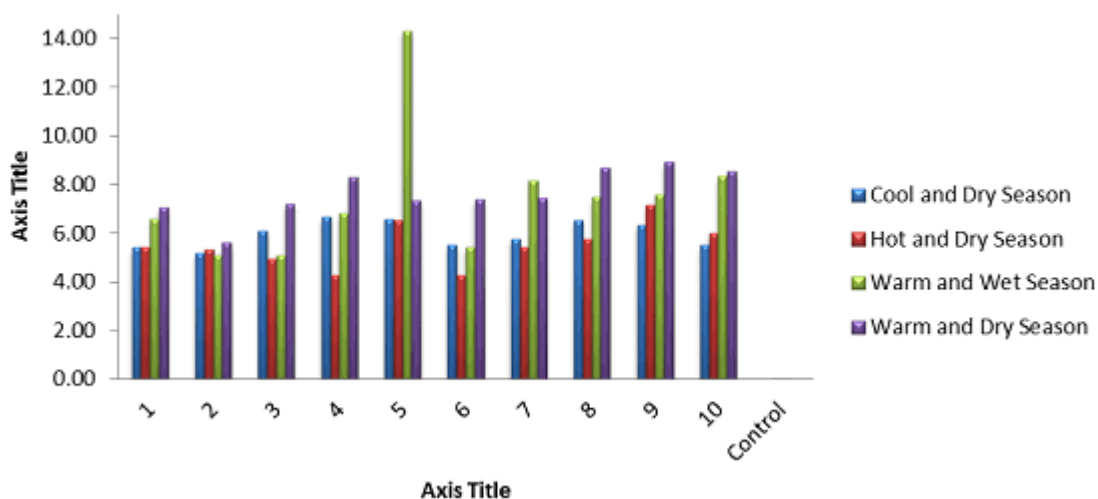


Figure 2. Variation of CO across the sampling sites

From the results for CO, season average ranged; 5.42 – 7.04 ppm for Site 1, 5.08 – 5.60 ppm for Site 2, 4.92 – 7.21 ppm for Site 3, 4.25 – 8.28 ppm for Site 4, 6.50 – 14.33 ppm for Site 5, 4.25 – 7.39 ppm for Site 6, 5.42 – 8.17 ppm for Site 7, 5.75 – 8.71 ppm for Site 8, 6.33 – 8.93 ppm for Site 9, 5.50 – 8.53 ppm for Site 10, and 0.00 – 0.01 ppm for control site. Highest concentration of CO at all sites (except Sites 5 and 7) was observed during the warm and dry season. The highest concentration of CO was at Site 5.

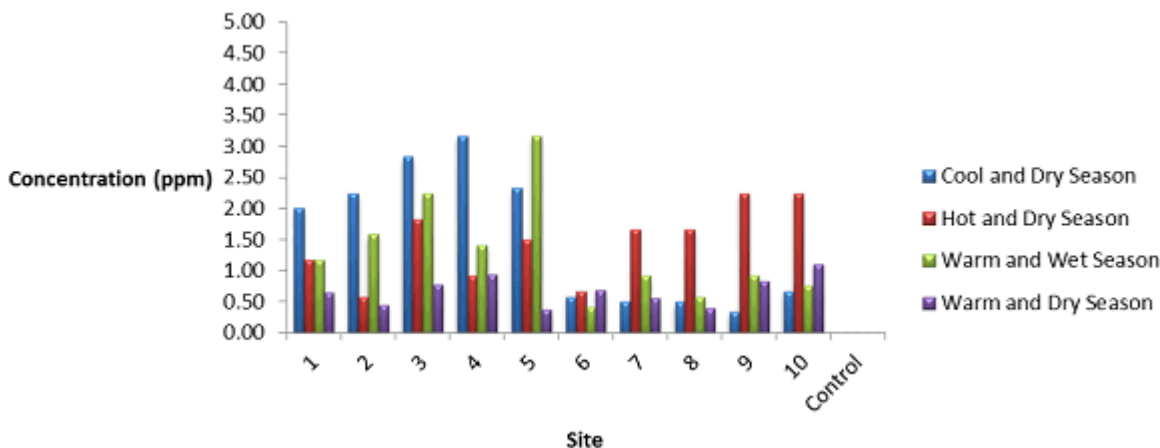


Figure 3. Variation of H₂S across the sampling sites

Season average of H₂S showed ranges: 0.64 – 2.00, 0.45 – 2.25, 0.78 – 2.83, 0.94 – 3.17, 0.37 – 3.17, 0.42 – 0.67, 0.50 – 1.67, 0.40 – 1.67, 0.33 – 2.25, and 0.67 – 2.25 ppm for Sites 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 respectively. No H₂S was detected at the control site. Similar to CO, highest concentrations of H₂S was obtained at Site 5. Average seasonal variation across the sites showed that highest concentrations were in hot and dry season for Sites 6, 7, 8, 9 and 10, cool and dry season for Sites 1, 2 and 3, and warm and wet season for Site 5.

The results of NO₂ revealed seasonal average ranges between: 0.14 – 0.35, 0.12 – 0.17, 0.11 – 0.16, 0.13 – 0.43, 0.14 – 1.09, 0.13 – 0.22, 0.14 – 0.31, 0.15 – 0.32, 0.13 – 0.36 and 0.14 – 0.39 for Sites 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 respectively. Similar to H₂S, NO₂ was not detected at the control site. Highest concentrations of NO₂ were observed in warm and dry season at Site 5. However, compared to CO and H₂S, for NO₂ majority of the sites have their highest concentrations in warm and wet season.

For SO₂, seasonal average ranged between; 0.00 – 0.03 ppm for Site 1, 0.00 – 0.03 ppm for Site 2, 0.03 – 0.06 ppm for Site 3, 0.03 – 0.26 ppm for Site 4, 0.03 – 0.14 ppm for Site 5, 0.03 – 0.06 ppm for Site 6, 0.03 – 0.07 ppm for Site 7, 0.03 – 0.12 ppm for Site 8, 0.03 – 0.09 ppm for Site 9, 0.03 – 0.19 ppm for

Site 10. Similar to NO_2 , SO_2 was not detected at the control site. Highest concentration of SO_2 at all sites was observed during the warm and dry season. The highest concentration of CO was at Site 4.

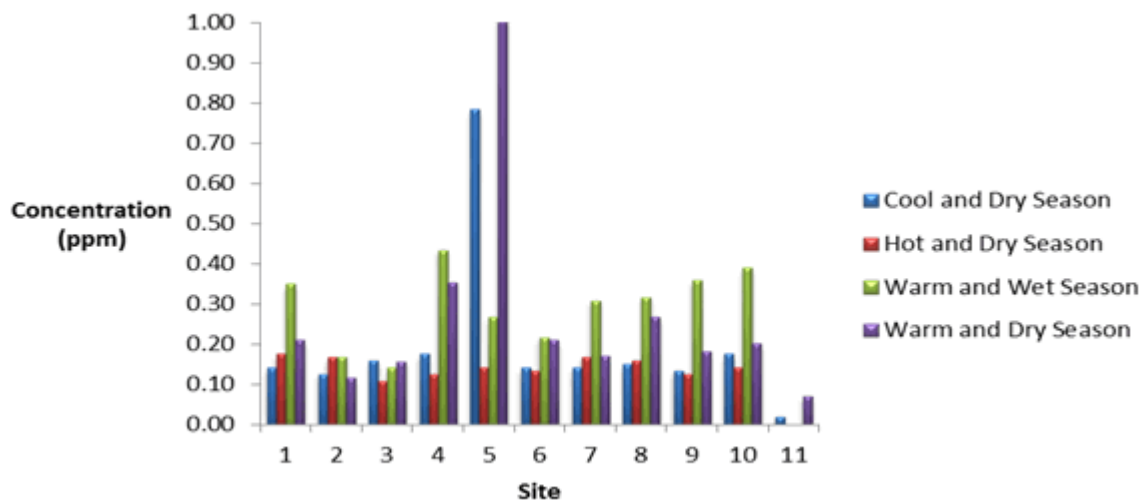


Figure 4. Variation of NO_2 across the sampling sites

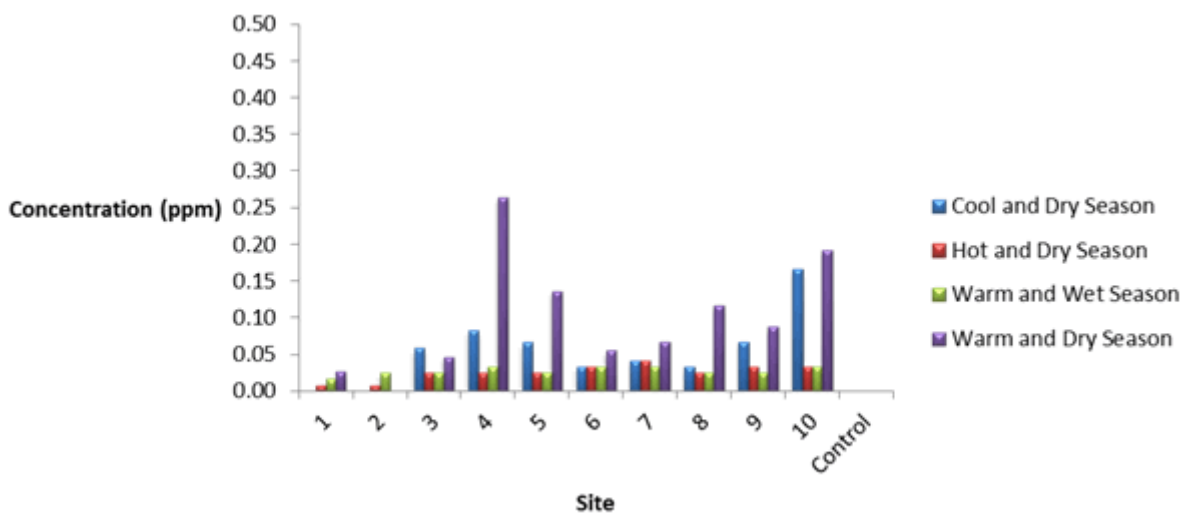


Figure 5. Variation of SO_2 across the sampling sites

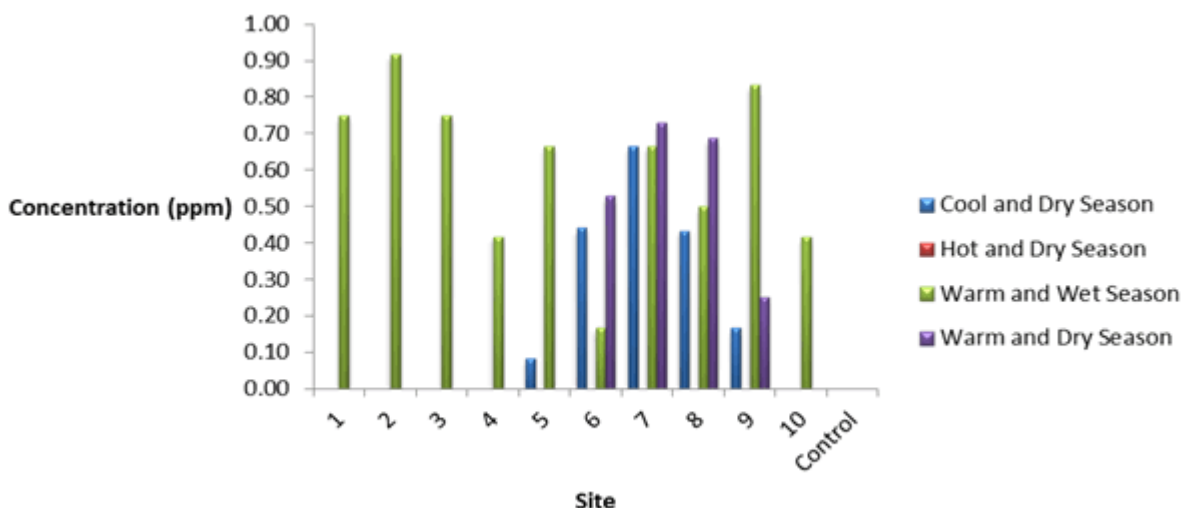


Figure 6. Variation of Flammable gas (FL) across the sampling sites

Season average of FL showed range: 0.00 – 0.75, 0.00 – 0.92, 0.00 – 0.75, 0.00 – 0.42, 0.00 – 0.67, 0.00 – 0.53, 0.00 – 0.73, 0.00 – 0.69, 0.00 – 0.83, and 0.00 – 0.42 ppm for Sites 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 respectively. No FL was detected at the control site. Highest concentration of H_2S was obtained at Site 2 in warm and wet season. Average seasonal variation across the sites showed that highest concentrations were in warm and wet season for Sites 1, 2, 3, 4, 5, 9 and 10, and warm and dry season for Sites 6, 7 and 8.

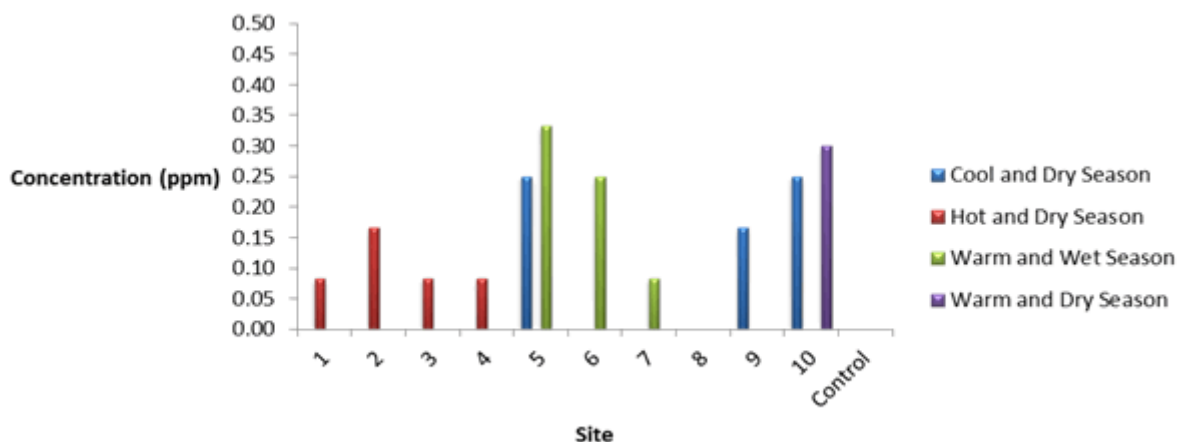


Figure 7. Variation of NH_3 across the sampling site

The results of NH_3 revealed seasonal average ranges between: 0.00 – 0.08, 0.00 – 0.17, 0.00 – 0.08, 0.00 – 0.08, 0.00 – 0.33, 0.00 – 0.25, 0.00 – 0.08, 0.00 – 0.17 and 0.00 – 0.25 for Sites 1, 2, 3, 4, 5, 6, 7, 9 and

10 respectively. NH_3 was not detected at Site 8 and control site. Highest concentration of NH_3 was observed in warm and wet season at Site 5. Average seasonal variation across the sites showed that highest concentrations were in cool and dry season for Sites 9 and 10, Hot and dry season for Sites 1, 2, 3, and 4, and warm and wet season for Sites 5, 6 and 7.

The mean temperature across the seasons showed the ranges: 31.8 (Site 9) – 39.1⁰C (Site 3), 33.1 (Site 7) – 36.6⁰C (Site 1), 30.8 (Site 1) – 33.9⁰C (Site 4), and 30.1 (Site 4) – 39.2⁰C (Site 3) for cool and dry, hot and dry, warm and wet, and warm and dry seasons respectively. Increasing temperature was observed between the studied sites and control site. This indicates that activities such as vehicular emission, along with traffic could be responsible for this increasing temperature. Highest temperature was obtained in cool and dry season at all sites without exceptions.

The degree of association between pollutant and metrological data, and traffic volume was investigated with Pearson correlation across the seasons. Some of the variables were either positive or negative significantly correlated at 0.01 and 0.05 p-levels. For cool and dry season, CO has strong correlation with H_2S and SO_2 , H_2S with NO_2 . Significant ($p < 0.05$) negative correlation was observed between CO vs. sound, and H_2S vs. NO_2 and temperature. During hot and dry season, significant positive correlation was found between CO vs. H_2S , NO_2 and SO_2 , H_2S vs. NO_2 and SO_2 , and NO_2 vs. SO_2 . Strong association ($p < 0.05$) between pollutants was observed in warm and wet season, CO vs. H_2S , NO_2 , SO_2 and NH_3 , H_2S vs. NH_3 , NO_2 vs. SO_2 , and SO_2 vs. FL. In warm and dry season, significant positive correlation ($p < 0.01$) was found between CO vs. H_2S , SO_2 and FL, and significant correlation ($p < 0.05$) between H_2S vs. SO_2 and NH_3 . According to Sharma *et al.* (2009), the significant positive correlation indicates that the emission sources are somewhat similar that is, vehicular exhaust generated by the traffic density affects the concentration of pollutants. If the changes in the emission and temperature are considered in parallel, it can be argued that the considerable variations in the pollution levels observed for all pollutants are mainly due to changes in the emission patterns and not in temperature. Mild relationship between traffic and gaseous pollutants could be due to the fact that vehicles produced after 1989 were all equipped with a catalyst which emit 8 to 12 times less CO and 3 to 6 times less NO_2 , depending on the catalyst type used in (Samaras *et al.*, 1997), comparison to the conventional technology vehicles (Kalabokas *et al.*, 1999). This could be the basic reason why the increase in traffic volume is not associated with a corresponding increase in atmospheric levels of the studied pollutants.

4. Discussion

From the results obtained, the concentrations of pollutants with exception of NO₂ and FL were maximal in the dry seasons. This was similar to report by Ragini *et al.* (2009), where higher concentrations of SO₂ and NO₂ were maximal in the afternoon and minimal during the morning period. However, the variations of these parameters may be attributed to the dynamics of the atmospheric boundary layer and associated convective turbulence, which extensively mixed and redistributed pollutants to a greater vertical extent. As observed from the graph, except at Sites 5 and 6, in Warm and Wet Season, highest concentrations of CO was recorded in Warm and Dry Season at all sites, with the highest at Site 9. This could be attributed to seasonal changes and sources of pollution at these sites, which could be stationary source and burning of refuse especially at Site 9. The atmospheric CO along the corridors of the roads when compared with values reported in literature was found to be higher than 1.6 – 3.8 ppm, an average range of atmospheric concentration of urban air pollutants in Athens, Greece (Kalabokas *et al.*, 1999).

Also, the values reported in this study were higher than range of 0.7 – 1.9 ppm in Jahara, Kuwait (Ettouney *et al.*, 2010). However, the values in this study were lower than range of 233 – 317 ppm reported in three cities of Nigeria: Lagos, Ibadan and Ado - Ekiti (Koku and Osuntogun, 1999). Comparing the values of CO at the 10 sites, the highest value was seen at Site 5 due to traffic congestion, since this site is located at a local market serving as last bus-stop for most intra-city buses and taxies, and the road leads to Kantin Kwari (an International Market) thereby experiencing flux of traffic, especially during the afternoon-evening hours.

In terms of air quality index (AQI), the CO variation across the seasons revealed that in Cool and Dry, and Hot and Dry Seasons, air quality is moderate at all sites except at Sites 4, 5 and 8, and Sites 5 and 9 respectively, where it is poor. Also, in Warm and Wet and Warm and Dry Season, air quality at Sites 2, 3 and 6, and Site 2 respectively is moderate while at other sites it is poor. Generally, condition of the air during afternoon – evening hours indicate poor air quality. This indicates that residents along these sites are exposed to CO that reduces the oxygen carrying capacity of blood, which in turn impairs oxygen release into tissue and adversely affects sensitive organs such as the brain and heart (Bascom *et al.*, 1996). CO results from incomplete combustion of diesel or gasoline in traffic engines, non-transportation fuel combustion, bush burning and some indoor sources such as a leaking gas stove (Han and Naeher, 2006).

Similarly, across the seasons H₂S was found to be the highest at Sites 1, 2, 3 and 4 during Cool and Dry Season, Site 5 in Warm and Wet Season, Site 6 in Warm and Dry Season and Sites 7, 8, 9 and 10 in Hot

and Dry Season. Seasonal and source variation could be responsible for variations in the sites. With the highest level of H_2S at Sites 4 and 5. H_2S is gases emitted during the decay of organic matter. This could be the source of bad odor at this sites as observed during sampling. Also, decay of food stuff, waste and refuse generated within these sites and left for a long time could be responsible for high H_2S emission. The H_2S level in this study is higher than range 0.167 – 0.265 ppm reported for Abeokuta metropolis, Nigeria (Oguntoke and Yusuf, 2008).

In terms of AQI, the air quality, from the results, highest levels of NO_2 were obtained at all sites during Warm and Wet Season except at Site 5 with highest level during Warm and Dry Season. This is an indication that at Site 5, there was an increase in emission due to automobiles. This corroborates with high correlation coefficient (0.397) between traffic and NO_2 in Warm and Dry Season. Also, when the levels of NO_2 were compared with values reported in literature, seasonal mean of NO_2 was found lower than 35 – 108 ppm reported in Athens, Greece (Kalabokas *et al.*, 1999), and fell within 0.20 – 0.521 ppm reported for Calabar metropolis, Nigeria (Okafor *et al.*, 2009) but quite high when compared with the limits set by FEPA (1991) for NO_2 which is 0.06 ppm. Also, in comparison with AQI, at all studied sites AQI is very poor. This is most likely due to high traffic density and stationary fuel combustion process emissions from running of generators (Etiuma *et al.*, 2006) which is very common within the metropolis due to erratic power supply. Generally, from the results of NO_2 , it can be deduced that the distribution pattern of NO_2 shows an increase during Warm and Wet Season across the sites, which could be due to air/wind velocity during this period.

Across all the studied sites, highest level of SO_2 was recorded in Warm and Dry Season with exception at Site 2. High positive correlation (0.502) between traffic volume and SO_2 during this season could be responsible. Furthermore the concentration of SO_2 is lower than ranges of 3.21 – 5.18 ppm, 7.4 – 15.5 ppm, and 16 – 64 ppm reported by Ayodele and Abubakar (2010), Ettouney *et al.* (2010), and Kalabokas *et al.* (1999), respectively. At some sites the emission values were within 0.14 ppm (average of 24hrs) limit of USEPA (2001) ambient air quality standards, while at Sites 4 and 10, SO_2 was above the USEPA limit. The reasons for high value at Sites 4 and 10 may be attributed to several processes such as, refuse dumpsite located along these sites. Comparing data with AQI levels, the air quality for SO_2 was in the range of moderate – very poor in Sites 3 – 10, while at Sites 1 and 2, AQI for SO_2 was in the range of very good – good.

The average seasonal value of NH_3 in the atmosphere at the studied sites ranged between 0.00 – 0.92 ppm. This range is lower than 0.861 – 4.300 reported for Calabar metropolis, Nigeria (Okafor *et al.*,

2009). NH₃ sources in the atmosphere are animal waste, ammonification of humus, followed by emissions from soil, loss of NH₃ based fertilizer from soil and industrial emission (Okafor *et al.*, 2009). Low concentrations of NH₃ from this study may be due to unavailability of some of these sources. Similar to NH₃, Flame gases (FL) are relatively very low at the studied sites, which could indicate fewer hazards due to this pollutant.

5. Conclusion

The results showed that traffic emissions in Kano metropolis include pollutants like CO, H₂S, NO₂ and SO₂ as well as traces of FL and NH₃. The concentrations of the CO, H₂S, NO₂ and SO₂ measured, with few exceptions, at some sites were above the AQI stipulated by USEPA especially during the dry seasons. This implies that traffic emission within Kano metropolis is not within the safe limits. Hence, the results reveal that transport-related pollution in Kano metropolis is significant with potentially hazardous health consequences. Another striking feature of the study is that average concentration of pollutants in all sites was noted across the seasons. From the study one can clearly discern a decrease in concentration during hot and dry season in most of the sites.

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