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Contribution of Vehicular Emission to Ambient Air Quality in Minna, Niger State, Nigeria

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Abstract:
This study examines the contribution of vehicular emission to ambient air quality in Minna, Niger State examined the concentration level of some selected air pollutants largely products of internal combustion in motor vehicle engines namely: nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and carbon monoxide (CO). From a fixed point, moving vehicles were counted at morning, afternoon and evening time while Crowcon (Tetra 3) model number IECEx BAS 05.0059 was used for monitoring the concentrations of the three selected gases at the selected motorways which are labelled X and Z. The point X represent road intersections where samples were obtained within the metropolis (urban area namely Top Medical junction, Kpakungu Roundabout, and Obasanjo Complex Roundabout), while point Z is the control station which is situated at the Government residential area ideal for less traffic flow in the city. Traffic volume ranged between 1775±06 at the various sampling points. From the results, the concentrations of CO, SO_2 and NO_2 ranged between 51.05±0.04 ppm, 0.119±0.017ppm and 0.115±0.029ppm respectively, they were found to exceed the stipulated threshold by Federal Ministry of Environment. Significant relationship ($p< 0.05$) was established between the volume of traffic and the concentration level of the sampled gases across the periods of the day at the selected motorways. Urgent precaution that seeks to minimize the level of emission of pollutants from automobile is required in Minna to protect the teeming population especially road users against the adverse impacts of these pollutants which ranges from difficulty in breathing to death when it is severe.

Keywords: *vehicular emission, pollutants, ambient air quality, motorways, traffic volume*

1. Introduction

Human activities and the environment are inter-related, this is because any activity of man is done in the environment and the resultant effect is either positive or negative to man. Human activities are however diverse. Uchegbu (1998), reported that such negative effects arise from economic and domestic activities of man such as burning of fossil fuels, exhaust fumes: All these emit harmful gases like sulphur dioxide, carbon monoxide, etc, that cause acid rain, global warming, and the malfunctioning of human haemoglobin etc. Ukpong (1994). The emittance of such gases is known air pollution.

(Odigure, 1998) defined air pollution as the presence in the outdoor or indoor atmosphere of one or more gaseous or particulate contaminants in quantities, characteristics and of duration such as to be injurious to human, plant or animal life or to property, or which unreasonably interferes with the comfortable enjoyment of life and property. Air quality in the urban centers all over the world are distinguished from those of the less built up areas by differences in carbon monoxide, volatile organic compounds, oxidants, oxides of Sulfur, Nitrogen and particulate matter. These differences are attributed in large part to anthropogenic interference of nature. According to Tawari and Abowei (2012) Anthropogenic sources of air pollution is mostly related to burning different kinds of fuel from motor vehicles, marine vessels, aircraft, dust and controlled burn practices in agriculture and forestry management.

Most of the vehicles today use internal combustion engines that burn gasoline or other fossil fuels (Prather, 1995). The ambient pollution over urban centres is characterized by higher concentrations of such chemicals beyond limit is introduced into the air by increased pollution from mobile sources. This includes: cars, buses, trucks as well as motor cycles, these has increased with per capital ownership over the years. For example, Abam and Unachukwu (2009) reported that the Federal Road Safety Commission of Nigeria (FRSC) had registered about six million (6,000,000) vehicles between 1999 and 2004 and that 70% of these were cars while 30% were buses and trucks. On the average, these have increased emissions from road transportation in Nigeria. The concentration level of these pollutants depends on the magnitude of local emission sources and the prevailing metrological ventilation of the area (Colls, 2002).

Emissions from vehicles have been verified to have negative effect on public health and the natural environment in and around the world, especially in urban areas where pollution levels are on the increase due to vehicular emission. Galen in 129- 199 AD, speculated that there was a change in the composition of the air which caused harm when inhaled. Chemicals found in polluted air could cause cancer, birth defects brain and nerve damage, and long-term injury to the lungs and breathing passages in certain circumstances. (Schwela 2000), reported that exposure to carbon monoxide can result in fatigue, headaches, dizziness, loss of consciousness, and even death at very high concentrations, Particulates are especially dangerous because they have been implicated in the development of lung cancer and higher rates of mortality (Schwela, 2000).

Pollutants released into the atmosphere from vehicles include carbon dioxide (CO2), carbon monoxide (CO), sulphur oxides (SOx), nitrogen oxides (NOx), particulate matter (particles of smoke, soot, and dust), hydrocarbons and lead (Corbitt, 1999). These pollutants are produced when fuel is burnt under less than ideal conditions. Non-uniform oxygen supply within the combustion chamber and lower flame temperature leads to incomplete combustion releasing CO, hydrocarbon (HC) and un-burnt particles in the exhaust (Garret and Newton, 2001).

Air is known to be primarily essential for the existence of all forms of life. 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). The health challenges experienced by road users, passers-by, residents and business operators in traffic flash points, having high concentration of vehicular traffic during some periods of the day are worrisome. A comparison of the monitored and inventory emissions with acceptable standards (threshold) is useful in determining the extent of safety of road side business operators and hawkers in traffic intersection congested traffic points.

Several studies have found a relationship between the degree of exposure to vehicular emissions and adverse health effects, such as increase hospitalizations and mortality rate. Studies such as this are being carried out where Urbanization brings about increases in population, which lead to corresponding increases in motor vehicles, either for private or for public transportation.

Jimoh and Ndoke (2007), assessed the Impact of Traffic Emission on Air Quality in Minna. The researchers obtained census of registered vehicles from the state licensing office, and questionnaire aimed at determining the age of vehicles. These were administered on a sampled population (50 for private cars, 100 for motorcycles, 200 and 50 for commercial cars and buses respectively). Findings from this research however shows that the concentrations of the gases measured are still within the limits stipulated by the WHO and FEPA. This implies that traffic emission in Minna, which has a population of about 300,000 people with 3,000 vehicles, is within the safe limit.

Furthermore, Koku and Osuntogun, (1999) studied the impacts of urban road transportation on the ambient air quality in three cities of Nigeria: Lagos, Ibadan and Ado – Ekiti all in South-west region of Nigeria. Air quality indicators namely CO, sulphur dioxide 'SO_2', NO_2, and total suspended particulates (TSP) were determined using automatic insitu gas monitors (Rae ii reusable). Conclusions of this research show a growing risk of traffic-related problems in Nigeria cities and demand for serious air quality measures.

In a recent research by (Okunlola, Uzairu and Gimba 2012) on the assessment of the concentration of CO, SO_2, NO_2 and H_2S in Kano city, 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, H_2S, SO_2, NO_2 and NH_3 were determined. It was observed that, with few exceptions at some sites, gases measured were above air quality index recommended by USEPA.

Also, all the studies conducted on vehicular emissions from the review done were conducted outside Minna except that of Jimoh and Ndoke (2007) which coincides with this current study. Average daily recordings from the study revealed that CO and CO_2 Concentration were a little below the limit stipulated by the Federal Environment Protection Agency. There is however, a strong possibility that the situation might have worsened due to the increase in vehicle ownership in the city, particularly the popular "tokunbo" vehicles. Moreover, the work conducted by Jimoh and Ndoke adopted two (2) open-air sampling method as well as a random selection on vehicles of population (50 for private cars, 100 for motorcycles, 200 and 50 for commercial cars and buses). But this might not be adequate for a fast-growing city like Minna. From 2007 till date there is therefore no doubt that there has been an increase in the total numbers of vehicles in the study area.

2. Study Area

Minna is the administrative capital of Niger State. It lies within latitudes $9^o36'$-$9^o38'$N and longitudes $6^o31'$- $6^o34'$ of the Greenwich Meridian. It is about 145 kilometers by road from Abuja, the Federal Capital Territory of Nigeria. The study area covers about 76,363km^2 and it's located at the south-eastern axis of the state, in the middle belt region of the country (figure 1). Politically, Minna town is bordered by Shiroro Local Government Area in the North, Shiroro and Paikoro to the east, Pikoro and Katcha Local Government Area in the south and Wushishi and Gbako in the west (Minna was predominantly a Gwari town and its name was derived from a yearly ritual performed by the Gwari's to observe the beginning of the New Year. The word

Minna literally means spread fire. Tribes such as Nupe, Yoruba, Hausa, Igbo and many others settled in different camps within the town as a result of the rail line construction that began in 1914 (Mudiare *et al*, 2015).

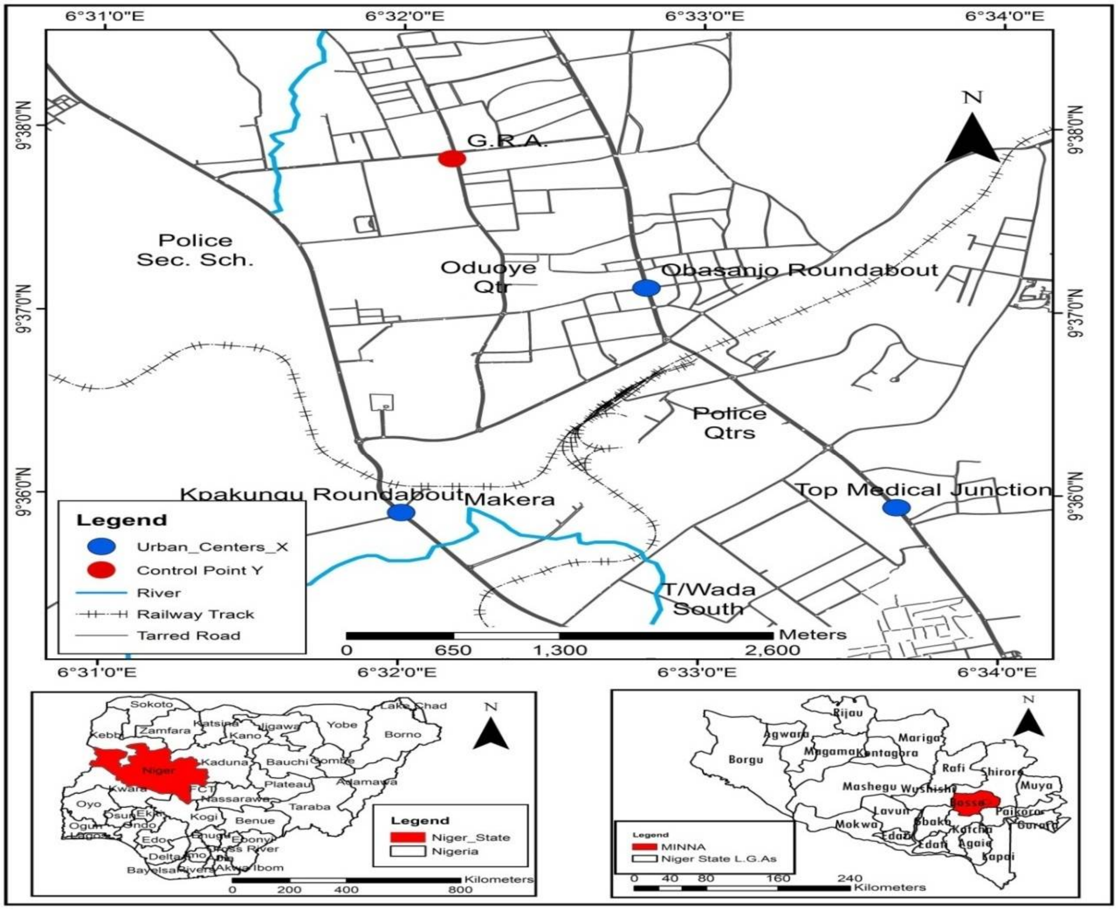

Figure 1: The Study Area

The climate of Minna is the result of the general atmospheric circulation of air masses over the earth modified by surface topography and elevation. The principal air masses affecting the weather of the Minna are the Tropical Maritime (M_T) and the Tropical Continental air masses (C_T). The broad rainfall pattern shows a distinct and fairly south-north gradient in which the annual rainfall decreases from the southern fringe (Ati and Sawa, 2008). The highest mean monthly temperature is recorded in March with at about 30.5^{o}C and the lowest in August at about 25^{o}C (Ati and Sawa, 2008).

3. Materials and Method

This study focuses on measuring the level of emission generated by vehicles in Minna Township and will be limited to major motor ways within the town which include Tunga Roundabout, Kpankungu Roundabout, and Obasanjo Roundabout. It will entail a direct measurement of some selected air quality indicators, which are largely products of internal combustion in motor vehicle engines are SO_2, CO and NO_2 in the study area without giving consideration to any weather parameter. The choice of this three air quality indicators is to reduce the overhead cost of this study. The field data was collected for 3 weeks in January, 2015.

Two types of data were used for this study, they primary and secondary types of data the primary types of data used includes: concentration level of SO_2, CO and NO_2 from the selected sample points for both urban and the control centre measured from vehicular emission in the study area, Rate of traffic flow at the designated sample points and Photo shots of vehicular movement were taken to boast the visual understanding during the field survey. The secondary sources of data for this work consists of published and unpublished works generated from existing materials, internet, journals conference papers research thesis and other documents related to the study as well as related websites.

3.1. Sampling Procedures

For this research, two points was outlined namely X and Z. The point X represent road intersections where samples were obtained within the metropolis (urban Area namely Top Medical junction, Kpakungu Roundabout, and Obasanjo Complex Roundabout, while point Z is the control station which is situated at the Government residential area ideal for less traffic flow. The choice of these locations was based on their potentially high traffic capacity and existing literatures, where the various researchers adopted the various sampling points because they are the major congested areas in such location. For instance, Okelola and Okhimamhe 2012 conducted a similar research to measure carbon emissions concentration in Minna, the researchers used seven points to obtain the result based on the fact that those points are the flash points. Similarly, Odhiambo, Kinyua and Gatebe 2010 in Kenya in a bid to study motor vehicle air pollution used one (Single) sampling point to make generalization about the entire Kenya metropolis. Also (Ojo and Awolola 2012) in a study to investigate air pollution on from automobiles at intersection in Ogbomosho used four sampling routes. For the purpose of this research, three (3) sampling points was adopted been the most notorious traffic flash points in the study area as well as a control station.

The pollutants were measured using Crowcon (Tetra 3) with model number IECExBAS 05.0059, air sampler for the detection of the gases (SO_2, CO and NO_2). This device was rented from Kaduna Environmental Protection Agency. (KEPA). The time frame for the collection from the three sampling points was 3 weeks. One week per each sampling point, in three different periods of the day. These periods according to Ndoke and Jimoh (2012) were termed peak and off-peak periods.

3.2. Concentration of SO_2, CO and NO_2 in the Study Area

To achieve objective which sought to examine the concentration of CO, SO_2 and NO_2 in the study area, the pollutants were measured near the road side for the period 45 minutes in the morning, afternoon and evening period. The mean and total concentration of these pollutants were evaluated on weekly basis as well as the corresponding vehicular headcount and presented in table 1 below.

		Air Quality Parameters (ppm)			
		SO_2	NO_2	CO	
Sample Point	**Time of Day**	**Total**	**Total**	**Total**	**Traffic**
Top Medical	Morning	0.119	0.029	30.5	227.33
	Afternoon	0.093	0.082	38	68.33
	Evening	0.084	0.076	20	241.14
Obasanjo Complex	Morning	0.017	0.109	51.5	224.81
	Afternoon	0.113	0.101	38	69.14
	Evening	0.089	0.082	23	228.81
Kpakunguu	Morning	0.114	0.108	50.8	196
	Afternoon	0.481	0.039	13.3	73.62
	Evening	0.122	0.115	56.8	201.85
GRA	Morning	0.058	0.045	004	15.22
	Afternoon	0.045	0.039	003	16.22
	Evening	0.035	0.039	004	14.21

Table 1: Average Weekly Concentration of SO_2, NO_2, CO and Traffic in the Study Area per week
Source: Field Survey, 2015

3.3. Relationship between the Rate of Traffic Flow and Concentration Level of the Pollutants

To achieve objective/research question II, which sought to address the relationship between the rate of traffic flow and concentration level of the pollutants, the collected data was subjected to test of association using correlation; the result obtained is presented in table 2 below:

Variable	N	Mean	Std.Dev.	Df	r-cal	r-crit	P	
Emission Measurement	266	2.765	.2417	484	0.266	0.088	0.01	
Traffic	266	95.576	98.652					

Table 2: Pearson Correlation Showing the Rate of Traffic Flow and Concentration Level of the Pollutants
*** Correlation is significant at the 0.05 level (2-tailed)*
Source: Authors Analysis, 2015

Table 2 above shows the test of association between the volume of traffic counted and the corresponding vehicular emission recorded for the sampling points. The total number of cases used for the analysis is 266 for both the vehicular head count as well as the recorded vehicular emission. The mean value of vehicular emission for all the cases is 2.765, while the mean value of vehicular head count is 95.576. Their standard deviations are 0.2416, 8.651 for emission measurement and traffic head count respectively.

4. Results and Discussion

Statistics from the test of association reveals low significant relationship, However, r (0.266=P <0.05) is significant. Hence relationship between vehicular head count and emission measurement was established, reason being that the p value of

0.01 is less than the 0.05 alpha level of significance. Also, the calculated coefficient of correlation (r) 0.266 was found to be higher than the critical r value of 0.088. The type of relationship between the two variables is directly proportional thus the null hypothesis which states that "there is no relationship between traffic volume and the concentration of the pollutants at the various sampling points is hereby rejected and the alternate hypothesis which states that "there is relationship between traffic volume and the concentration of the pollutants at the various sampling points" is hereby accepted

Table 1 shows the average total concentration of CO, SO_2 and NO_2 per week measured within the space of thirty minutes duration in the morning, afternoon and evening period. These measurements were taken at the designated sample points. The emission level of CO at top medical were 30.5ppm, 38ppm and 20ppm across the periods of the day which are morning, afternoon and evening. They were found to exceed the Nigerian ambient air quality standard which is 10ppm (11.4 Ng/m^3) FEPA (2000) similarly the average weekly emission of CO for Obasanjo roundabout was 51.5pm, 38ppm and 23ppm across the period of the day. This also exceeded the FEPA threshold. The CO weekly concentrations for kpakungu across the periods of the day were also found to be 50.8ppm, 13.3ppm and 56.8ppm. This also exceeded FEPA threshold. Furthermore, the average weekly CO concentration across the day at the control points was found to be lower than the FEPA stipulated limit across the day. Which are 004ppm, 003ppm and 004ppm. This confirms the claim of Akpan and Ndoke, (2006), Ojolo, Oke, Dinrifo, and Eboda, (2007) that Nigerian cities are fast becoming unfriendly especially as regards to air quality.

In the same vein, the average weekly $S0_2$ concentration at top medical junction was found to be 0.119ppm, 0.093 and 0.084ppm across the time of the day. The measurement for the morning rush exceeded the FEPA stipulated limit which is 0.01ppm-0.1ppm FEPA (2000). The $S0_2$ reading for Obasanjo roundabout was also found to be 0.0890ppm, 017ppm and 0.109ppm. Both the recordings for the morning and afternoon periods were found to be slightly higher than the threshold. Furthermore, $S0_2$ recording for kpakungu was found to be 0.481ppm, 0.114ppm and 0122ppm across the period. These values are higher than the FEPA standard. In a likely manner, $S0_2$ reading for the control point (GRA) was found to be 0.058ppm, 0.045ppm and 0.035ppm across the periods of the day which is below the threshold by FEPA. The variation in the measurement of SO_2 can be attributed to leaded fuel in Vehicles (Gorham, 2002).

5. Conclusion

The end result of this study showed that relationship exists between the volume of traffic and vehicular emission where the calculated coefficient of correlation (r) 0.266 was found to be higher than the critical r value of 0.088. Furthermore, significant difference was also found in the concentration of the pollutants measured between the urban area and the control point. The comparison of the pollutants across the points also showed that CO has the highest concentration in the study area with mean emission value 14.50ppm as compared to other pollutants ($S0_2$ = 0.357ppm and $N0_2$ = 0.452ppm.) Majority of the emission measured also exceeded the National regulatory limits. Which are CO (10-20ppm), NO_2 (0.04.66ppm), and SO_2 (0.01-0.1 ppm)

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