Vehicular Carbon Emissions Concentration Level in Minna, Nigeria: The Environmental Cum Climate Change Implication

African Technology Policy Studies Network

WORKING PAPER SERIES | No. 71

Vehicular Carbon Emissions Concentration Level in Minna, Nigeria: The Environmental Cum Climate Change Implication

Okelola Olumayokun Francis
Geography Department,
Federal University of Technology, Minna, Niger state, Nigeria.

Appollonia Okhimamhe
Climatology and Remote Sensing
Federal University of Technology, Minna, Niger state, Nigeria

This paper should be cited as:

African Technology Policy Studies Network, ATPS 2013: *Vehicular Carbon Emissions Concentration Level in Minna, Nigeria the Environmental Cum Climate Change Implication* [Okelola Olumayokun Francis, Okhimamhe Apollonia], ATPS WORKING PAPER No. 71

The African Technology Policy Studies Network (ATPS) is a multi-disciplinary network of researchers, private sector actors and policy makers promoting the generation, dissemination, use and mastery of science, technology and innovation (ST&I) for African development, environmental sustainability and global inclusion. ATPS intends to achieve its mandate through research, capacity building and training, science communication/dissemination and sensitization, participatory multi-stakeholder dialogue, knowledge brokerage, and policy advocacy.

Published by the African Technology Policy Studies Network
P O Box 10081, 00100 GPO Nairobi Kenya

ISBN: 978-9966-030-58-0

Table of Contents

Acknowledgement

This report was produced as part of the implementation of the African Technology Policy Studies Network (ATPS) Phase VI Strategic Plan, 2008 – 2012 funded by ATPS Donors including theMinisterie van Buitenlandse Zaken (DGIS) the Netherlands and the Rockefeller Foundation. The authors hereby thank the ATPS for the financial and technical support during the implementation of the program. The Authors specially thank Prof. Kevin Chika Urama, the ATPS Executive Director for his visionary leadership as Program Director; Prof. Atieno Ndede-Amadi, Program Coordinator; Dr. Nicholas Ozor, Senior Research Officer, ATPS; Mr. Ernest Nti Acheampong, ATPS Research Officer and the ATPS Team for the technical support during the research process.

Abstract

This paper examines the trend of level of vehicular carbon footprints emissions in Minna, Niger State, Nigeria. It provides an insight into the obtainable emission levels in the selected flashpoints for the study. These flashpoints are spread across the city of Minna’s road network. The measurements were achieved using gasman meters for each type of gas investigated in this study namely: carbon dioxide (CO_2), carbon monoxide (CO), sulphur dioxide (SO_2), ammonia (NH_3), nitrogen dioxide (NO_2), chlorine (Cl_2) and hydrogen sulphide (H_2S). The measurements were carried out at the peak and off peak traffic times within the city due to temporal variations. The average emission values for the peak and off-peak times were calculated and also represented with the Arc-GIS software. The complete data have also been computed and analysed using the SPSS software. The results established that emissions’ level of carbon dioxide from vehicular emissions in particular exceeded the internationally accepted safe limits of 350 parts per million in the atmosphere. Upon the completion of this research, necessary measures for climate change mitigation via emissions reduction would be documented for effective and efficient urban and regional planning.

1. Introduction

Vehicular pollution is defined as pollution caused by vehicles which comprises of exhaust (pollution) released into the air (environment) from a vehicle (car, truck, bus). The large minority of today's cars and heavy duty vehicles use internal combustion engines that burn petrol or other fossil fuels such as diesel. The process of burning petrol to power cars and heavy duty vehicles contributes to air pollution by releasing a variety of emissions into the atmosphere.

Vehicular emissions constitute a threat, both to the environment and global health in terms of climate change and air pollution respectively. According to the United Nations Environment Program (UNEP), over 600 million people are exposed annually to vehicular pollutants (Cacciola et al; 2002, UN, 1989). Pollutants released into the atmosphere from vehicles include carbon dioxide (CO_2), carbon monoxide (CO), sulphur oxides (SOx), nitrogen oxides (NOx), particulate matter (particles of smoke, soot, and dust), hydrocarbons and lead (Corbitt, 1999). (National Research Council, 2010) published that carbon emissions from vehicles are a major source of atmospheric greenhouse gases (GHGs). In addition, the average emission per vehicle differs from one automobile to another as seen from Figure 1 is that emissions' rate of vehicles is proportional to the size of the vehicle type. The rate of emissions of (CO_2)

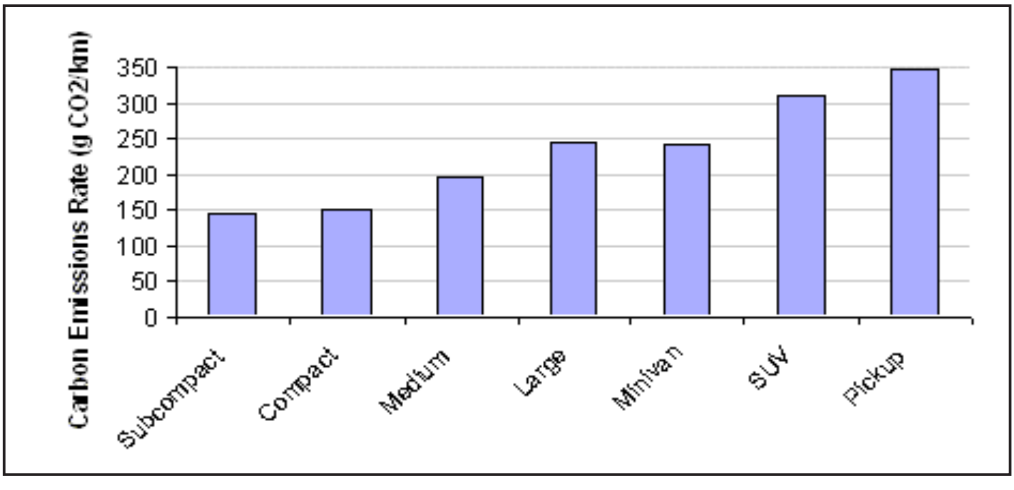

Figure 1: Average CO_2 Emissions Rates by Vehicle Type
(Source: World Resource Institute 2003)

Climate change is considered to be one of the greatest environmental threats and development challenges facing the world today. When petrol, diesel or certain alternative fuels are burnt for energy in an engine, the main by-products are water and carbon dioxide (CO_2). CO_2, although not directly harmful to human health, is the most significant of the greenhouse gases (GHGs) contributing to climate change. The actions of individuals, companies and nations as a whole, are all generating carbon emissions, which are unequivocally linked to the climate change phenomenon the planet is facing. In the USA alone, driven vehicles release over 1.7 billion tonnes of CO_2 into the atmosphere each year, contributing to global climate change (Walker, 2012). The nature of the air pollution problem relating to vehicles is dictated not just by the volume of traffic but, also by the prevailing weather conditions (Holman, 1999).

The USA is among the highly industrialized countries of the world with the highest vehicle ownership per capita in the world with 769 vehicles in operation per 1000 people. The USA therefore, has one of the highest levels of carbon dioxide emission from vehicles. Increase in vehicles therefore results in more carbon dioxide emissions, hence more global warming or climate change impacts. Although, more emission takes places in regions of industrialized and richer countries of the world, the climate change impacts are felt globally. Unfortunately, poor countries with minimal emissions have been observed to be more vulnerable to losses from the climate change impacts of the emissions that did not emanate from these poor countries. Carbon dioxide emission impacts on the climate of the environment are therefore not restricted to where it is being emitted but the effect is global (U.S. Global Change Research Program, 2005). However, other associated gasses with vehicular emissions as being investigated in this study have negative impacts such as pollution and human health hazards. In high concentration, CO_2 causes an increase in the breathing rate, unconsciousness, and even death in man (EHC, 2003).

1.2 Carbon Dioxide (CO2) and the Vehicular Carbon Footprints Concept

The term "carbon footprint" refers to the amount of carbon (CO_2) emitted as result of activities. Carbon dioxide, CO_2 is produced from many sources and it is the primary gas responsible for global warming and the resulting alarming changes in our climate. Nearly everything we do in our modern society requires energy. This energy is generated primarily by burning fossil fuels carbon.

In the context of vehicular carbon footprints refer to various amounts of the concentration level of emissions of vehicular emissions. These emissions are the end product of combustion of fossil fuel (Carbon) in vehicles. They constitute exhaust gases detected and sampled from Minna roads in Nigeria. The gases of interest in this study are mostly vehicular emissions associated with greenhouse gases the raw form of the energy usage from fossil fuels is in the form of carbon. The footprints are the end impact as evidently detected and measured in parts per million. The first step to taking effective action is to reduce the carbon footprint on the planet. Hydrocarbons and nitrogen dioxide emitted principally from automobiles are the major ingredients of photochemical smog (Enemari, 2001). This phenomenon has become noticeable at very busy junctions in Minna during peak traffic hours which are usually between (8 to 10) a.m and (4 to 6) p.m daily.

1.3 The 350 Parts per Million Safe Limits target

There is now scientific evidence that, carbon dioxide (CO_2) concentrations in the atmosphere increased from approximately 280 parts per million (ppm) in pre-industrial times to 382 ppm in 2006, a 36 percent increase. According to the National Oceanic and Atmospheric Administration's (NOAA) Earth Systems Research Laboratory, almost all of the increase is due to human activities (IPCC, 2007). The current rate of increase in CO_2 concentrations is about 1.9 ppm volume per year. Present CO_2 concentrations are higher than any time in at least the last 650,000 years (IPCC, 2007). Figure 2 shows the history of atmospheric carbon dioxide concentrations as directly measured at Mauna Loa, Hawaii. This curve is known as the Keeling curve, and is an essential piece of evidence of the man-made increases in greenhouse gases that is believed to be the cause of global warming.

Hansen et al (2006) noted that, 350 parts per million is the safe upper limit of carbon dioxide in the atmosphere, above which the planet is in a state of climate crisis. To preserve our planet, scientists tell us we must reduce the amount of CO_2 in the atmosphere from its current level of 392 parts per million to below 350 ppm. The target posed by leading NASA climate scientist James Hansen of stabilizing atmospheric carbon dioxide at 350 parts per million (ppm) is increasingly understood in conjunction with the need to keep cumulative emissions within a tight global "budget". From a CO_2 concentration at the time of 385 ppm, Hansen argued, the level needed to be cut to 350 ppm at most.

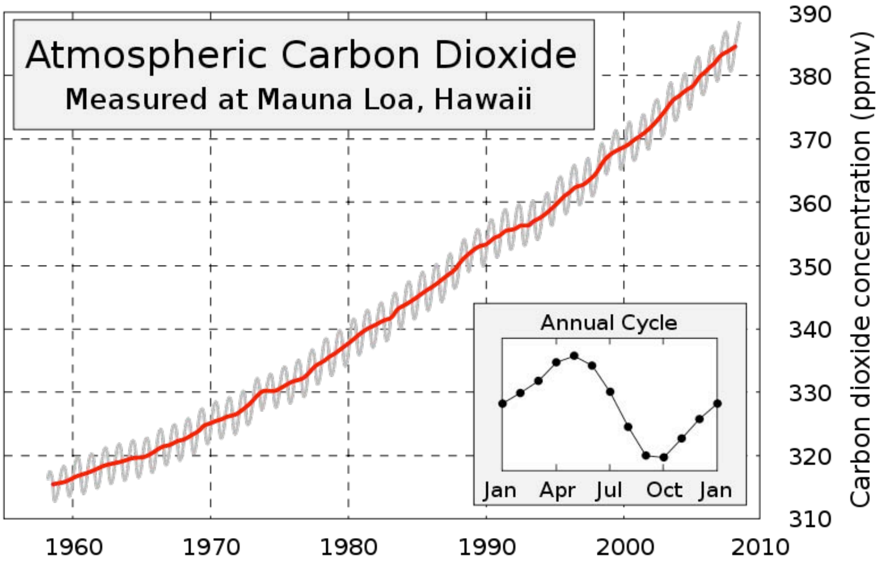

Figure 2 Atmospheric Carbon dioxide measured at Mauna Loa, Hawaii (Source: 350.org, 2011)

Table 1 lists the vehicular emission constituent gases investigated in this study and their internationally acceptable safe limits above which exposures to them become toxic to man and needed to reduce global warming in the case of carbon dioxide.

Table 1: Surveyed Gases and their internationally accepted safe limits

Gases	Safe Limits
NH_3	50 ppm
CO	50 ppm
SO_2	5 ppm
NO_2	5 ppm
CO_2	350 ppm
H_2S	10 ppm
Cl_2	0.08 ppm

1.4 Problem statement

Presently, not much is known about the climate change implications of vehicular emissions from the road transportation system of Minna, the capital of Niger State, Nigeria especially the levels of deviation of the carbon dioxide from the internationally accepted safe limit of 350 parts per million. Also, not much is known about the emission level of other constituent gases of vehicular emission from the road transportation system in Minna. Whereas, constituent gases of vehicular emission poses grievous health risk at certain high dangerous concentration levels of exposure to them. Cumulative exposure of humans to them at lower concentration levels can also pose grievous health risk. These constituent gases include: carbon monoxide (CO), sulphur dioxide (SO_2), ammonia (NH_3), nitrogen dioxide (NO_2), chlorine (Cl_2), hydrogen sulphide (H_2S) and carbon dioxide (CO_2), include. Much more, beyond the health risk that exposure to carbon dioxide may cause, carbon dioxide emission as a principal green house gas is critical to the global climate change effect and this need to be properly studied.

1.5 Objectives

The principal research objectives of the study are to:

1. Assess the level of carbon dioxide and other green house gases carbon footprint equivalents concentrations emanating from vehicles emissions in the transport sector of Minna.
2. Provide data on air pollution and use the research result to create public enlightenment together with the government on the hazards of vehicular emissions, particularly Carbon dioxide and other greenhouse gases Carbon footprints equivalent values in Minna, the state capital of Niger State.
3. Provide useful information for both transportation and urban planning development.
4. Propose pertinent STI policy recommendations for the mitigation of vehicular emission in Minna towards a sustainable environment

2. Literature Review

2.1 Trends in Vehicular Carbon Emission Concentration in Nigeria
Given the fact that, there are more vehicles in Nigeria today, in comparison to the past, it would be safe to deduce that the trend in vehicular emissions in the country seem to be on the increase. The following factors may be used in justifying this observation:

2.2 Steady Increase in the Use of Road Transportation
The mode of transportation in Nigeria is largely by road and air, with water transport in the coastal areas. The fleet of road vehicles has steadily increased since independence in 1960. A study by Balogun and Federal Road Safety Commission (FRSC) (2008) indicates that from 1988 to 2008, all fleets of licensed vehicles increased from 580,997 to 944,619 (See Figure 3).

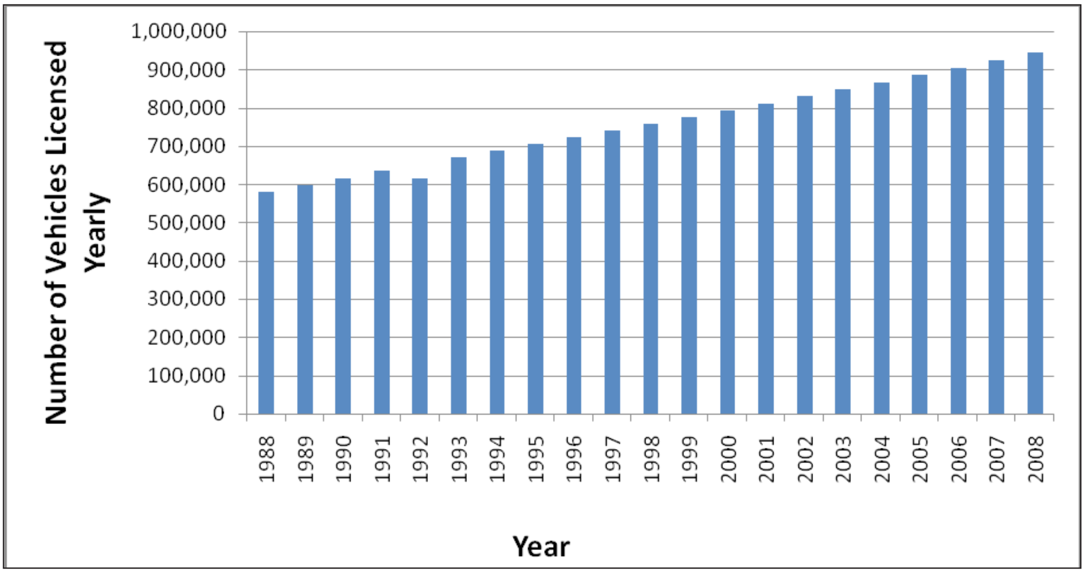

Figure 3: Vehicle Registration in Nigeria: 1988-2008 Source: Balogun and FRSC (2008)

The road transport induced environmental pollution in Niger State, is further compounded by recent influx of motorcycles and tricycles, most of which have 2-stroke highly polluting engines. The effect of all these is increased emissions particularly with the prevalence of second-hand vehicles as old as 20 years being imported to this country. With the pegging of the age of second-hand vehicle to 5 years for importation, to this country, we could have a sizeable reduction of emission. However, the enforcement and compliance with this law is weak as obtainable in other related sectors in Nigeria.

Table 2 Vehicle Registration in Niger State: 2004-2007

Type of Vehicle	2004	2005	2006	2007	Total
Saloon cars	1,868	2,210	2,340	2,600	9,018
Buses	1,468	1,746	1,987	1,727	6,928
Lorry/Trailers	214	302	337	520	1,373
Other Vehicles	-	-	-	-	
Motorcycle	2,126	2,472	2,556	3,216	10,370
Total	5,676	6,730	7,220	8,063	27,689

(Source: National Bureau of Statistics 2009).

2.2.1 Poor Maintenance Culture of Vehicles and its Effect on Emission

Maintenance is crucial to efficient vehicle performance. A well-tuned vehicle is fuel-efficient and generates minimal emission (Enemari, 2001). But a sizeable number of the mechanics we have are poorly trained. They are largely ignorant of what needs to be done. Also, many drivers exhibit poor driving habits such as over speeding. The result is that, most vehicles are performing below manufacturer's technical standard, consuming excessive fuel and emitting excessive gases and particulate matter.

2.3 Recent Studies on Vehicular Emissions in Nigeria

Minna

A study conducted by Ndoke and Jimoh (2007) in Minna - which coincides with our study area - to identify the effect of traffic emission on the city on an average day 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 or used vehicles (with highly-inefficient combustion engines) and the ubiquitous nature of commercial motor-cycles ("okada"). Furthermore, their study objectives did not include the implications of CO_2 emission level on global warming.

Kaduna and Abuja

Ndoke et al (2006) in a study carried out in Kaduna and Abuja found that districts with heavy traffic congestion reveal a higher concentration of CO_2 .The authors noted that there was remarkable evidence linking higher atmospheric carbon concentrations to more traffic congested regions like A.Y.A. junction and Mabushi round about in Abuja and also, Stadium round about, Sabo and Kasuwa which are in Kaduna (Figure 4).

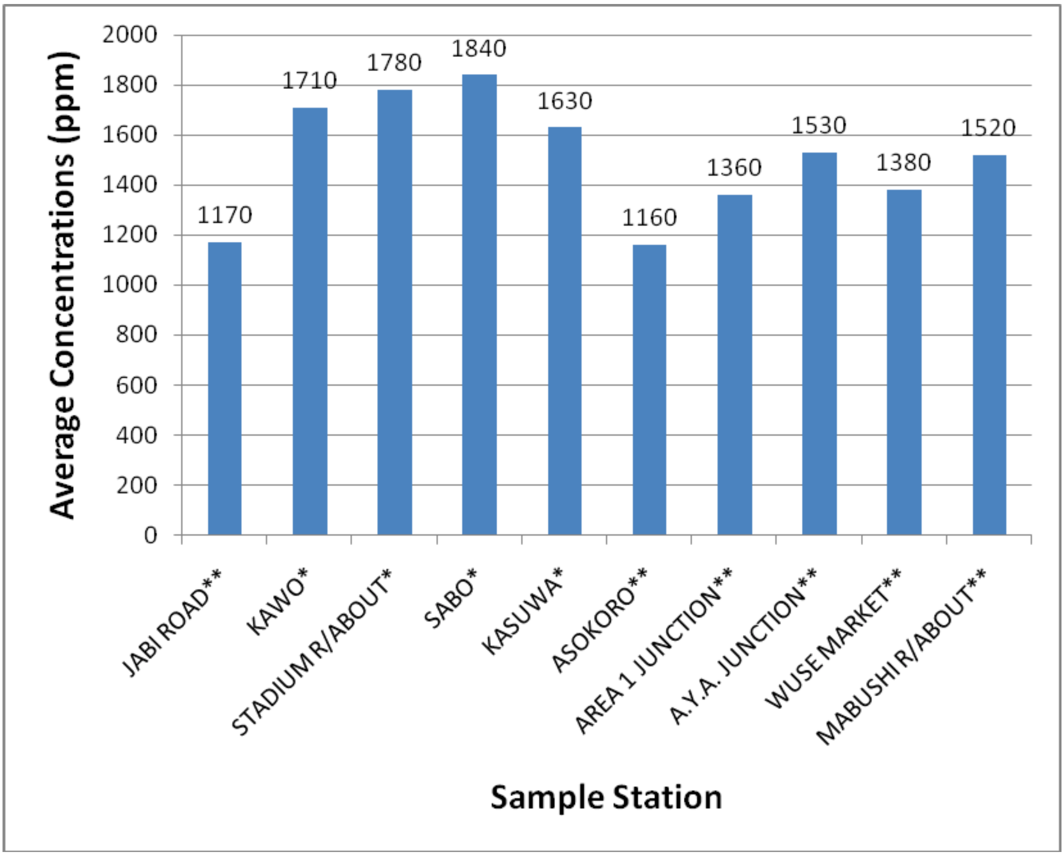

Figure 4: Average Hourly Concentration of CO_2 in Ten Stations in Abuja and Kaduna
Note: * Sampling stations in Kaduna; **Sampling stations in Abuja
Source: Ndoke et al (2006).

The threat of climate change has increased interest in climate research, which focuses on observing, understanding and modelling the five interconnected components that comprises the climate system: atmosphere, oceans, land surface, cryosphere, and biosphere. Feedbacks at variety of spatial and temporal scales shape the system's overall behavior, and the carbon cycle plays a critical role in this respect.

2.4 Climate change assessment of Minna

Buba (2009) studied the variations in rainfall and temperature patterns in Minna and the North using 1916 to 2000 and 1941 to 2000 data sets. These data sets enabled the researcher to observe successive climatologically 'normal' periods in accordance with the World Meteorological Organization (WMO) standard period of 1961-1990. Descriptive statistics of the long-term mean monthly values of minimum temperature, maximum temperature, mean temperature and rainfall as well as annual mean temperature and rainfall were therefore computed for Minna. Subsequently, the standard deviation (a measure of dispersion) and coefficient of variation (measure of variability) were computed of mean temperature and rainfall for each year enabling temperature and rainfall anomalies to be expressed as departure from the long-term mean. Correlation coefficients were also calculated to determine the existence of relationships between years and the two climatic elements considered by the investigation. Inter-annual rainfall was analyzed based on standardized annual rainfall time series for each year and downward trends were observed. The 1940s to 1960s are characterized by negative anomalies (i.e. decrease in rainfall). Buba (2009) also found that the 1980s are marked by positive anomalies (i.e. increase in rainfall) across the entire region including Minna. Further, the last decade (1990s) has been marked by significant positive anomalies. The temperature anomalies are measures that describe temperature behaviour as being normal, above or below normal. Mean annual temperature anomaly time series reveals a shift in trend; the temperatures show an increase (significant at the 95% confidence level). Generally, climatic warming seemed to have begun in the 1970s within the region. This downward trend is in agreement with the findings of other researchers' findings (Folland et al., 1986; Fontaine et al., 1995). They are, however, characterized by irregular variations in both time and space. The downward trends were observed to have started from the 1970s which is also consistent with earlier findings (Tarhule and Woo, 1998; Nicholson, 2001).

Furthermore, Wang and Eltahir (2002) used models to predict increases in rainfall as CO_2 levels rise. They found that, an increase of CO_2 concentration causes the regional biosphere-atmosphere system to become wetter and greener, with the irradiative effect of CO2 and improved plant water relation dominant in the Sahelian grassland region and the direct enhancement of leaf carbon assimilation dominant in the tree covered region to the south. However, recent research conducted by Held et al (2005), using new global climate model, both simulates the 20th century drought years and predicts a significantly drier Sahel guinea savannah where Minna is located by the end of the 21st century, due primarily to greenhouse gases. Nonetheless, similar studies in Minna have not examined the emissions of automobiles in relation to the global warming sensitivity safe limits of the emissions especially for carbon dioxide, the major greenhouse gas and a major effluent from vehicular emissions from road transportation in Minna. Thus, this is a major gap being filled by this study.

3. Methodology

The procedures adopted are as follows:

1. Sampling site selections within Minna metropolis for readings in Parts per Million of vehicular carbon footprints emissions with temporal considerations such as the peak and off-peak periods of vehicular transportation movement and with the level of emissions. Average traffic counts and the road map network of Minna were considered in doing this component of the study.
2. Using hand held Global Positioning System (GPS) to obtain the spatial attributes (Longitudes and Latitudes) of the selected sites, and measuring the amount of the vehicular carbon footprints in the sites with temporal consideration.
3. Digitizing the topographic map of Minna and overlaying it on a satellite image of the city.
4. Developing a database of the selected sites containing both spatial and attribute data as it relates to the rate of vehicular carbon footprints emission.
5. Carrying out statistical tests on the temporal vehicular carbon footprints emission to determine the carbonated compound with greatest effect as it relates to environmental pollution as well as contributing to climate change. Statistical correlation determines the relationship existing between variables. For perfect correlation between variables, the R value should be 1. This means all values for the relationship between variables tends to 1. The closer the correlation coefficients to 1, the stronger the relationship between the variables. Negative correlation coefficient means the variables are not correlated i.e. there is no relationship. Statistical Package for Social Sciences (SPSS) software was used to compute the correlation between the traffic volume and the measured gaseous emission values using Pearson Correlation 2- tailed test at 0.01 significant levels

4. Results and Analysis

The peak emissions measurements at various junctions (sampling stations) from the preliminary field work data are shows in Table 3.

Table 3: Average mean peaks vehicular carbon footprints gases concentration levels measured in parts per Million (PPM) during the peak traffic period

EASTINGS	NORTHINGS	LOCATIONS	CO	H_2S	NO_2	CL_2	SO_2	NH_3	CO_2
230769	1064155	Central Mosque Junction	8.83	0.00248	0.00258	0.167	0.00632	2.50	2823.33
229285	1063800	Engr. A.A Modern Market Gate	8.00	0.00275	0.00313	0.167	0.00315	2.67	2578.33
229272	1061852	Kpakungu Roundabout	10.00	0.00237	0.00312	0.167	0.00295	2.83	2916.67
231941	1064497	Kuta Garage	10.67	0.00283	0.00350	0.200	0.00295	2.83	2870.00
231856	1062525	Broadcasting Road Junction	13.17	0.00280	0.00340	0.167	0.00298	2.83	3111.67
233139	1065550	Maitumbi Junction	3.17	0.00205	0.00245	0.027	0.00257	2.00	2453.33
222745	1071602	Maikunkele motor garage	11.17	0.00293	0.00350	0.167	0.00315	2.83	2661.67

The database of the preliminary selected locations developed in ArcGIS9.2 software is shown in Figure 3. This software provides a platform for an interaction between the attribute data of the gases and their spatial relationship.

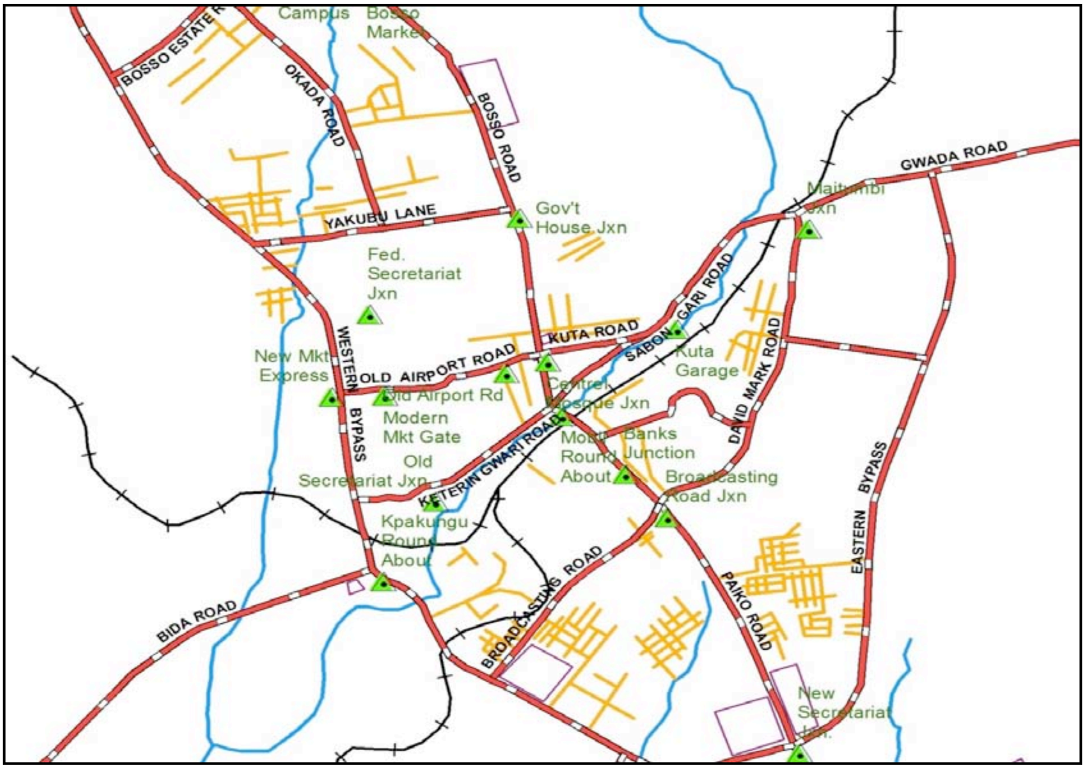

Figure 3: Showing the Attribute Data of the Gases and their Spatial Relationship
Source: Authors, 2011

The database of the preliminary selected locations developed in ArcGIS9.2 software is shown in Figure 3. This software provides a platform for an interaction between the attribute data of the gases and their spatial relationship.

Correlation of the vehicular gases was measured with the traffic volume at the sample stations in the study in order of their decreasing correlation is presented in Table 4 below. From Table 4 the "r" value shows the correlation of each of the gas types sampled versus traffic volume. It can be seen that carbon monoxide with "r" value of 0.849 has the highest correlation with traffic volume. This implies that, the concentration of carbon monoxide is the highest at the flash points where the study was carried out on Minna roads. This was closely followed by carbon dioxide with an "r" value of 0.756. Of all the values calculated, the least correlation was obtained for sulphur dioxide.

Table 4: R-values of Vehicular Emissions in Minna

Vehicular Emission type	R value
Carbon Monoxide (CO)	0.849
Carbon Dioxide (CO_2)	0.756
Hydrogen Sulphide (H_2S)	0.752
Nitrous Oxide (NO_2)	0.731
Chlorine (Cl_2)	0.701
Ammonia (NH_3)	0.541
Sulphur dioxide (SO_2)	0.321

(Source: Authors 2011)

The results obtained show that there are variations in the emission values during the peak and off peak period of traffic across the flash points in the study. The calculated Analysis of Variance (ANOVA) for the peak and off-peak of each gas is significant at 0.005 for the F distribution.

5. Conclusion and Recommendations

This preliminary study has established the presence and emissions levels of carbon dioxide as the major greenhouse gas and other gases arising from the road transportation in Minna. Of great concern is the measured emission level of carbon dioxide which was found to be higher than 350ppm. This implies that although Minna not being an industrialised city is contributing to global anthropogenic carbon dioxide emission through road transportation. Apart from the apparent health effects of other constituent gases of vehicular emission, the carbon dioxide global warming direct impact on Minna could not be determined as this takes place higher up in the atmosphere. The emissions levels of all the gases surveyed were discovered to be below the international toxic levels of exposure to human health. However, it is worthy to mention that cumulative exposure will have health effects on the vulnerable residents in Minna. It is hoped that the complete objectives of the study would have been achieved upon the completion of the research.

In the light of the foregoing, the following recommendations are made:

- Introduction of the urban mass transit would definitely reduce the intensity of traffic on the roads, hence the emissions from the number of vehicles that would have been on the road. This would also be a cheaper means of transportation for the masses.
- Encouraging the production of vehicles using alternative sources of energy like electric and biofuel in commercial quantities as these will result in lower emission of GHGs.
- Research program should be initiated providing alternative sources of fuels for road transport.
- Urban afforestation should be promoted by tree planting especially along transport corridors. This should be put in place by the government to help salvage the environment by absorbing CO2 being emitted from vehicles on the roads.

References

Buba, L. F. (2011). Evidence of Climate change in northern Nigeria using temperature and rainfall patterns. Unpublished doctoral dissertation, Department of Geography, Bayero University, Kano.

Cacciola, R.R., Sarva, M., & Polosa, R. (2002). Adverse respiratory effects and allergic susceptibility in relation to particulate air pollution: flirting with disaster. Allergy 57, 281–286.
Corbitt, R. A. (1999). Standard Handbook of Environmental Engineering. 2nd Ed. New York: McGraw-Hill.

Enemari, J.J. (2001). Vehicular Emission, Environmental and Health Implications. Federal Ministry of Environment at the Conference on Phase-Out of Leaded Gasoline In Nigeria at Nicon Hilton Hotel, Abuja 15th - 16th November 2001. http:// www.airimpacts.org/documents/local/articles-36225_pdf (Accessed on June 5, 2011).

Environmental Health Centre (EHC). (2003). Air Pollution Fact Sheet (For New Drivers), Washington. Environmental Health Centre http://www.nsc.org/ehc/mobile/airpollu.htm (Accessed on December 2, 2010).

Folland, C. K., Palmer, T. N & Parker, D. E. (1986), Sahel rainfall and worldwide sea temperatures, 1901–85, Nature International Journal of Science, volume: 320, issue 6063, pages 602 – 607.

Fontaine, B., Janicot, S., & Moron, V. (1995). Rainfall anomaly patterns and wind field signals over West Africa in August (1958–1989). Journal of Climate, 8, 1503–1510.

Hansen, J., Sato, M., Kharecha, P., Beerling, D., Berner, R., Masson-Delmotte, V., Pagani M., Raymo, M., Royer, D. L. & Zachos, J. C. (2008). "Target Atmospheric CO2: Where Should Humanity Aim?" The Open Atmospheric Science Journal. Volume 2, 217-231.

Held, I. M., Delworth, T. L., Lu, J., Findell, K. L. & Knutson T. R. (2005). Simulation of Sahel drought in the 20th and 21st centuries, Journal of National Academy of Science. For U. S. A., Volume 102, Pages 17,891 – 17,896.

Holman, C., (1999). Sources of Air Pollution, In: S. T., Holgate, H. S., Koren, J.M., Samet, & R L. Maynard, eds. (1999). Air Pollution and Health, London: Academic Press. Pp: 115-148.
IPCC. (2007). Climate Change 2007: The Physical Science Basis. In: S., Solomon, D. Qin,

M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor & H.L. Miller, eds. (2007). Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge. Cambridge University Press. http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg1_report_the_physical_science_basis.htm (Accessed on September 17, 2012).

National Bureau of Statistics (NBS), (2009). Annual Abstract of Statistics, Abuja. NBS.

National Research Council (NRC). (2010). Advancing the Science of Climate Change.

Washington DC: National Academies Press. http://www.scribd.com/doc/44923217/Advancing-the-Science-of-Climate-Change-Report-in-Brief (Accessed on June 20, 2011).

Ndoke, P. N. Akpan, U.G., and Kato, M. E. (2006), Contributions of Vehicular Traffic to Carbon Dioxide Emissions in Kaduna and Abuja, Northern Nigeria. Leonardo Electronic Journal of Practices and Technologies (online). http://lejpt.academicdirect.org/A09/081_090.htm (Accessed on August 15, 2012).

Ndoke, P.N. & Jimoh, O.D. (2007). Impact of Traffic Emission on Air Quality in a Developing City of Nigeria. Department of Civil engineering, Federal University of Technology, Minna, Niger State. http://www. enginpro.blogspot.com/2007/07/impact-of-traffic-emission-on-air.html (Accessed on July 4, 2012).

Nicholson, S. E. (2001). Climatic and environmental change in Africa during the last two centuries, Climate Research Journal, Vol. 17: 123–144.

United Nations (1989). Prospect of World Urbanization, (Population Study No. 112). New York: United Nations.

Tarhule, A. and Woo, M. (1998). Changes in rainfall characteristics in northern Nigeria. International Journal of Climatology, 18(11): 1261-1271.

U.S. Global Change Research Program (USGCRP). (2005). Our Changing planet: The U.S. Climate Change Science Program for Fiscal Year 2006. Washington D.C.: U.S. Global Change Research Program. http:// http://library.globalchange.gov/products/annualreports/our-changing-planet-the-u-s-climate-change-science-program-for-fy-2006-cd (Accessed on November 1, 2011).

Walker, M. (2012). Vehicle emissions and global warming. Celsias, (online) http://www.celsias.com/article/vehicle-emissions-and-global-warming/ (Accessed on December 19, 2011).

Wang, G. and Eltahir, E. A. (2002). Impact of CO2 concentration changes on the Biosphere-Atmosphere System of West Africa, Global Change Biology journal, Volume 8, Pages 1169-1182.

The African Technology Policy Studies Network (ATPS) is a multi-disciplinary network of researchers, private sector actors and policy makers promoting the generation, dissemination, use and mastery of science, technology and innovation (ST&I) for African development, environmental sustainability and global inclusion. ATPS intends to achieve its mandate through research, capacity building and training, science communication/dissemination and sensitization, participatory multi-stakeholder dialogue, knowledge brokerage, and policy advocacy.

African Technology Policy Studies Network
Contact the Executive Director at
The Chancery, 3rd Floor, Valley Rd.
P O Box 10081, 00100-Nairobi, Kenya
Tel: (254 020) 2714092, 2714168, 2714498, 2723800
Fax: (254 020) 2714028

http://www.atpsnet.org

Science, Technology and Innovation for African Development

ISBN: 978-9966-030-58-0