



Spatio-Temporal Analysis of Vehicular Noise Pollution Between Days of The Week and Weekend in Port Harcourt Metropolis of Rivers State, Nigeria

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Abstract

This study investigated the spatio-temporal variability of vehicular noise pollution between days of the week and weekend in Port Harcourt metropolis of Rivers State, Nigeria. The study used both systematic and purposive sampling techniques to attain to the reliable results. The study used Noise Level Meter (NLM) to derive the noise level data set. It used observational counting of vehicles at junctions and roundabouts to determine the vehicular flow on each of the roads. The study used the Global Positioning System (GPS) to establish the sample locations of the roundabouts and junctions. However, the Analysis of Variance (ANOVA) was employed to understand the difference in vehicular noise pollution between the days of the week and the weekend. The findings showed that there was more noise pollution in the weekdays than the weekend. Thus, in the morning of the weekdays, vehicular noise pollution recorded 85.54dB and weekend had 76.4dB. Afternoon of the weekdays had 84.74dB and weekend recorded 75.1dB. Furthermore, the evening of the weekdays had 88.2dB and weekend recorded 80.1dB respectively. The analysis indicated that there was no statistically significant variation in the level of vehicular noise pollution between days of the week and weekend. The black spot and road network development framework were recommended to ameliorate the health disaster resulting from vehicular noise pollution in Port Harcourt, Rivers State of Nigeria.

1. Introduction

Globally, vehicular noise pollution is the type of unwanted sound generated by vehicles on the roadway. Vehicular noise pollution has turned a worldwide challenge due to the explosive population, industrialization and urbanization process taking place in the cities. Vehicular noise pollution can occur from the sound generated by the engine and passengers in the vehicle. A bad engine can generate greater disturbing sound especially at bottle neck roads and roundabouts as well as junctions. The vehicular noise can be worsened by over throttling of the acceleration pedal of the vehicle in motion [1]. There are various factors that can raise vehicular noise pollution such as bad roads, uncontrolled traffic, high vehicular loud speakers, shouting of passengers, bad exhaust of vehicles, bad engine and others [2]. The explosive rise in the population of vehicles and people has yielded serious noise pollution with the attendant psychological and physiological effects on human health which has resulted to discomfort to the city dwellers [3].

In some cities of the developing countries like Nigeria, some roads are very close to one another and others are very long routes. Along the roadways, are found tall buildings that are close to the road, and others are far and short buildings to the roadway. The structure and arrangement of these buildings along the roads can influence the escape of sound from engines and exhaust pipes of the vehicles thereby increasing or reducing the level of vehicular noise pollution [4]. Thus, vehicular noise pollution is expected to differ from days of the week and the weekend resulting from variation in traffic volumes. [5] suggested that researchers and scholars should embark on intensive vehicular pollution inquiries using space-time approach at different days of the week and weekend.

Noise pollution responds to the density of vehicles on the road. Thus, number of vehicles and people on the road can influence the generation of vehicular noise pollution. The engine, horn, loud speaker, bad exhaust pipes and people are major contributors to vehicular noise pollution. Often, people and vehicles are stocked on the road thereby generating noise that could cause psychological and physiological problems such as misunderstanding, ulcer and heart ailments [6] [7]. The city of Port Harcourt has experienced rapid urbanization, explosive population and industrialization thereby, resulting to increased population of vehicles resulting to the study of vehicular noise pollution at various degrees in order to objectively reduce human discomfort caused by vehicular traffic noise. Traffic congestion will increase noise pollution compared to free flow conditions [8]. Also, speed at different nodal points or intersections will be influence by vehicular queue, upstream and downstream vehicular volumes, type of lane, type of vehicle and speed limit [9]. The atmospheric weather condition and environmental characteristics such as land scape, rainfall, humidity and temperature as well as visibility influence vehicular noise pollution to some extent [10]. For example, bad weather condition is capable of reducing the speed of vehicles to 6-7 mph along the roadway thereby influencing noise level [11] [12].

Some studies have been carried out to understand the impact of vehicular noise pollution across days of the week and weekend and the implication to human health such as those of [13] [14] [15] [16] [17]. Vehicular noise pollution can induce sleep disorder, psychological symptoms, create annoyance, cardiovascular disease, bad social behavior, loss of long-term memory, psychiatric disorders, disrupts reading and understanding, raise catecholamine secretion, high blood pressure and hypertension [17]. According to [18] vehicular noise pollution is capable of causing big risk of increased preeclampsia ailment in pregnant women. Resultantly, vehicular noise pollution has become a human disaster of the 21st century, causing death and accelerated ailment of greater number of people in the cities which needs urgent attention to control the threat so as to have a safe and healthy city across the world [19]. In this vein, the objective of this study is to investigate the spatio-temporal analysis of vehicular noise pollution between days of the week and weekend in Port Harcourt metropolis of Rivers State, Nigeria.

2. Methodology

The city of Port Harcourt is located within longitude 70°E and 70°5 E and latitude 4045'N and 4050'N in the Tropical country of Nigeria; surrounded by Okirika, Eleme, Etche, Ikwere and Emohua Local Government Areas (Figure 2.1). Port Harcourt as a coastal city has close proximity with the Atlantic Ocean, which affects the general atmospheric weather pattern. The annual mean temperature of the area records 28°C and the relative humidity is usually high with annual mean of 85% [20]. The area is known for its heavy rainfall from April to October ranging from 2000 to 2500 mm [21].

Data for this study were derived from three sources for the vehicular noise investigation in Port Harcourt city, Rivers State, Nigeria. The Global Positioning System (GPS) was used to geo-reference the coordinates of purposively selected junctions and roundabouts across the road network of the city

(Figure 2.2) at nine (9) roads and five (5) sample points per road totaling forty-five (45) sample points at a height between 1.20 m and at a distance 2 - 3m from the road.

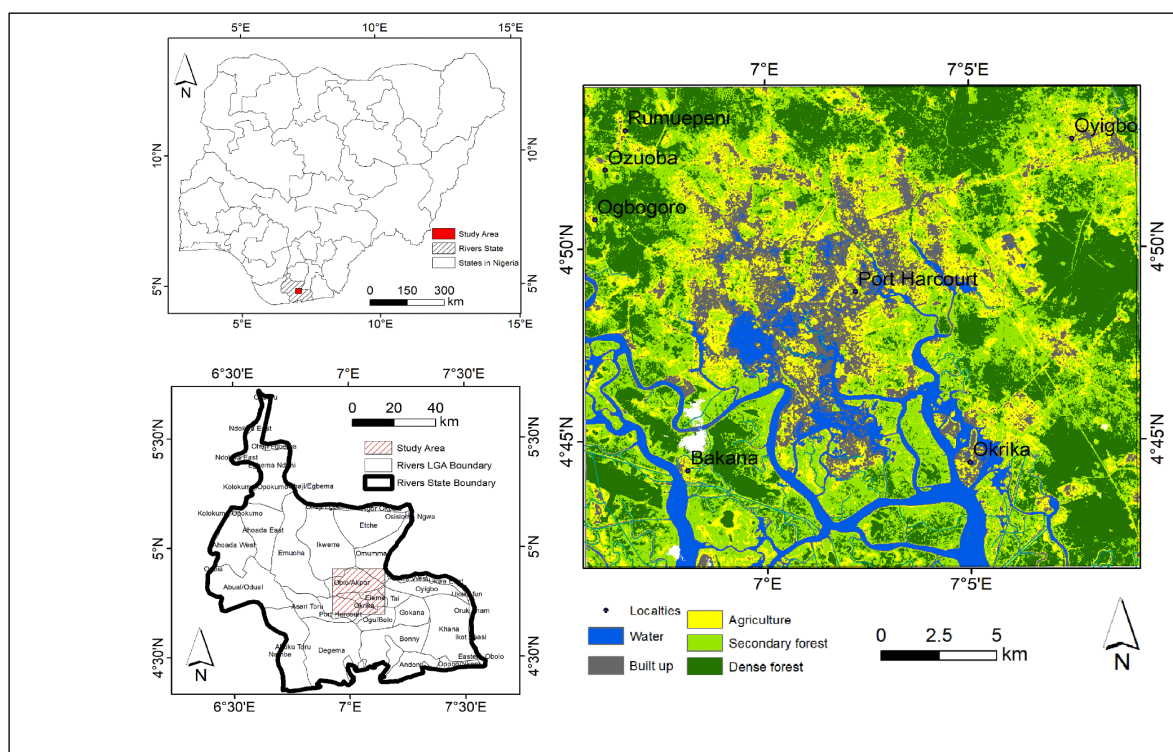


Figure 2.1: Base map of Port Harcourt Study Area

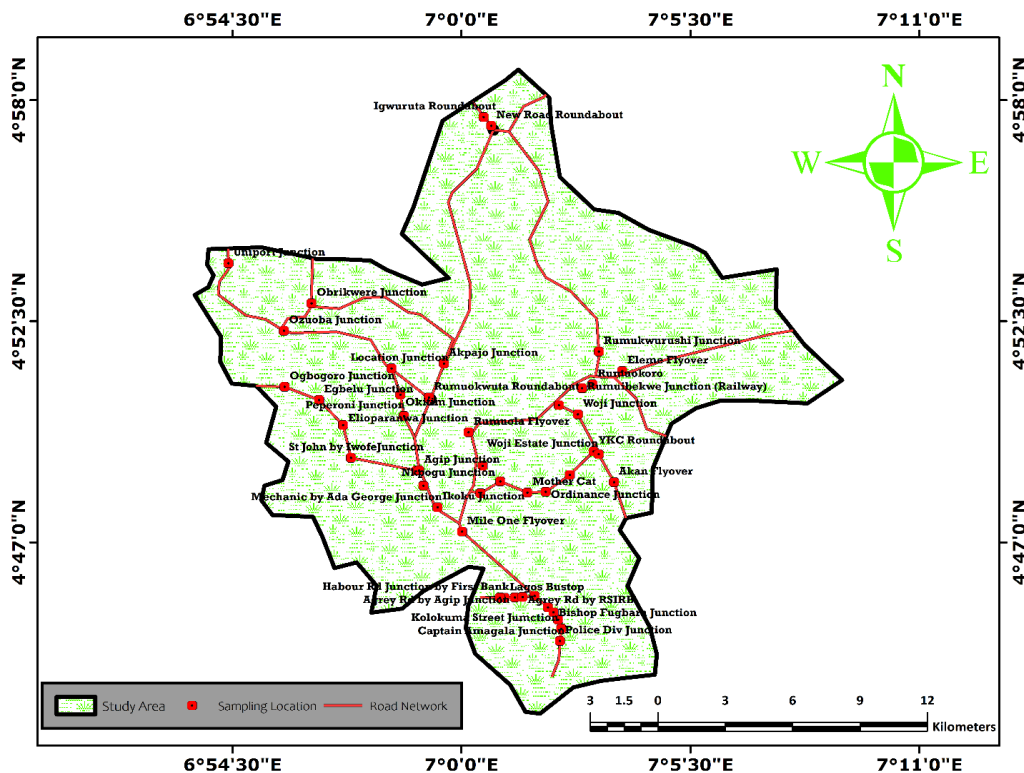


Figure 2.2: Sample Locations map across Different Observation Sites

3. Results and Discussion

3.1 Temperature profile

The Noise Level Meter or Noise Dosimeter was used to collect data for the vehicular noise level in decibel (dB). The data for vehicular traffic counts or flow were carried out by observation and counting. The sampled roads with their junctions and roundabouts were Aba road, East-West road, Ikwerre-Airport road (Trunk A), Ada George road, Transamadi road, Aggrey road (Trunk B) and Rumuolumeni-Ogbogoro-Ozuoba Road, Borokiri road and Woji roads respectively (Trunk C) as in Table 2.1.

Table 2.1: Sampled Road Classification, Roundabouts/Junctions and GPS Coordination

Road Trunks (A, B, C)	Name of Roundabout/Junction	GPS Coordinate Easting	GPS Coordinate Northing
Trunk A (Federal Roads)			
Aba Road	Eleme Flyover	6 ⁰ 57' 56"	4 ⁰ 51' 06"
	Artillery Junction	6 ⁰ 58' 24"	4 ⁰ 50' 39"
	Rumuola Flyover	6 ⁰ 58' 36"	4 ⁰ 50' 07"
	Waterlines Junction	6 ⁰ 58' 58"	4 ⁰ 48' 46"
	Mile One Flyover	6 ⁰ 59' 05"	4 ⁰ 48' 23"
Airport/Ikwerr e Road	Igwuruta Roundabout	7 ⁰ 02' 04"	4 ⁰ 45' 22"
	New Road Roundabout	7 ⁰ 02' 22"	4 ⁰ 44' 32"
	Rumuokwuta Roundabout	7 ⁰ 02' 24"	4 ⁰ 44' 49"
	Agip Roundabout	7 ⁰ 02' 19"	4 ⁰ 45' 03"
	Ikoku Junction	7 ⁰ 02' 13"	4 ⁰ 45' 14"
East-West Road	Uniport Junction	7 ⁰ 02' 48"	4 ⁰ 50' 10"
	ObirIkwerre Junction	7 ⁰ 02' 54"	4 ⁰ 50' 49"
	Rumuokoro	7 ⁰ 03' 10"	4 ⁰ 49' 14"
	Rumukwurushi Junction	7 ⁰ 03' 18"	4 ⁰ 49' 10"
	Akpajo Junction	7 ⁰ 03' 40"	4 ⁰ 48' 28"
Trunk B (State Roads)			
Agrey Road	Lagos Bustop	7 ⁰ 01' 02"	4 ⁰ 45' 36"
	Harbour Rd Junction by First Bank	7 ⁰ 00' 55"	4 ⁰ 45' 36"
	Agrey Rd by Agip Junction	7 ⁰ 01' 17"	4 ⁰ 45' 36"
	Agrey Rd by RSIRB	7 ⁰ 01' 28"	4 ⁰ 45' 37"
	Agrey Rd by Post Office	7 ⁰ 01' 46"	4 ⁰ 45' 39"
Trans-Amadi Road	Garrison Junction	7 ⁰ 00' 27"	4 ⁰ 48' 12"
	Nkpogu Junction	7 ⁰ 00' 55"	4 ⁰ 48' 30"
	Mother Cat	7 ⁰ 01' 35"	4 ⁰ 48' 13"
	Ordinance Junction	7 ⁰ 02' 01"	4 ⁰ 48' 14"
	Slaughter Roundabout	7 ⁰ 02' 36"	4 ⁰ 48' 39"

The primary roads (Trunk A) were Federal roads that link vehicles in and out of the Port Harcourt city and metropolis with heavy traffic volumes. The Trunks B and Trunk C were internal road linkages within the Port Harcourt city area.

Road Trunks (A, B, C)	Name of Roundabout/Junction	GPS Coordinate Easting	GPS Coordinate Northing
Ada-George Road	Location Junction	6 ⁰ 57' 56"	4 ⁰ 51' 06"
	Okitim Junction	6 ⁰ 58' 24"	4 ⁰ 50' 39"
	Peperoni Junction	6 ⁰ 58' 36"	4 ⁰ 50' 07"
	Agip Junction	6 ⁰ 58' 58"	4 ⁰ 48' 46"
	Mechanic by Ada George Junction	6 ⁰ 59' 05"	4 ⁰ 48' 23"
Trunk C (Neighborhood Roads)			
Borokiri Road	Thumson Numbere Junction	7 ⁰ 02' 04"	4 ⁰ 45' 22"
	Police Div Junction	7 ⁰ 02' 22"	4 ⁰ 44' 32"
	Kolokuma Street Junction	7 ⁰ 02' 24"	4 ⁰ 44' 49"
	Captain Amagala Junction	7 ⁰ 02' 19"	4 ⁰ 45' 03"
	Bishop Fugbara Junction	7 ⁰ 02' 13"	4 ⁰ 45' 14"
Woji Road	Woji Junction	7 ⁰ 02' 48"	4 ⁰ 50' 10"
	Rumuibekwe Junction (Railway)	7 ⁰ 02' 54"	4 ⁰ 50' 49"
	YKC Roundabout	7 ⁰ 03' 10"	4 ⁰ 49' 14"
	Woji Estate Junction	7 ⁰ 03' 18"	4 ⁰ 49' 10"
	Akan Flyover	7 ⁰ 03' 40"	4 ⁰ 48' 28"
Rumuolumeni-Ogbogoro-Ozuoba Road	St John by Rumuolumeni Junction	7 ⁰ 57' 21"	4 ⁰ 49' 05"
	Elioparanwa Junction	6 ⁰ 57' 09"	4 ⁰ 49' 54"
	Ogbogoro Junction	6 ⁰ 55' 45"	4 ⁰ 50' 51"
	Egbelu Junction	6 ⁰ 56' 34"	4 ⁰ 50' 31"
	Ozuoba Junction	6 ⁰ 55' 44"	4 ⁰ 52' 14"

Also, for the vehicular traffic counts, the Septa Square 15-minute observation and measurement time period was used to conduct the vehicular counts and noise level measurements in the morning (7:00- 8:00am), afternoon (14:00-15:00pm) and evening (17:00-18:0 pm) for a period of one month; from Monday to Sunday of the weekdays summarized in their mean values. The vehicles counted were Car, Van, Lorry and Tricycle [19]. The Analysis of Variance (ANOVA) was used to understand whether differences exist between vehicular noise pollution across days of the week and the weekend with Null hypothesis (Ho) stating that: there is no statistically significant difference in vehicular noise pollution between days of the week and the weekend.

3. Results and Discussions

Generally, on the average, there were more noise pollution in the weekdays than the weekend (Figure 3.1). In the morning of the weekdays, vehicular noise pollution recorded 85.54dB and weekend had 76.4dB. Afternoon of the weekdays had 84.74dB and weekend recorded 75.1dB. Furthermore, the evening of the weekdays had 88.2dB and weekend recorded 80.1dB respectively. The increased vehicular traffic noise pollution in the weekdays could be as a result of increased vehicular movement in and out of the city by workers, students and traders in Port Harcourt metropolis of Nigeria. The evening of the weekdays had the highest noise pollution level, followed by the morning and the least was in the afternoon period. On the other hand, the evening of the weekend had the highest vehicular traffic noise, seconded by the morning hours and least was the afternoon period. It was obvious that afternoon of both days of the weekdays and weekend had the least vehicular noise pollution hours due to the fact that people were usually at rest during the high sun rising period of the afternoon. It therefore, communicates that people would have less physiological and psychological health effects in the afternoon as a result of vehicular noise pollution.

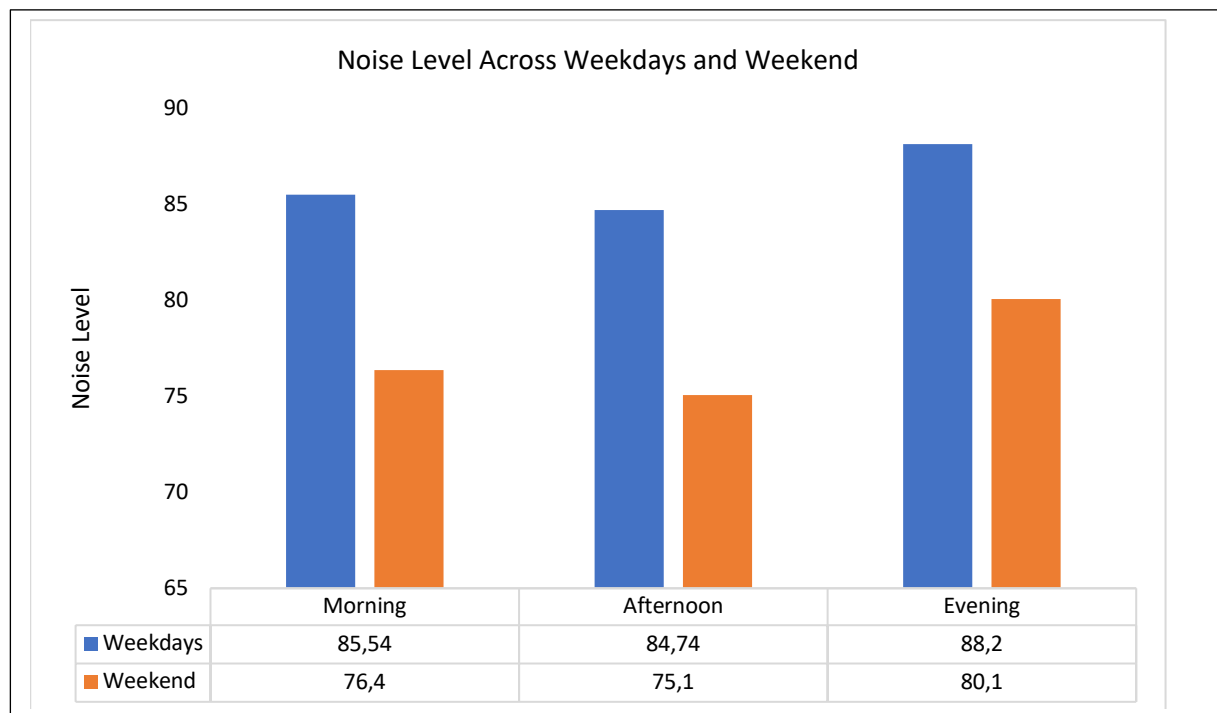


Figure 3.1: Vehicular Noise Pollution between Days of the Week and Weekend

It is very pertinent to discuss the state of vehicular noise pollution between days of the week and weekend to enable city commuters properly manage their noise comfort threshold. The maximum vehicular noise pollution was severe in the weekend (80.1dB) than days of the week (71.5dB). These results are supported by the findings of [22] who assessed noise pollution in and around a sensitive zone in North India and its non-auditory impacts. The study indicated that there was significant difference (10dB) between weekend and weekdays noise pattern at new OPD gate and old hospital during the office hours; but with a difference of 2dB and 4dB during the night between weekend and weekdays. The researchers noted high noise pollution during weekend night at old hospital than weekday showing variability of noise pollution across weekend and weekdays resulting from variation in commuters' activities in the city. High noise in the days of the week in Port Harcourt was as a result of increased activities and movement of people for economic reasons during the days of the week such as the influx of people around Oil Mill market on every Wednesday.

The hypothesis (Ho) recognized that there is no significant difference in vehicular noise pollution between days of the week and weekend (Table 3.2). The vehicular noise pollution between days of the week and weekend has the calculated value of 1.894562 and critical F-value of 2.265567 with 6 and 56 Degrees of Freedom (DF) for a two-tailed test at 0.05 Significant Level (SL). It denotes that calculated value (1.894562) is lesser than the critical F-value of 2.265567. It therefore shows that vehicular noise pollution in days of the week does not significantly differ from those of the weekend. In this vein, this study stated that the morning of the weekdays vehicular noise pollution recorded 85.54dB and weekend had 76.4dB. Afternoon of the weekdays had 84.74dB and weekend recorded 75.1dB. Furthermore, the evening of the weekdays had 88.2dB and weekend recorded 80.1dB respectively. But the hypothesis indicated that actually there is no statistically significant difference in vehicular noise pollution between days of the week and weekend.

Table 3.2: ANOVA Test Explaining difference in Vehicular Noise Pollution between Days of the Week and Weekend

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	2134.487	6	355.7478	1.894562	0.097798	2.265567
Within Groups	10515.3	56	187.7731			
Total	12649.78	62				

Conclusion

This study purpose was to investigate the spatio-temporal variability of vehicular noise pollution between days of the week and the weekend in Port Harcourt metropolis of Rivers State, Nigeria. It is common knowledge that some cities across the world have explosive population of vehicles, urbanization problem and industrialization that are causing severe pollution to the human environment in the form of psychological and physiological discomfort. This study used systematic and descriptive techniques to generate traffic counts, vehicular noise levels and the coordinates of junctions as well as roundabouts. The Analysis of Variance (ANOVA) was employed to understand whether differences occurred in vehicular noise pollution between days of the week and the weekend. The Port Harcourt city dwellers had severe discomfort during the days of the week (Monday to Friday) than the weekend (Saturday and Sunday). The morning (85.54dB), afternoon (84.74dB) and the evening (88.2dB) of the

days of the week had intense vehicular noise pollution greater than those of the weekend. The vehicular noise level values have exceeded the recommended 75dB national and international standards thereby exposing the people to hearing impairment, sleep disorder, bad social behavior, cardiovascular disease, psychological symptoms, loss of long-term memory, disrupts reading and understanding, raise annoyance, raised catecholamine secretion, high blood pressure and disorders as well as hypertension. The study indicated that vehicular noise pollution in days of the week does not significantly differ from those of the weekend. The study recommends the black spot strategy to basically improve traffic noise pollution and safety by establishing speed calming measures such as speed humps and roundabouts at various locations considered triggers to vehicular noise and high volume traffics as well as vehicular collision. Furthermore, there is need to develop and implement a road-safety management framework targeting improving the attitude of road users and the environment. It involves other strategies of creating more road networks that can cushion traffic congestion in the urban areas such as Port Harcourt, Nigeria.

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References

- [1] B. Olivier, “Urban Traffic Calming and Environmental Noise. Effects and Implications for Practice. National Collaborating Centre for Healthy Public Policy,” 2012. www.inspq.qc.ca/english
- [2] H. Gary, and S. Dieter, “Transport and Environment in Sub-Saharan Africa. TEST network,” 2012. www.afritest.net.
- [3] D. S. Morrison, H. Thomson, and M. Petticrew, “Evaluation of the health effects of a neighbourhood traffic calming scheme,” *Journal of Epidemiology and Community Health*, 58(2004), 837-840. <https://doi:10.1136/jech.2003.01750>
- [4] B. Rajiv, “Noise Pollution: Managing the Challenge of Urban Sounds,” *Earth Journalism Network*, 2014. <https://earthjournalism.net/resources/noise-pollution-managing-the-challenge-of-urban-sounds>
- [5] M. D. V. Karina, R. A. C. Maria, and M. C. R. Rui, “Noise pollution and annoyance: An urban soundscapes study,” *Noise Health journal*, 17(2015), 125-133. doi: 10.4103/1463-1741.155833.
- [6] A. Smargiassi, K. Berrada, I. Fortier, and T. Kosatsky, “Traffic intensity, dwelling value, and hospital admissions for respiratory disease among the elderly in Montreal (Canada): a case-control analysis” *Journal of Epidemiology and Community Health*, 60(2006), 507-512. <https://doi:10.1136/jech.2005.037044>
- [7] P. Abbott, J. Tyler, and R. Layfield, “Traffic calming: vehicle noise emissions alongside speed control cushions and road humps, Crowthorne, Berkshire: Transport Research Laboratory, 1995.
- [8] M. Z. Mohammad and T. Adam “Theoretical Comparison of the Effects of Different Traffic Conditions on Urban Road Traffic Noise,” *Journal of Advanced Transportation*, (2018) Article ID 7949574; 1-11. <https://doi.org/10.1155/2018/7949574>

- [9] G. C. Emenike and C. Orjinmo, "Vehicular Emissions Around Bus Stops in Port Harcourt Metropolis, Rivers State, Nigeria" *European Journal of Research in Social Sciences*, 5(2017) 19-36. www.idpublications.org.
- [10] O. Nick, S. Stephen, and F. Harindra, "How the weather affects the scale of urban noise pollution, 2011. <https://acoustics.org/pressroom/httpdocs/161st/Ovenden.html>
- [11] M. Kilpelaninen and H. Summala, "Effects of weather and weather forecasts on driver behavior," 3rd International Conference on Traffic and Transport Psychology, Finland, 2011.
- [12] M., Andre and U. Hammarstrom, "Driving Speeds in Europe for Pollutant Emissions Estimation," *Transportation Research Part D Transport and Environment*, 5 (2000) 321-335.
- [13] S. Stansfeld, M. Haines, and Brown, B. "Noise and health in the urban environment" *Rev. Environ. Health*, 15(2000), 43-82. <https://pubmed.ncbi.nlm.nih.gov/10939085/>
- [14] W. Passchier-Vermeer and W. F. Passchier, "Noise exposure and public health," *Environmental Health Perspective Supply*, 108 (2000) 123-131. <https://doi/10.1289/ehp.00108s1123>.
- [15] D. Quis, "Annoyance from Road Traffic Noise: A Review," *Journal of Environmental Psychology*, 21 (2001) 101-120. <https://www.sciencedirect.com/science/article/abs/pii/S0272494400901877>
- [16] R. F. S. Job, "The influence of subjective reactions to noise on health effects of the noise," *Environmental Int.*, 22 (1996) 93-104.
- [17] G. W. Evans and S. Hygge, "Noise and performance in children and adults," In D. Prasher (Ed.), *Handbook of noise and health*, 2000.
- [18] A. Nathalie, D. Mathilde, B. B. Marianne, L. Ernest, and S. Audrey, "Environment Noise Pollution and Risk of Preeclampsia," *Journal of Environmental Pollution*, 239 (2018) 599-606. <https://doi.org/10.1016/j.envpol.2018.04.060>.
- [19] World Health Organization [WHO], *Deafness and hearing loss*, 2020. <https://www.who.int/en/news-room/fact-sheets/detail/deafness-and-hearing-loss>.
- [20] E. Happiness, H. U. Ihueze, and U. O. Victor, "Land-use and land-cover changes in Port Harcourt and Obio/Akpor Local Government Areas of Rivers State - using remote sensing and GIS approach," 2007. <https://uchenwogwugwu.wordpress.com/.../land-use-and-land-cover-changes-in-port>.
- [21] J. Fasote, "Assessment of land-use and land-cover changes in Port Harcourt and Obio/Akpor local government areas using remote sensing and GIS approach," 2007. maxwellsci.com/print/rjees/v3-307-313.pdf.
- [22] R. Khaiwal, S. Tanbir, P. Jaya, A. Tripathy, M. Suman, M. Sanjay, P. Binod, and P. Naresh, "Assessment of noise pollution in and around a sensitive zone in North India and its non-auditory impacts," *Science of the Total Environment*, 566(2016) 981-987. <https://doi.org/10.1016/j.scitotenv.2016.05.070> 0048-9697.

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