

Geographic Analysis of Traffic Congestion in FCT-Abuja, Nigeria

Paul Ojochenemi Abuh^{1*}, James Apeh John¹

¹Department of Geography and Environmental Sciences, Kogi State University, Anyigba, Kogi State Nigeria

*Corresponding author: abuh.po@ksu.edu.ng

Abstract: Traffic congestion is responsible for increased urban pollution in urban centers in developing countries. The condition of Abuja traffic congestion is no diverse. The study examines geographic analysis of traffic congestion in FCT-Abuja Nigeria. Efforts were made in this study to accomplish the objectives which are to map traffic congestion areas along selected corridors of Federal Capital Territory (FCT) Abuja using Geographical Information System (GIS) Techniques, Determine the major causes of traffic congestion in the study area and examine the solutions to traffic congestion in the study area. The study adopted random sampling techniques in the administration of well-structured 384 questionnaires to help achieve objective II and III. The data that was collected were analyzed using descriptive statistics. The descriptive analysis that was used includes means, percentage, standard deviation and structured Likert scale. The study revealed that the three major road corridors to the FCT are Abuja- keffi expressway Kubwa –Zuba express and Gwagwalada-Lokoja expressway. The study shows that too many taxis with mean score of 4.14 are the major cause of traffic congestion. While, maintenance of road is the major solution to traffic congestion in the study area with mean score of 4.19. This study recommends the provision of railway service and speedy completion of Apo-Karshi road.

Keywords: Abuja, Traffic congestion, Transportation, Urban, Urban pollution

Conflicts of interest: None

Supporting agencies: None

Received 20.10.2022; Revised 07.01.2023; Accepted 08.02.2023

Cite This Article: Abuh, P.O., & John, J.A. (2023). Geographic Analysis of Traffic Congestion in FCT-Abuja, Nigeria. *Journal of Sustainability and Environmental Management*, 2(1), 26-32.

1. Introduction

One of the major challenges faced by urban centers all over the world and particularly developing countries such as Nigeria is traffic congestion. This phenomenon is encouraged by in-migration taken place as a result of the desire for better standard of living. It has been observed that traffic congestion has been responsible for urban pollution. In fact emission of pollutants due to traffic congestion is seen as contributor to bad health situation experienced by citizens in urban centres. According to Odogun and Georgakis (2019), the major source of greenhouse gases (GHG) in urban setting is from the emissions from the vehicles. Consequently, emissions from vehicles accounts for high rate of morbidity and mortality. Odogun and Georgakis (2019) asserted that ambient air pollution is responsible for approximately 3.7 million premature deaths.

Matin, Herani, and Warraich, (2012) posits that traffic congestion would produce carbon dioxide (CO₂) and contribute to air pollution. According to Bigazzi and

Figliozi (2013), CO₂ has been classified as greenhouse gases (GHG) that comes from transportation sector where the emission is directly related to fossil fuel consumption, vehicles characteristics, travelling speed and road infrastructure.

It has been observed that Abuja being the capital city of Nigeria has attracted various calibers of people from different spheres of life in search of better life. Equally the location of Government ministries and other big private sector organizations and offices are located at the central business district (CBD) in the heart of the city. However the high cost of living in the city center has led to most migrant to reside or relocate to remote and satellite areas of the city. Interestingly, most migrant work at the city center and this has led to high inflow of vehicular movement during the early hours of the morning when they are going to their various offices thereby leading to high traffic and the same goes during the end of office activities at the end of the day with high outflow of traffic from the city center to this satellite areas.

Furthermore, the growth pattern of the population and vehicle registration of Abuja between the years of 2000

and 2010 and till date are rapidly in a swift rise rate. The implication of all these is an unexpected growth in the traffic levels which has led to overloading of some major sub-urban corridor such as Abuja – Keffi Expressway, Abuja-Gwagwalada-Lokoja Expressway, and Abuja-Kubwa-Kaduna Expressway. It can be established that there is a corresponding increase in the number of vehicles being registered to the rise in the population. Consequently, the impact of the increase vehicular movement is responsible for increase pollution of the environment. It is on this premise that the major corridor will be studied and attempt to understand the nature and extend of traffic congestion.

Several researchers have worked on traffic congestion. Maan, Rawand and Mohammed (2019), worked on Evaluating the Negative Impact of Traffic Congestion on Air Pollution at Signalized Intersection. The study considered traffic congestion as one of the largest contributors to the problem of air pollution currently. This is majorly due to emissions from vehicles. It is observed that intersections of road are responsible for high level of air pollution as a result slow down and stop situation. The study focused on estimating the negative impact of traffic congestion by calculating the quantities of gases emitted during the traffic congestion at the signaled intersection in Baghdad city. Data on traffic flow was obtained by video recording of the area under study. SIDRA 8.0 software (Signalized and Un-signalized Intersection Design and Research Aid) was used to analyze. Based on delay and LOS computation at the signalized intersection emissions of HC, CO, NOX and CO₂ were selected. Findings of the study were to provide solutions to transportation and public health officials to mitigate the risk of air pollutant by ecorouting and eco-signaling. Odogun, A., Georgakis, P. (2019), examines Transport Pollution: A Research of the Nigerian Transport Sector. The study posits that the growth in the road-based transport is connected to environmental problems. In fact the major source of environmental pollution is from emissions from automobiles. This is caused by inadequate transport infrastructure to support the growing vehicles plying the roads. The study recommends methods of reducing environmental problems as a result of automobile emission through introduction of various technologies, local traffic reduction measures and three – way catalyst.

Furthermore, Wan,Wahidah , Wan, Che, Atikah, and Zakiah (2019), examines the Effect of Traffic Congestion on Quality of Community Life. The study asserted that population growth has put pressure on transportation thereby increasing the number of vehicles on the road. This situation was responsible for traffic congestion in Seri Kembangan. The work attempts to determine the extent traffic congestion affected quality of community life due to daily routines and lifestyle. Site survey strategy was adopted for the study. A total of 382 respondents were administered questionnaire and the data were

statistically analyzed. Findings of the study indicate that traffic congestion is responsible for poor quality life. The study recommends that traffic planning and policy should be given attention in other to improve the quality of community life. Likewise, Raheem , Olawoore, Olagunju, Adeokun (2015), studied the Cause, Effect and Possible Solution to Traffic Congestion on Nigeria Road (A Case Study of Basorun-Akobo Road, Oyo State). The study emphasis that increases population allows for increase human activities which increases demand for transport space. The study used experimental and theoretical approaches in its analyses. Traffic counting and traffic delay survey method was adopted in the study. Findings of the study indicates that the effects of traffic congestion in the study area includes waste of time, inability to forecast travel time, environmental pollution, road rage, fuel consumption, accident and delay movement. The study recommends provision of adequate parking space, dualization of road network, construction of proper drainage and installation of traffic control devices as measures to control traffic congestion in the study area.

More so, Irunokhai , Onihunwa, Oni, Adigun and Dada (2020), worked on Analysis of Traffic Congestion on Nigerian Roads (A Case Study of Sango T Junction, Ibadan, Oyo State). The study asserted that population increase and urban-rural migration has led to high increase in traffic congestion. Direct observation, time count down of vehicles within traffic queue and traffic data was employed in the study. Mean plot, t-test and analysis of variances was used to analysis the data collected for the study. Findings of the study shows that peak period of traffic are in the morning. However, average waiting hour for the road users is in the evening. Also, the study indicates that traffic flow does not have much significant difference between its peak and off peak period. The study recommends proper planning of road infrastructure in other to reduce the impact of traffic congestion. Equally, Awosusi and Akindutire (2010), worked on Urban Traffic Congestion and Its Attendant Health Effects on Road Users in Ado-Ekiti, Nigeria. The study affirms that road users are faced with mental, physical and psycho social impact due to traffic congestion. The study indicates that traffic congestion is responsible for near-road pollutant exposure. Also, when cars are idle, fuel is still burnt and fuel emissions are released into the atmosphere. This situation is responsible for various health challenges. The study recommends concerted effort by all stakeholders for proper road network planning.

However, none of these studies mentioned looked at the Geographic Analysis of Traffic Congestion in FCT, Abuja Nigeria and how it relates to increase in air pollution. Therefore, this study attempts to fill the gap in knowledge.

2. Materials and methods

The study area lies between latitude 8°25' and 9°20' north of the equator and longitude 6°45' and 7°39' east of Greenwich Meridian, with an elevation of 360 meters (Britannica 2021). The territory is located north of the confluence of the Niger River and Benue River. It is bordered by the states of Niger to the West and North, Kaduna to the northeast, Nassarawa to the east and south and Kogi to the southwest. Abuja is geographically located in the center of the country. The Federal Capital Territory has a landmass of approximately 7,315 km², and it is situated within the Savannah region with moderate climatic conditions. The city is being categorized into six (6) area councils which include Amac, Abaji, Bwari, Kwali, Kuja and Gwagwalada.

According to the 2006 national population and housing conducted throughout the country, Abuja has a population of 2,591,000 persons (2006 population census). Using a population growth rate of 3.2 the population for Abuja is projected to be 4,026,932 in 2020. Abuja features a tropical wet and dry climate under the koppen's classification of climate, the FCT experiences three distinct weather condition annually (Babagana 2020). Generally, the territory consists of soils that are sandy and shallow in nature. This can be seen in the major plains such as IkuGurara, Rubochi, and Roboes (Etu-Efeotor, 1998). The vegetation type found in the FCT falls within the guinea savanna vegetation zone of Nigeria (Anononkaa, 2012). The FCT is characterized by a predominantly underlain high grade metamorphic and igneous rock of Precambrian origin (Mamman and Oyebanji, 2000). The highest elevation in territory where are many peaks is over 760m above sea level which are found in the northeast. As the capital of Nigeria various land use are carried out in the FCT which includes; residential land use, industrial land use, institutional land use, administrative land use, commercial land use and agricultural land use which varies from one locality to another (Balogun, 2019).

This study utilized a cross-sectional research method in order to achieve accurate data. Random sampling technique was used to administer the questionnaire to the respondents in the study area. The questionnaires was administered at strategic location which include Nyanya-AYA, Kubwa junction as well as Gwagwalada junction. Given the population of 4,026,932 in 2020 and using Krejcie and Morgan's sample size, 384 questionnaires were distributed. The data analysis procedure for the mapping of the traffic corridor is shown below (Figure 1.3).

The Abuja satellite imagery was geo-referenced and digitized using Arc GIS 10 through the onscreen digitization process. The study area's road networks were digitized as line features, and locations of selected corridors were plotted as point features using the space analysis tool. The primary source data were then structured in a GIS system implementation format and were linked to the digitized features as their attributes, which also used for database creation. Figure 1.3 shows the methodology flowchart of data collection and processing. Consequently, people responses to the

questions in the questionnaire administered was transferred to the SPSS statistical package, which enabled both frequencies and percentages to be computed, which was later presented in a tabular form for easy understanding. However, before the SPSS analysis of the present study, all the returned questionnaire booklets were checked and sorted out. The data that was collected were analyzed using descriptive statistics. The descriptive analysis that was used includes means, percentage, standard deviation and structured likert scale.

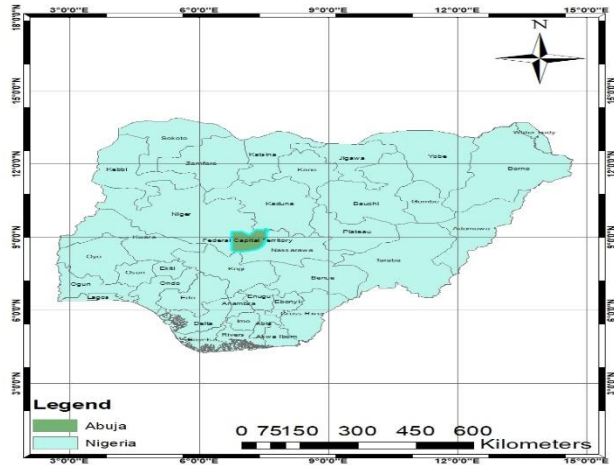


Figure 1.1: Map of Nigeria showing F.C.T Abuja (Zainab, 2021)

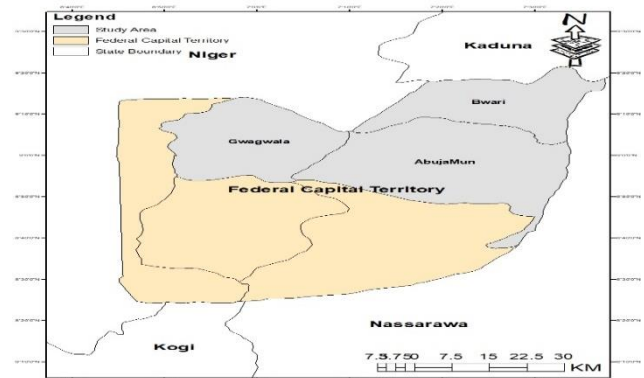


Figure 1.2: Map of Abuja showing study area

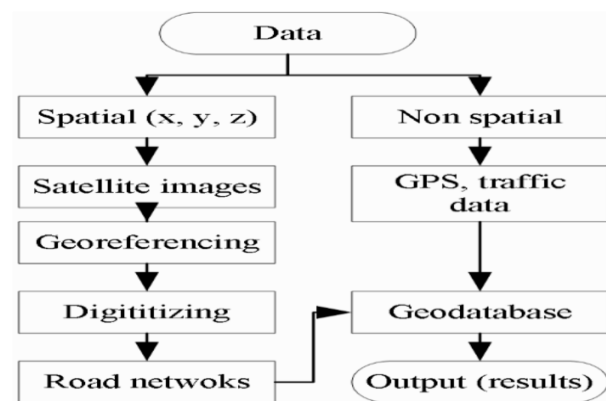


Fig 1.3: Methodology flow chart

3. Results and discussion

The Figure 1.4 ascertain the three major road corridors to the FCT are Abuja- keffi expressway with traffic congestion at strategic places which include Nyanya Bridge, Karu Bridge, Kugbo furniture junction down to Abacha barracks and city gate. And this are in linear pattern which implies that it's an onward follow due to the interjection from various junction such as Karu federal housing, and Nyanaya-jikwoyi road all due to the mass and influx of people around those axis. Secondly the Murtala Mohammed Expressway commonly known as the Kubwa –Zuba express which is at the boundary of Niger State, the traffic along this Axis are experience majorly along NNPC filling station down to Kagini junction. Lastly, Gwagwalada-Lokoja expressway. The point of traffic along this route includes Dagiri to GSS Gwagwalada.

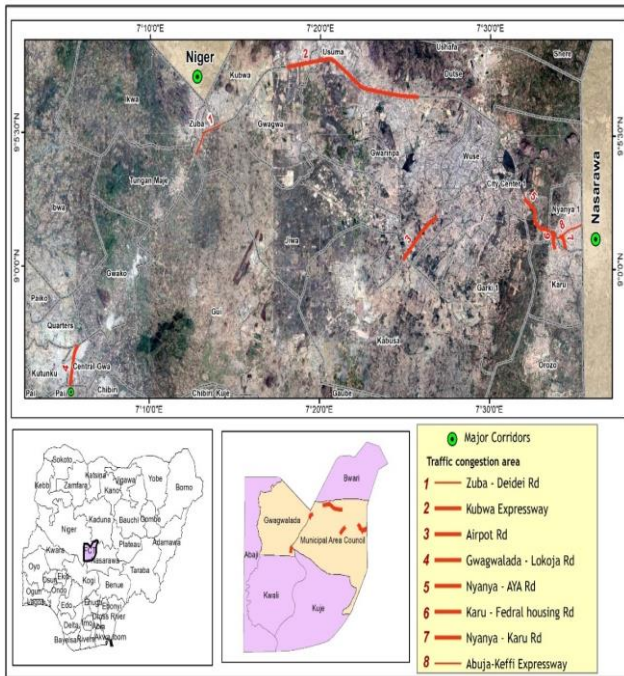


Figure 1.4: Map showing traffic congestion areas

3.1. Causes of traffic congestion in the FCT (Abuja)

Table 1: Causes of Traffic Congestion in the FCT

S.N.	Variables	SA	A	D	SD	UD	Mean	Decision
1.	Poor parking Habit	140 (36.5%)	129 (33.6%)	37 (9.6%)	58 (15.1%)	20 (5.2%)	3.91	Accepted
2.	Poor road network	19 (5.0%)	49 (12.8%)	182 (47.4%)	89 (23.2%)	45 (11.7%)	2.76	Rejected
3.	Lack of parking facilities	142 (37%)	134 (34.9%)	58 (15.1%)	34 (8.9%)	16 (4.2%)	3.92	Accepted

Table1 indicates the causes of traffic congestion in Abuja metropolis. From the table, the cause of the traffic was analyzed using the structured likert scale, and decisions were accepted based on the set decision rule that if the mean is greater than or equals to 3, the statement is accepted, but if it is less than 3, it is rejected.

Table 1, reveals the causes of traffic congestion in the FCT (Abuja). The table revealed that the causes of traffic congestion in FCT (Abuja) includes; poor parking habits, lack of parking facilities, poor traffic control management, malfunctioning vehicles and too many taxis. This was indicated by majority of the respondents as their mean response was above the acceptance benchmark of 5-point Likert scale of 3.0, hence, the acceptance benchmark was gotten by adding (SA)5+ (A)4+ (D)3+ (SD)2 + (UD)1 = 15/5 = 3.0. However, poor road network was rejected as one of the causes of traffic congestion in the FCT (Abuja). This is expected as the FCT is the new federal capital of Nigeria and better road constructed are seen all over the city and its environs. Furthermore, given the mean score of 4.14, the table indicates that too many taxis are the major causes of traffic congestion in the study area. This is expected as economic activities and government establishments are concentrated in the city centre.

Importantly, table 2 indicates the ranking of the causes of traffic congestion in the study area.

Table 2 shows that too many taxis with mean score of 4.14 is the first cause of traffic congestion, poor traffic control management with 4.06 as the second, malfunctioning vehicle with mean score of 4.02 as the third. While, lack of parking space with mean score of 3.92 as the fourth and poor parking habits with mean score of 3.91 as the fifth. Above all, poor road network with mean score of 2.76 is the sixth in ranking of the causes of traffic congestion in the study area. The finding is expected as more commuters in the FCT, necessitated the presence of more taxis, while poor road network remain the least as the FCT is known to have good road network as a result of being the new Federal Capital of Nigeria.

Therefore, the high volume vehicular movement from both private and taxis is generally responsible for both air and noise pollution in the FCT. According to Levy, Buonocore, & Stackelberg (2010), transportation does not only change the community's daily routines as well as their lifestyle, but it also contributes to the bad health of the users as a result of emissions of pollutant.

4.	Poor traffic control management	173 (45.1%)	122 (31.8%)	38 (9.9%)	42 (10.9%)	9 (2.3%)	4.06	Accepted
5.	Malfunctioning vehicles	197 (51.3%)	83 (21.6%)	35 (9.1%)	39 (10.2%)	30 (7.8%)	4.02	Accepted
6.	Too many taxis	184 (47.9%)	121 (31.5%)	39 (10.2%)	27 (7.0%)	13 (3.4%)	4.14	Accepted

Keys: SA= Strongly Agree; A= Agree; D= Disagree; SD= Strongly Disagree; UD= Undecided

Table 2: Ranking of Causes of Traffic Congestion in the FCT

S.N.	Variables	Mean score	Ranking
1.	Too many taxis.	4.14	1 st
2.	Poor traffic control management	4.06	2 nd
3.	Malfunctioning vehicles	4.02	3 rd
4.	Lack of parking space	3.92	4 th
5.	Poor parking habits	3.91	5 th
6.	Poor road network	2.76	6 th

3.2. Solution to traffic congestion in the FCT (Abuja)

Table 3 reveals solutions to traffic congestion in the FCT (Abuja). The table revealed that the solutions to traffic congestion in FCT (Abuja) includes; improved off-street parking space, provision of pedestrian facilities, traffic management/planning and public mass transport. Other solutions are education and enlightenment, maintenance of road and enforcement of traffic laws. This was indicated by majority of the respondents as their mean response was above the acceptance benchmark of 5-point Likert scale of 3.0, hence, the acceptance benchmark was gotten by adding (SA)5+ (A)4+ (D)3+ (SD)2 + (UD)1 = 15/5 = 3.0. Result from table 4 shows that maintenance of road is the major solution to traffic congestion in the study area with mean score of 4.19. This is expected as the roads in the FCT have been constructed for a while and needs maintenance. Also to avoid traffic congestion, education and enlightenment on the need to avoid traffic congestion unnecessarily is needed. This is supported by the mean score of 4.14. In the same manner traffic

management/planning with mean score of 3.95 suggest that the problem of poor traffic control can be solved with that approach. Equally, the problem of too many taxis can be solved with provision of public mass transport. This is supported with the mean score of 3.42.

It is imperative to note that applying the necessary solution to traffic congestion in the FCT (Abuja) will reduce the impact of air and noise pollution. This will improve the living condition of the residents and commuters in the study area.

Table 4 indicates the ranking of solutions to traffic congestion in the FCT (Abuja). The table shows that maintenance of road with mean score 4.19 is the first solution to traffic congestion in the study area. It is followed by education and enlightenment with 4.14 mean score. While, traffic management/planning, provision of pedestrian facilities and enforcement of traffic laws with mean scores of 3.95, 3.77 and 3.54 respectively as solutions to traffic congestion in the study area in that order. Likewise improved off-street parking space and public mass transport with mean score of 3.54 and 3.42 as 6th and 7th in ranking of solution to traffic congestion in the FCT (Abuja).

Table 3: Solution to Traffic Congestion in the FCT (Abuja)

S.N.	Variables	SA	A	D	SD	UD	Mean	Decision
1.	Improved off-street parking space	108 (28.1%)	117 (34.5%)	99 (25.6%)	46 (11.9%)	14 (3.7%)	3.54	Accepted
2.	Provision of Pedestrian facilities	100 (26.1%)	199 (51.8%)	26 (6.8%)	20 (5.2%)	39 (10.2%)	3.77	Accepted

3.	Traffic management/ planning	121 (31.5%)	190 (49.5%)	42 (11%)	19 (4.9%)	12 (3.1%)	3.95	Accepted
4.	Public mass transport	96(25%)	107 (27.9%)	98 (25.5%)	64 (16.7%)	19 (4.9%)	3.42	Accepted
5.	Education and enlightenment	92 (23.9%)	272 (70.8%)	8 (2.1%)	7 (1.8%)	5 (1.3%)	4.14	Accepted
6.	Maintenance of road	210 (54.7%)	100 (26%)	30 (7.8%)	27 (7%)	17 (4.4%)	4.19	Accepted
7.	Enforcement of traffic laws	141 (36.7%)	98 (25.5%)	97 (23.7%)	34 (8.9%)	14 (3.6%)	3.66	Accepted

Table 4: Ranking of Solutions to Traffic Congestion in the FCT

S.N.	Variables	Mean score	Ranking
1	Maintenance of road	4.19	1 st
2	Education and enlightenment	4.14	2 nd
3	Traffic management/planning	3.95	3 rd
4	Provision of Pedestrian facilities	3.77	4 th
5	Enforcement of traffic laws	3.66	5 th
6	Improved off-street parking space	3.54	6 th
7	Public mass transport	3.42	7 th
6	Improved off-street parking space	3.54	6 th
7	Public mass transport	3.42	7 th

The study established the fact that traffic congestion is a common phenomenon along the three corridors of the FCT, Abuja. This is not unconnected with the presence of economic activities in the city centre which attract most commuters. Availability of many taxis is the major cause of traffic congestion in the FCT, Abuja. This situation is responsible for increase air pollution due to the emission of gases from the automobiles. Apparently, about 94% of the Nigerians are liable to air pollution, including PM. The PM can be suspended in air over an elongated period and travel over long distances, causing a variety of diseases that significantly reduces the life expectancy of the entire population (Kim, Kabir and Kabir 2015,).

Air pollution consists of nitrogen, lead, hydrocarbons, and carbon II oxide emission from the car exhaust pipes (Mihaela, Alina and Nicuta, 2018; Bigazzi and Figliozzi, 2013). Matin, Herani, and Warraich, (2012), asserted that traffic congestion is responsible for carbon dioxide (CO₂) emission and contribute to air pollution. According to Maan, Rawand and Mohammed (2019), air pollutant emission is caused by vehicles. This view was supported based on their findings that traffic congestion has a significant impact on the air pollution at the intersection during the peak hour, where gases are emitted from cars (2817.3 kg / h) of CO₂, (151.8 kg / h) of CO, (5.569 kg / h) of HC and (4.470 kg / h) of NO_x.

Furthermore, the effect of increased emission by vehicles is responsible for several health issues on the Journal of Sustainability and Environmental Management (JOSEM)

commuters. Levy, Buonocore, and Stackelberg, (2010) asserted that one over three of Particulate Matter (PM 2.5) emitted by vehicles was considered as air pollutants and could be harmful to human's health. Zhang and Batterman, (2013), posits that this emission contributes to health issues for the drivers and those who are living near the road where they are exposed to the pollution and it might bring them to morbidity and mortality . WHO (2012), affirms that air pollution is responsible for silent killer diseases such as chronic and acute respiratory diseases, stroke, asthma and lung cancer to mention a few.

Essentially, to reduce the impact of traffic congestion in the FCT, Abuja, maintenance of the road network is the major solution. This can be achieved by provision of railway service in other to diversify means of transportation from these areas to the central business district, as this will decentralize means of movement and dependency of cars and heavy vehicles, which will also reduce traffic congestion and therefore reducing the emission of carbon and pollution of the atmosphere. Equally, speedy work should be carried out on the ongoing road construction of the Apo- Karishi road to ease traffic from people coming from such axis.

4. Conclusion

Pollution of the urban environment can be increased by the impact of traffic congestion. This is so as emission of carbon monoxide (CO), Nitrogen Dioxide (NO₂), and hydrocarbons (HC) in the atmosphere are released from vehicles. Consequently, the need to reduce the impact of traffic congestion in the study area is of great importance. Therefore all stakeholders in the transport sector should ensure deliberate and reliable means of reducing the impact of traffic congestion.

References

- Awosusi, A.O and Akindutire, I.O(2010), Urban Traffic Congestion and Its Attendant Health Effects on Road Users in Ado-Ekiti, Nigeria. *An International Multi-Disciplinary Journal, Ethiopia*. 4(4), 434-446 <http://doi.org/10.4314/afrev.v4i4.69241>
- Bigazzi, A.Y., & Figliozzi, M.A. (2013). Role of heavy-duty freight vehicles in reducing emissions on congested freeways with elastic travel demand functions. *Transportation Research Record. Journal of the Transportation Research Board*, 2340(1), 84–94. <https://doi.org/10.3141/2340-10>
- Irunokhai, E.A. and Adigun, J.O. (2019). Reducing Traffic Congestion and Violation Using Round Robin Algorithm. *International Journal of Applied Research and Technology*, 8(3), 50-54. Available on <https://www.researchgate.net/publication/344518836>
- Irunokhai E.A, Onihunwa.J.O, Oni E.K, Adigun.J.O, and Dada.O.S (2020). Analysis of Traffic Congestion on Nigerian Roads (A Case Study of Sango T Junction, Ibadan, OYO STATE). *International Journal of Computer Applications* (0975 – 8887), 176(27). <https://doi.org/10.5120/ijca2020920289>
- Krejcie, R. V., and Morgan, D. W.(1970). Determining sample size for research activities educational and psychological measurement small-sample techniques. *The NEA Research Bulletin*, 38(30), 607–610 <https://doi.org/10.1177/001316447003000308>
- Kim, K.H, Kabir, E, and Kabir, S. (2015). A Review on the Human Health Impact of Airborne Particulate Matter. *Environment International*. <https://doi.org/10.1016/j.envint.2014.10.005>
- Levy, J.I, Buonocore, J.J, and Stackelberg, K.V. (2010) The Public Health Costs of Traffic Congestion a Health Risk Assessment. *Environmental Health*, 9(65), 1–12. <https://www.semanticscholar.org/...>
- Matin, F., Herani, G. M., and Warraich, U. A. (2012) Factors Affecting Traffic Jam in Karachi and its Impact on Performance of Economy. *KASBIT Business Journal*, 32, 25–32. <http://ideas.repec.org/s/ksb/journal.html>
- Maan K.A, Rawand M.B and Mohammed M.S (2019).Evaluating the Negative Impact of Traffic Congestion on Air Pollution at Signalized Intersection Conference Paper · October 2019. <https://www.researchgate.net/publication/340137373>
- Mihaela, C., Alina, M. and Nicuta, R. (2018) Environmental Impact of Road Transport Traffic A case Study for County of Iasi Road Network. *Procedia Engineering*, 181, 123-130 <https://doi.org/10.1016/j.proeng.2017.02.379>
- Odogun, A., Georgakis, P.(2019). Transport Pollution: A Research of the Nigerian Transport Sector. *International Journal of Innovative Technology and Exploring Engineering*. <https://doi.org/10.35940/ijitee.K1083.09811S19>
- Oluwaseyi, J.A and Gbadamosi, K.T. (2017). Road Traffic Crashes in Nigeria: Causes and Consequences. *The International Journal Transport & logistics*, 17(42): 40-49. <https://www.researchgate.net/publication/316091150>
- Orisaleye, J., Ope, A., Busari, O., and Adefuye, O (2018). Environmental and Health Effects of Industrial and Vehicular emissions in Lagos, Nigeria *Annals of Faculty of Engineering Hunedoara – International of Engineering Tome XVI*
- Raheem, S.B., Olawoore, W.A., Olagunju, D.P., Adeokun E.M. (2015). The Cause, Effect and Possible Solution to Traffic Congestion on Nigeria Road (A Case Study of Basorun-Akobo Road, Oyo State). *International Journal of Engineering Science Invention*, 4(2). <https://www.researchgate.net/publication/282246248>
- Wan, N., Wahidah, B., Wan, G., Che, N., Atikah, B.Z. and Zakiah, P. (2019). The Effect of Traffic Congestion on Quality of Community Life. *The European Proceeding of Multiciplinary Sciences*. <https://doi.org/10.15405/epms.2019.12.77>
- Zhang, K., and Batterman, S. (2013). Air pollution and health risks due to vehicle traffic. *Science of the total Environment*, 450, 307-316 <https://doi.org/10.1016/j.scitotenv.2013.01.074>



© The Author(s) 2023. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license.