THOMAS ADEWUMI UNIVERSITY, OKO, KWARA STATE
Science | Technology | Medicine

Thomas Adewumi University
Journal of Innovation,
Science and Technology (TAU-JIST)

ISSN: 3043-503X

RESEARCH ARTICLE

EVALUATION OF WET SEASON GROUND LEVEL VEHICULAR AIR POLLUTION AND HEALTH INDEX OF MINNA METROPOLIS, NIGER STATE NIGERIA

Nwaerema P., Ijah, M. & Yusuf, A. M.

Department of Geography, Ibrahim Badamasi Babangida University, Niger State,

Department of Geography, Ibrahim Badamasi Babangida University, Lapai, Nigeria

Department of Geography, Ibrahim Badamasi Babangida University, Lapai, Nigeria.

Corresponding Author Email: pnwaerema486@gmail.comv

ARTICLE DETAILS

Article History:

Received 02 July 2024
Accepted 05 October 2024
Available online 10 November 2024

ABSTRACT

This study evaluated wet season ground level vehicular air pollution and health index of Minna metropolis, Niger State Nigeria. The study employed the use of Testo 350XL Gas Analyzer for NOx and CO. It also used air quality instrument of 5 in 1 multi-function laser sensor BRV8 detector for PM_{10} and $PM_{2.5}$. The generated data from the field were transformed into the air quality index values. Thus, Geographic Positioning System (GPS) instrument was utilized to identify the positions of the sampled junctions and roundabouts. Findings showed that $PM_{2.5}$ in Minna metropolis had average concentration level of 130.85µg/m^3, PM_{10} had average concentration of 165.15µg/m^3, NO_x had average concentration level of 0.49mg/m^3 exceeding the World Health Organization (WHO) recommended standard. However, CO_x in Minna metropolis had concentration level less than 30mg/m^3. Thus, 167,648 of the population inhaled quality air and 328,352 persons were exposed to unhealthy air quality. The junctions and roundabouts at the fringes of Minna metropolis had good air quality compared to those in the inner city area. It is recommended that a good air quality management framework should be developed and implemented by considering effective monitoring and evaluation of the sources of air pollution and the practice of effective tree planting as well as general urban greening in order to achieve a sustainable Minna metropolis in Nigeria

KEYWORDS

Evaluation, Ground Level, Health Index, Pollution, Vehicle, Wet Season

Quick Response Code	Access this article online	
	Website: https://journals.tau.edu.ng/index.php/tau-jist	**DOI:** https://doi.org/10.5281/zenodo.14197771

Introduction

Air pollution is a critical public health challenge facing mankind in the 21st century due rise in industrialization, overpopulation and urbanization. Reports of the World Health Organization (WHO) has indicated that worldwide air pollution has caused the death of over 4.2 million premature people in each year since the beginning of 2019 because of the exposure of humans to Particulate Matter (PM) leading to cardiovascular, respiratory diseases and cancers. Also, it is estimated that 37% of pollution from outdoor engagement causes premature death as a consequent of ischemic heart disease and stroke. The range of 18% to 23% of deaths are the consequences of chronic obstructive pulmonary disease as well as acute lower respiratory infections, but 11% of the total deaths is resulting from cancer within the respiratory tract. This rate of deaths is very high in the low and middle income countries where 89% (4.2 million premature deaths) take place in this region of the world (World Health Organization [WHO], 2023).

Air pollution can be generated from both primary and secondary sources. Some of the primary air pollutants generated by man's activities are poisonous metals in the form of Chlorofluorocarbons (CFCs), toxic lead, Ammonia (NH3), mercury. Others are garbage smell, discharge from sewage and industrial practices, effluents from radioactive nuclear blasts, gaseous Sulphur Oxides (SOx), toxic Nitrogen Oxides (NOx), Carbon Oxide (CO), Volatile Organic Compounds (VOC), Particulate Matter (PM) and Persistent free radicals. Conversely, the secondary air pollutants are products of the primary effluents. It is usually from the secondary effluent of air pollution compounds of ozone (O_3) at ground level, outcome of NOx and VOCs, photochemical smog (Mahendra & Vaibhav, 2013; Nwaerema *et al.,* 2020).

Air pollution in the cities has been greatly contributed by influx of vehicles. Thus, there are over 1.2 billion vehicles in the world and World Health Organization (WHO) has estimated 16% rise in the production of vehicles between 2010 to 2030 globally (Green Car Report [GCR], 2014; World Health Organization [WHO], 2015). This suggests that there is expectant increase in vehicular pollution resulting from vehicular traffic. Vehicular air pollution has recorded this rise due to the fact that there is upsurge in human movement and congestion of vehicular traffic at junctions and roundabouts. Also, many urban areas are facing intense burning of domestic wastes such as abattoir and other petroleum effluents in the form of black carbon. The key sources of environmental pollution in the country are from vehicular discharge, power generators, industries, pollution from road construction and building for shelter (Obanya *et al.,* 2018).

The impact of vehicular air pollution in the cities has been contributed by the poor planning of roads and buildings. This has amounted to poor dispersal of pollutants along roadways and having greater effects on human health in the cities. Also, pollution from vehicles can be exacerbated by rise in the number of bad vehicles and their congestions at junctions and roundabouts especially when they are bottlenecked. Rise in pollution from vehicles can be increased by over throttling of the speed pedals when the automobile is in motion (Olivier, 2012). Other factors which could contribute to increased vehicular air pollution include bad roads, uncontrolled traffic, bad exhaust of vehicles, bad engine and others (Gary and Dieter, 2012). Therefore, this study evaluated wet season ground level vehicular air pollution and health index of Minna metropolis, Niger State Nigeria.

Materials and Method

This study carried out vehicular air pollution at junctions and roundabouts in Minna metropolis with the aim to examine the degree of pollutants at ground level concentration during the periods of peak human activities in the wet season. These junctions and roundabouts were purposively selected based on the level of vehicular traffic and anthropogenic activities taking place in the areas where they are located (Figure 1). Also, these roads were the busiest routes that had the highest traffic volumes and linking Minna town to other cities in the state. In Minna Metropolis, there was the use of power generators for energy consumption in both residential and industrial areas due to power epileptic that is common in most Nigerian cities. Instrument of the Geographic Position System (GPS) was adopted to ascertain the actual positions of the selected junctions and roundabouts for mapping purposes. The air pollutants that were instrumentally captured were Oxides of Nitrogen (NOx), Carbon Monoxide (CO), Particulate Matters PM_{10} and $PM_{2.5}$ by utilizing the air quality detectors. The employed instrument was the Testo 350XL Gas Analyzer that was able to capture and analyze NOx and CO and the use of digital hand-held air detector (5 in 1 multi-function sensor of BRV8) for measuring PM_{10} and $PM_{2.5}$ respectively. The instruments had natural diffusion accuracy of ≤± 5% with response time of 5 minutes. Thus, twenty (20) locations were sampled in June, 2024. The essence of selecting this period was because the objective is to examine vehicular air pollution during the wet season. The measurements were carried out in the morning and evening periods (6-9am and 5-8pm) due to the fact that these periods were the rush hours with higher vehicular traffic volumes. The measurements of the air pollutants were done *in situ* with the calibrated instruments. The generated air pollution raw data were worked with the air quality index equation by employing the formula:

$$IP = \frac{IHi-ILo}{BPHi-BPLo}(Cp-BPLo) + ILo \quad (1)$$

Where IP = the index for pollutant P
CP = the rounded concentration of pollutant P
BPHi = the breakpoint that is greater than or equal to CP
BPLo = the breakpoint that is less than or equal to CP
IHi = the AQI value corresponding to BPHi
ILo = the AQI value corresponding to BPLo

The vehicular air quality index results were corresponded with categories of air quality index and their meaning (Table 1).

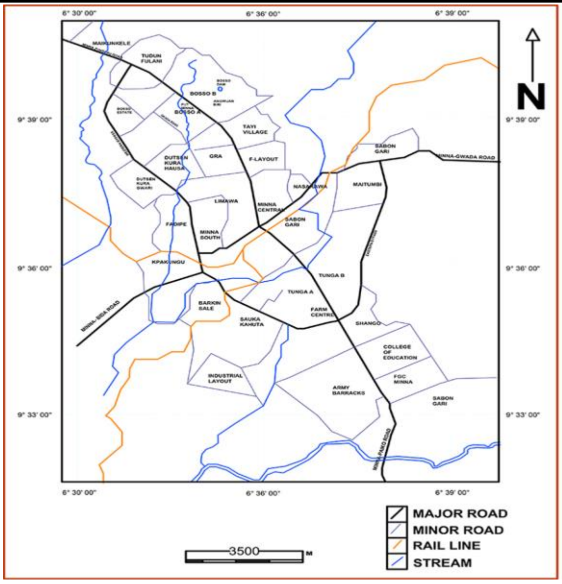

Figure 1: Minna Metropolis, Niger State, Nigeria

Table 1: Categories of Air Quality Index and their meaning

Air Quality Index (AQI) Values	Levels of Health Concern	Colors	Meaning
When the AQI is in this range:	...air quality conditions are:	...as symbolized by this color:	
0-50	Good	Green	Air quality is considered satisfactory and air pollution poses little or no risk.
51-100	Moderate	Yellow	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
101-150	Unhealthy for Sensitive Groups	Orange	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
151-200	Unhealthy	Red	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
201-300	Very Unhealthy	Purple	Health warnings of emergency conditions. The entire population is more likely to be affected.
301-500	Hazardous	Maroon	Health alert: everyone may experience more serious health effects.

Results and Discussion

The junctions and roundabouts with green colour indicate areas less than WHO recommended limit and those in red colour showed areas higher than the recommended WHO limit (Table 3). Generally, $PM_{2.5}$ in Minna metropolis had exceeded the recommended WHO limit of 75µg/m^3 having an average concentration level of 130.85µg/m^3. The PM_{10} had average concentration of 165.15µg/m^3 exceeding the WHO recommended limit of 150µg/m^3. Thus, NO_x had concentration level of 0.49mg/m^3 indicating that it was at the boundary of 0.5 mg/m^3 recommended limit by WHO. However, CO_x in Minna metropolis had concentration level less than 30mg/m^3. The junctions and roundabouts with highest vehicular air pollution were Metunbi Roundabout and Gbeganu Junction having high concentration of $PM_{2.5}$, PM_{10} and NO_x that were above the recommended dose. Other junctions and roundabouts with high vehicular air pollution were City Gate Roundabout, Tunga Market Junction, Bago Roundabout, Metunbi Roundabout and Gwurara Junction. The high concentration of $PM_{2.5}$ and PM_{10} were suspected to be caused by the ongoing road construction projects taking place across various roads in the city of Minna metropolis. The high concentration of NO_x in Minna is as a result of anthropogenic activities such as emission from vehicles due to combustion of engines, burning of wood, construction equipment, diesel generators, burning of waste, application of fertilizers and aviation activities. The high concentration of these pollutants could result to respiratory issues such as coughing, wheezing, shortness of breath, chest tightness, asthma, chronic bronchitis and emphysema. Furthermore, high pollutant concentration in the air can lead to reduced lung function, increased risk of cancer, neurological effects, adverse pregnancy outcome and increased mortality. This study revealed that $PM_{2.5}$, PM_{10} and NO_x had the highest pollution concentration in Minna metropolis. This is contrary to the result of Nwaerema *et al.* (2020) in a study that was carried out in Port Harcourt tropical littoral city which showed that Carbon Oxide (CO) at 32.7% contributed the greatest threat to life and $PM_{2.5}$ (15%) had the least harmful effect.

Table 3: Wet Season Vehicular Air Pollution across Junctions and Roundabouts in Minna Metropolis

Location	Northing Latitude	Easting Longitude	$PM_{2.5}$ (µg/m^3)	PM_{10} (µg/m^3)	NO_x (µg/m^3)	CO_x (µg/m^3)
Water Board Junction	9.536342	6.579512	40	52	0.61	2.29
City Gate Roundabout	9.582004	6.567922	208	272	0.16	3.36
Tunga Market Junction	9.602194	6.558329	170	223	0.26	3.42
Mobile Roundabout	9.614131	6.547550	110	143	0.77	2.82
Complex Roundabout	9.618971	6.546367	53	110	0.82	3.29
Bago Roundabout	9.639502	6.541682	402	515	0.45	2.31
Mypa Junction	9.651430	6.533453	82	107	0.33	3.33
Tudun Fulani Junction	9.665381	6.519300	47	61	0.28	2.38
Peda Junction	9.619931	6.553212	500	513	0.36	2.87
New Market Junction	9.622284	6.549150	30	39	0.98	3.44
Flamingo Junction	9.632011	6.567610	79	90	0.76	3.23
Metunbi Roundabout	9.636235	6.579301	155	200	0.55	2.29
String Roundabout	9.6178902	6.542492	30	39	0.79	3.39
Hoe/Fish Roundabout	9.616590	6.538483	30	38	0.25	2.48
Market Flyover Junction	9.615294	6.528452	30	39	0.65	3.56
AP (Book) Roundabout	9.605008	6.530148	30	39	0.29	3.19
Kpakungu Roundabout	9.598300	6.532443	45	75	0.34	2.84
Gbeganu Junction	9.594975	6.519843	500	600	0.88	3.87
Gwurara Junction	9.591928	6.515814	87	110	0.68	3.92
Gidankwanu Junction	9.537295	6.467692	29	38	0.21	2.44
Mean			130.85	165.15	0.49	3.04
WHO Interim Target 1			**$PM_{2.5}$ (75µg/m^3 for 24 Hr)**	PM_{10} (150µg /m^3 for 24Hr)	NO_x 0.5mg/m^3 **(1Hr)**	CO_x **30mg/ m^3 (1Hr)**
Colour Meaning			**Below WHO Limit**		**Above WHO Limit**	

Table 4 showed the wet season air quality health index of Minna metropolis. The junctions and roundabouts having maroon colour indicated that air quality in these areas were hazardous revealing significant aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly, significant increase in respiratory effects in general population. The junctions and roundabouts having the hazardous health effects were Bago Roundabout, Peda Junction and Gbeganu Junction respectively. The area with purple indicated health emergency which the entire population was more likely to be affected. The junctions and roundabout under the emergency zone having high concentration of $PM_{2.5}$ and NO_x were City Gate Roundabout, Tunga Market Junction, City Gate Roundabout, Tunga Market Junction, Metunbi Roundabout, String Roundabout, Market Flyover Junction, Gbeganu Junction and Gwurara Junction. The unhealthy junctions and roundabouts were coloured red indicating that every one may begin to experience health effects and members of the sensitive groups may begin to experience more serious health effects. Thus, the orange coloured junctions and roundabouts had high concentration of $PM_{2.5}$, PM_{10} and NO_x showing that it was unhealthy for sensitive groups. It indicated that members of the sensitive groups may experience health effect. The general public was not likely to be affected. The areas affected by the unhealthy for sensitive group were Water Board Junction, City Gate Roundabout, Tunga Market Junction, Complex Roundabout, Bago Roundabout, Mypa Junction, Tudun Fulani Junction, Peda Junction, Metunbi Roundabout, Hoe/Fish Roundabout, AP (Book) Roundabout, Kpakungu Roundabout and Gidankwanu Junction.

The areas with yellow coloure unveiled that moderate health condition but individuals with breathing or heart disease, those of the elderly as well as little children should not be recommended for outdoor. The areas with moderate air quality effects of $PM_{2.5}$ and PM_{10} were Mobile Roundabout, Complex Roundabout, New Market Junction, Flamingo Junction, String Roundabout, Hoe/Fish Roundabout, Market Flyover Junction, AP (Book) Roundabout, Kpakungu Roundabout, Gwurara Junction and Gidankwanu Junction. The green areas with low CO_x concentration showed that air quality was considered satisfactory and air condition posed little or no risk cut across all the junctions and roundabouts, indicating the CO_x pollution was minimal in Minna metropolis. The low concentration of CO_x pollution in Minna metropolis is contrary to the findings of Cartaxo (2018) who observed that pollution source of automobile donates 75% of the emitted carbon monoxide in urban areas. Also, the report of Francis *et al.* (2015) unveiled that in a city, the degree of pollution can be influenced by location, space and time as it was experienced in Imo State, Nigeria.

Air quality has effects on the population of Minna metropolis (Table 4 and Figure 2). With projected population of 496,000 in Minna metropolis, 167,648 (33.8%) of the people inhale good air quality and 80,848 (16.3%) inhale moderate air quality. The number of people under unhealthy for sensitive groups was 99,200 (20%) of the population, unhealthy 43,648 (8.8%) and very unhealthy 67,456 (13.6%). Thus, 37,200 (7.5%) of the population inhale hazardous air quality indicating significant aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly as well as significant increase in respiratory effects in the entire population. The general air quality index of Minna metropolis has revealed that people with respiratory or heart disease, the elderly and children are the groups most at risk. This finding is the same with that of Nwaerema *et al.* (2020) who investigated the behavior of air quality index of Port Harcourt, Nigeria. The result revealed that those with status of unhealthy and unsatisfactory category amounted to 2,951,655 people which was 91.2% expected to have different forms of respiratory symptoms. The group classified unhealthy air quality index were located within Aba Road, Mile One, Artillery, Garrison, Rumuola and Woji areas.

Table 4: Wet Season Air Quality Health Index of Minna Metropolis

Location	Northing Latitude	Easting Longitude	$PM_{2.5}$ (µg/m³)	PM_{10} (µg/m³)	NO_x (µg/m³)	CO_x (µg/m³)
Water Board Junction	9.536342	6.579512	111	47	193	25
City Gate Roundabout	9.582004	6.567922	258	159	111	37
Tunga Market Junction	9.602194	6.558329	220	132	131	25
Mobile Roundabout	9.614131	6.547550	179	94	220	31
Complex Roundabout	9.618971	6.546367	144	78	228	37
Bago Roundabout	9.639502	6.541682	434	410	165	37
Mypa Junction	9.651430	6.533453	164	76	144	37
Tudun Fulani Junction	9.665381	6.519300	129	53	134	26
Peda Junction	9.619931	6.553212	500	404	150	43
New Market Junction	9.622284	6.549150	88	35	255	38
Flamingo Junction	9.632011	6.567610	162	68	218	36
Metunbi Roundabout	9.636235	6.579301	205	123	183	25
String Roundabout	9.6178902	6.542492	88	35	223	38
Hoe/Fish Roundabout	9.616590	6.538483	88	35	129	40
Market Flyover Junction	9.615294	6.528452	88	35	200	40
AP (Book) Roundabout	9.605008	6.530148	88	35	136	35
Kpakungu Roundabout	9.598300	6.532443	124	60	146	32
Gbeganu Junction	9.594975	6.519843	500	495	238	43
Gwurara Junction	9.591928	6.515814	167	78	205	44
Gidankwanu Junction	9.537295	6.467692	86	35	121	27
Colours and Meaning	Good (33.8%)	Moderate (16.3%)	Unhealthy for Sensitive Groups (20%)	Unhealthy (8.8%)	Very Unhealthy (13.6%)	Hazardous (7.5%)
Population at Risk	167,648	80,848	99,200	43,648	67,456	37,200

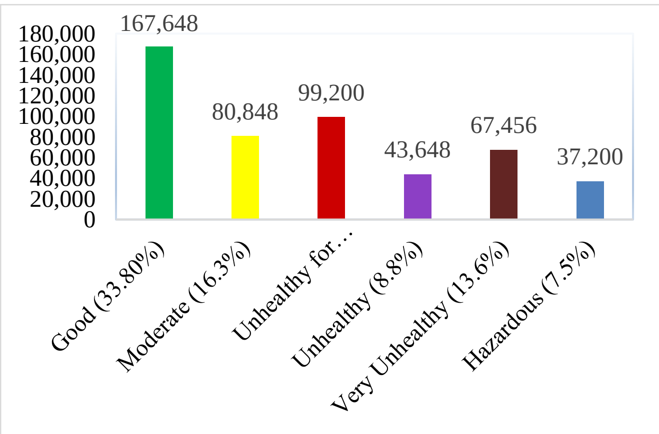

Figure 2: Effects of Air Quality Index on Population

Conclusion

Study of the evaluation of wet season ground level vehicular air pollution and health index of Minna metropolis, Niger State Nigeria has become a critical investigation in this era of high influx of vehicles into the city. The study has revealed that $PM_{2.5}$, PM_{10} and NO_x are the most common air pollutants causing serious health effects to the population. Thus, CO_x emission in the city has minimal effects on the city dwellers. Also, $PM_{2.5}$, PM_{10} have exceeded the WHO recommended pollution limit in Minna metropolis indicating the city dwellers are at high risk of respiratory problems. Thus, 167,648 of the population inhale quality air and 328,352 persons are exposed to unhealthy air quality. The junctions and roundabouts at the fringes of Minna metropolis have good air quality compared to those in the inner city area. The rise in air pollution in the city of Minna will continually lead to poor air quality, health risks and subtle death of the people. Granted, the ecosystem of flora and fauna species are undergoing unimaginable disaster due to pollution rise which has made survival very difficult. Therefore, this investigation has suggested the government should develop and execute the policy of tree planting, adequate monitoring and evaluation of sources of pollution as well as actual punishment to offenders using the Polluters Pay Principle (PPM) for a sustainable urban area.

References

Cartaxo, E., Ilsa, V., Vladimiro, M., & Marcia, C. (2018). Issuances of automotive vehicles and the impacts on air quality in the largest city in the Brazilian Amazon. Sustainability, 10(11), 12-25. https://doi.org/10.3390/su10114091

Francis, C. I., Alexander, I. O., Chidi, E. D., Isiuku, B. O., & Margaret, C. E. (2015). Statistical analysis of atmospheric pollutant concentrations in parts of Imo State, Southeastern Nigeria. Scientific Africa, 7, 1-217. https://doi.org/10.1016/j.sciaf.2015.07.001

Gary, H., & Dieter, S. (2012). Transport and environment in Sub-Saharan Africa. TEST network. http://www.afritest.net

Green Car Report. (2014). Billion by 2035 report. Green Car Report. Retrieved June 28, 2020, from https://www.greencarreports.com/news/1093560_1-2-billion-vehicles-on-worlds-roads-now-2-billion-by-2035-report

World Health Organization. (2015). Global Health Observatory (GHO) data. https://www.who.int/gho/road_safety/registered_vehicles/number/en/

Mahendra, P. C., & Vaibhav, G. (2013). Causes, consequences, and control of air pollution. In All India Seminar on Methodologies for Air Pollution Control (pp. 1-25). Malviya National Institute of Technology, Jaipur, Rajasthan, India.

Nwaerema, P., Jia, S. N., & Fred-Nwagwu, F. W. (2020). Characterization of air quality index of Port Harcourt tropical littoral city. International Journal of Health, Safety and Environment, 6(7), 627-637.

Obanya, H. E., Amaeze, N. H., Togunde, O., & Otitoloju, A. A. (2018). Air pollution monitoring around residential and transportation sector locations in Lagos mainland. Journal of Health and Pollution, 8, 1-9. https://doi.org/10.5696/2156-9614-8.19.180910

Olivier, B. (2012). Urban traffic calming and environmental noise: Effects and implications for practice. National Collaborating Centre for Healthy Public Policy. http://www.inspq.qc.ca/english

World Health Organization. (2023). Ambient (outdoor) air pollution. World Health Organization Fact Sheets. https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health