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Characterization of vehicular noise pollution and established health standards in Port Harcourt Metropolis, Rivers State, Nigeria

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Abstract

This study investigated the characterization of vehicular noise pollution and established health standards in Port Harcourt metropolis, Rivers State, Nigeria. There were four types of data collected for this study: vehicular noise data were collected across the junctions and roundabouts using the Noise Level Meter (NLM); vehicular traffic data were generated by observation and counting vehicles that passed each junction and roundabout; vehicular traffic map was developed using the Global Positioning System (GPS) device analyzed in the Geographic Information System (GIS) environment and vehicular noise levels were matched with national and international standards respectively. The result indicated that Port Harcourt metropolis has exceeded both the national and international vehicular traffic noise standard of 70dB which has triggered physiological and psychological health challenges to residential areas and the general road users as well as the public. This study recommended that there should be improved road network across the city, especially the southern and western segments in order to ameliorate vehicular noise pollution. Effective road-safety management framework should be developed and implemented. Finally, state and national laws on noise pollution offenders should be implemented in order to reduce vehicular noise pollution and provide a safe as well as livable environment for Port Harcourt city dwellers.

Keywords: Health; Noise; Pollution; Standards; Vehicle

1. Introduction

Globally, noise pollution has become a contemporary pollution as over 466 million people are affected by it. There is global rise in vehicle as over 1.2 billion vehicles are in circulation. World Health Organization (WHO) has predicted a vehicular rise of 16% from 2010 to 2013 [1, 2]. Thus, Noise pollution is triggered by the density of vehicles that are on the roads. However, noise pollution is compounded by the noise from the engine, loud speaker, exhaust pipes and noise from passengers. Noise pollution has caused both psychological and psychiatric health challenges such as misunderstanding, ulcer and heart ailments [3, 4]. There is rapid growth of urbanization with people migrating to the cities, vehicles and loud speakers will continuously accelerate the noise pollution of cities across the world. This has attracted interest in the study of noise pollution in order to objectively reduce human discomfort caused by vehicular traffic.

According to [5], high traffic congestion will exacerbate noise pollution than a free flow situation. Vehicular speed at different nodal points (junctions and roundabouts) can affect vehicular congestion in both upstream and downstream of the road. Also, land use type, type of road lanes, type of vehicle and speed limit will influence vehicular noise pollution [6]. Noise pollution in the city can be influenced by the atmospheric weather conditions and other environment factors

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such as land scape type, building types, rainfall, temperature, humidity and visibility [7, 8]. For instance, bad weather condition can influence the speed of vehicle by 6-7 mph along an express way, thereby affecting the noise pollution of a moving vehicle [9, 10].

Noise pollution has to be properly managed with established health standards to enable people to better live in the cities. Thus, noise pollution standards and managements have been established at international, regional and local levels. The noise level standards have been distributed among residential, commercial, industrial and educational land uses. Which implies that noise pollution is regulated according to land use types. The issue of community noise known as environment and residential noise are noise generated outside industrial activities which are mainly from road, rail, air traffic, public work and neighborhood construction. Main indoor noise sources are office machines, ventilators and home appliances. Thus, WHO in a guideline report to European Union (EU) has established that outdoor residential noise level should not exceed 55dBA. The greater source of traffic noise is generated from road traffic at 75 to 80 dBA for 24 hours noise level pressure [11]. Indoor noise level for bedrooms is 30dB for continuous noise level and not exceeding 45dB for single sound. Ceremonies, festivals and entertainment events should not exceed 100dB [11]. In Nigeria, noise level range between 45dB and above 70dBA in the day for all land use types and 35dBA to 60dBA in the night for all land use types ranging from hospital area to industrial land use [[12].

However, with rigorous studies of the characteristics and effects of noise pollution, certain criteria have been developed to manage noise in the city. These include monitoring people's exposure to noise, health control and abatement by considering the type of environment, sources of noise and strategies of noise abatement. These will result to transport planning, creation of surveillance system, adoption of noise level management framework and general precautionary measures as well as other policy statement and their implementation groups. In this vein, this study is to objectively carry out the characterization of vehicular noise pollution and established health standards in Port Harcourt metropolis, Rivers State, Nigeria.

2. Methodology

Port Harcourt metropolis is situated between longitude $06^{0}30E$ and $07^{0}30E$ and latitude $04^{0}30N$ and $05^{0}30N$ of Nigeria (Figure 1). The purposively sampled roads, GPS coordinates, traffic counts and vehicular traffic noise are shown in Table 1. There were four types of data collected for this study. Vehicular noise were collected across the junctions and roundabouts using the Noise Level Meter (NLM). Vehicular traffic data were generated by observation and counting vehicles that passed each junction and roundabout. The vehicular traffic map was developed using the Global Positioning System (GPS) device analyzed in the Geographic Information System (GIS) environment. The vehicular noise levels were matched with national and international standard scores. The field work lasted for a period of one month and two weeks (January 17th to February 27th, 2021).

The Noise Level Meter devices were placed at purposively selected intersections (junctions and roundabouts) totaling 9 roads at 5 different points summing up to 45 sample points by maintaining the device height at 1.20m with a distance of 2-3m from vehicular noise level source as stated by the studies of [13, 14, 15]. Thus, the study collected traffic flow counts at the various purposively established junctions and roundabouts by observing the vehicles and counting vehicles across the different categories of the road (Trunks A, B and C) respectively. Choosing roundabouts and junctions enabled the researcher to easily and holistically collect the total noise generated by traffic flow such as noise from the vehicles, hooting of passengers on board and vehicular loud speakers, all resulting from the bottleneck nature of the roads [16].

The study adopted the Square 15-minute measurement period in which there were counting and recording of vehicular flow in every 15 minutes interval for an hour starting from (7:00- 8:00am), afternoon (14:00-15:00pm) and evening (17:00-18:00pm). The mean noise levels were generated and calculated as well as recorded. The vehicles counted were Cars, Vans, Lorries and Tricycles [13, 6,]. The GPS devices were employed to locate the sample points of the vehicular traffic noise and traffic counts as in Table 1. The combination of both the vehicular traffic flow and traffic counts were used to produce the study area vehicular traffic map (Figure 2).

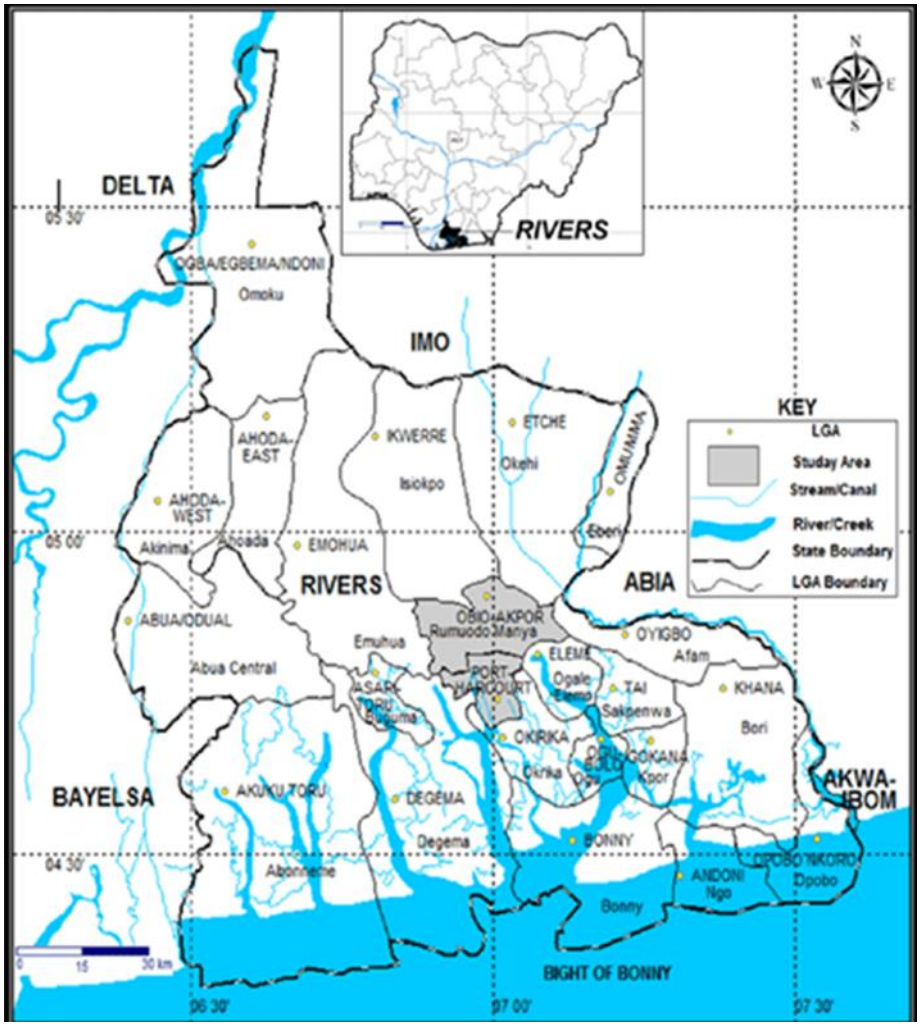

Figure 1 Port Harcourt Metropolis in Rivers State, Nigeria

Table 1 Sampled Roads, GPS Coordinate, Traffic Counts and Vehicular Traffic Noise

Road Trunks (A, B, C)	Name of Roundabout/Junction	GPS Coordinate Easting	GPS Coordinate Northing	Vehicular Traffic Count	Noise
Trunk A (Federal Roads)					
Aba Road	Eleme Flyover	7⁰ 03' 26"	4⁰ 51' 14"	6735	98.1
	Artillery Junction	7⁰ 02' 20"	4⁰ 50' 23"	5539	95.5
	Rumuola Flyover	7⁰ 00' 16"	4⁰ 49' 43"	5200	98.6
	Waterlines Junction	7⁰ 00' 31"	4⁰ 48' 33"	5424	95.8
	Mile One Flyover	7⁰ 00' 00"	4⁰ 47' 15"	6252	97.4
Airport/Ikwerre Road	Igwuruta Roundabout	7⁰ 00' 32"	4⁰ 57' 33"	1566	96
	New Road Roundabout	7⁰ 00' 43"	4⁰ 57' 20"	2311	99.5
	Rumuokwuta Roundabout	6⁰ 59' 22"	4⁰ 50' 18"	1859	92.6
	Agip Roundabout	6⁰ 58' 56"	4⁰ 48' 46"	1616	98
	Ikoku Junction	6⁰ 59' 25"	4⁰ 47' 51"	1654	92.8
East-West Road	Uniport Junction	6⁰ 54' 24"	4⁰ 53' 56"	258	80.6

	ObiriKwerre Junction	6⁰ 57’ 14”	4⁰ 52’ 28”	268	82.3
	Rumuokoro	7⁰ 03’ 02”	4⁰ 50’ 54”	180	76.5
	Rumukwurushi Junction	7⁰ 03’ 18”	4⁰ 51’ 43”	288	82.2
	Akpajo Junction	7⁰ 01’ 16”	4⁰ 51’ 28”	478	95
Trunk B (State Roads)					
Aggrey Road	Lagos Bustop	7⁰ 01’ 02”	4⁰ 45’ 36”	5168	90.9
	Habour Rd Junction by First Bank	7⁰ 00’ 55”	4⁰ 45’ 36”	6108	92.5
	Aggrey Rd by Agip Junction	7⁰ 01’ 17”	4⁰ 45’ 36”	5388	92.8
	Aggrey Rd by RSIRB	7⁰ 01’ 28”	4⁰ 45’ 37”	4219	88.1
	Aggrey Rd by Post Office	7⁰ 01’ 46”	4⁰ 45’ 39”	5558	88.3
Trans-Amadi Road	Garrison Junction	7⁰ 00’ 27”	4⁰ 48’ 12”	383	77.8
	Nkpogu Junction	7⁰ 00’ 55”	4⁰ 48’ 30”	333	73.9
	Mother Cat	7⁰ 01’ 35”	4⁰ 48’ 13”	344	75.2
	Ordinance Junction	7⁰ 02’ 01”	4⁰ 48’ 14”	354	75.7
	Slaughter Roundabout	7⁰ 02’ 36”	4⁰ 48’ 39”	388	77.8
Ada-George Road	Location Junction	6⁰ 57’ 56”	4⁰ 51’ 06”	328	72.5
	Okitim Junction	6⁰ 58’ 24”	4⁰ 50’ 39”	203	62.1
	Peperoni Junction	6⁰ 58’ 36”	4⁰ 50’ 07”	317	72.6
	Agip Junction	6⁰ 58’ 58”	4⁰ 48’ 46”	422	78.0
	Mechanic by Ada George Junction	6⁰ 59’ 05”	4⁰ 48’ 23”	441	79.7
Trunk C (Neighborhood Roads)					
Borokiri Road	Thumson Numbere Junction	7⁰ 02’ 04”	4⁰ 45’ 22”	3304	87.0
	Police Div Junction	7⁰ 02’ 22”	4⁰ 44’ 32”	4835	87.9
	Kolokuma Street Jumction	7⁰ 02’ 24”	4⁰ 44’ 49”	3250	85.8
	Captain Amagala Junction	7⁰ 02’ 19”	4⁰ 45’ 03”	4292	87.4
	Bishop Fugbara Junction	7⁰ 02’ 13”	4⁰ 45’ 14”	5432	82.7
Woji Road	Woji Junction	7⁰ 02’ 48”	4⁰ 50’ 10”	280	79.7
	RumuibekweJunction (Railway)	7⁰ 02’ 54”	4⁰ 50’ 49”	401	86.9
	YKC Roundabout	7⁰ 03’ 10”	4⁰ 49’ 14”	455	90.5
	Woji Estate Junction	7⁰ 03’ 18”	4⁰ 49’ 10”	170	69.8
	Akan Flyover	7⁰ 03’ 40”	4⁰ 48’ 28”	325	80.2
Rumuolumeni-Ogbogoro-Ozuoba Road	St John by Rumuolumeni Junction	7⁰ 57’ 21”	4⁰ 49’ 05”	328	73.2
	Elioparanwa Junction	6⁰ 57’ 09”	4⁰ 49’ 54”	297	74.4
	Ogbogoro Junction	6⁰ 55’ 45”	4⁰ 50’ 51”	351	76.1
	Egbelu Junction	6⁰ 56’ 34”	4⁰ 50’ 31”	350	75.3
	Ozuoba Junction	6⁰ 55’ 44”	4⁰ 52’ 14”	407	80.2

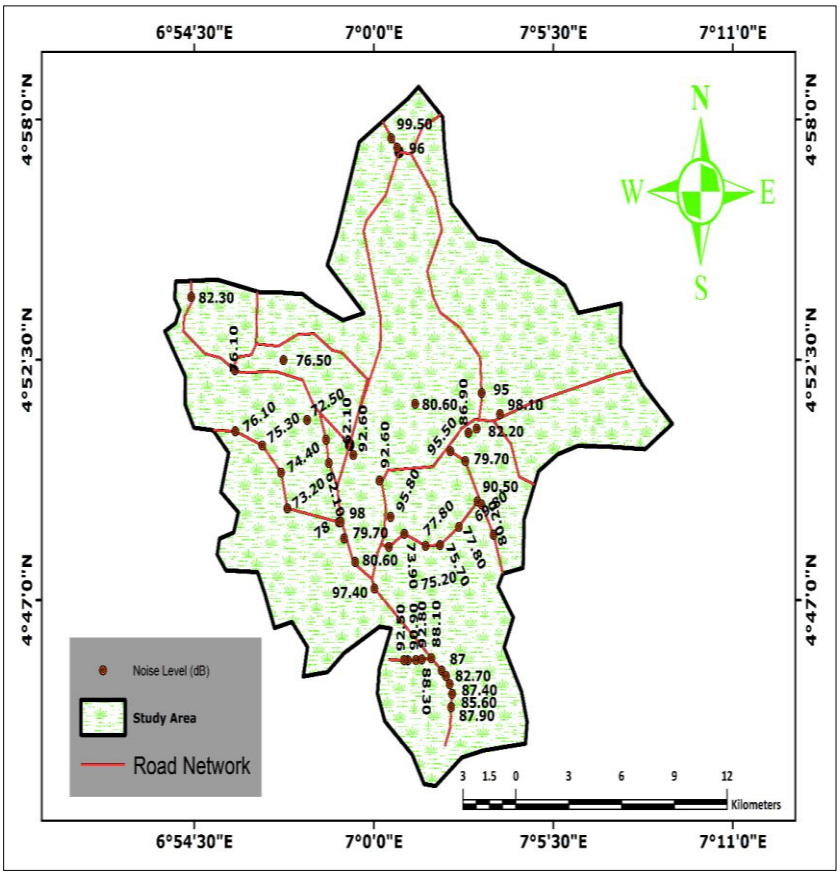

Figure 2 Vehicular Traffic Area Map of Port Harcourt Metropolis

3. Results and discussion

The noise levels were classified into four categories of less than 55dB considered not a problem, 56-65dB as permitted range of values, 66-75dB as higher values and above 76dB as the not permitted value (Table 2) taking into cognizance the national and international standards for vehicular traffic noise pollution allowable limits [11, 13]. The noise levels were considered, compared and established with that of WHO and Nigeria of both national and international values as in Tables 3 and 4 respectively. However, exceeding the existing national and international noise level standards could result to sleep disorder, increased blood pressure, increased heart rate, increased pulse amplitude, vasoconstriction, changes in respiration, cardiac arrhythmias and increased body movement [17]. Accordingly, The Trunk A roads had the highest levels of vehicular noise pollution (Table 2). The New Road Roundabouts had 99.5dB noise pollution, seconded by Rumuola Flyover (98.6dB). There was no record of Trunk A roads having lesser than 75dB noise level indicating that city dwellers and road users along Trunk A roads in Port Harcourt metropolis were vulnerable to physiological and psychological health disaster. Thus, Aggrey Road by Agip Junction (92.8dB) recorded the highest traffic noise pollution among the Trunk B roads, seconded by Habour Rd Junction by First Bank which had (92.5dB). However other junctions and roundabouts with moderately traffic noise levels among the Trunk B roads were Nkpogu Junction (73.9dB), Ordinance Junction (75.7dB), Mother Cat Junction (75.2dB), Location Junction (72.5dB), Peperoni Junction (72.6dB) and Okiltim Junction (62.1dB) respectively. Moreover, the YKC (90.5) had the highest vehicular traffic noise among the trunk C roads, seconded by Police Division Junction (87.9dB) and thirdly by Captain Amagala Junction which had 87.4dB. Other Junctions with moderate vehicular traffic noise were Woji Estate Junction (69.8dB), St John by Rumuolumeni Junction (73.2dB), Eliporanwa Junction (74.4dB) and Egbelu Junction (75.3dB) respectively. According to the vehicular traffic noise index, Aba Road, Airport/Ikwerre Road, East-West Road, Aggrey Road had the highest noise pollution in Port Harcourt metropolis showing possible increase in vehicular traffic counts on these roads. Conversely, Rumuolumeni-Ogbogoro-Ozuoba Road had the least vehicular traffic noise pollution indicating that the people and users of the road would have relatively low-level noise pollution disaster. It was obvious that people around these high noise pollution roads, junctions and roundabouts were vulnerable to health disorder in Port Harcourt metropolis of Nigeria.

Table 2 Index of Roads and Noise Levels Standard Matrix

Road	Junction/Round Abouts	Standards				Scores
		< 55dB (not a problem)	56-65dB (permitted range)	66-75dB (higher range)	> 76dB (there is a problem)	dB
Trunk A						
Aba Road	Eleme Flyover				⌵	98.1
	Artillery Junction				⌵	95.5
	Rumuola Flyover				⌵	98.6
	Waterlines Junction				⌵	95.8
	Mile One Flyover				⌵	97.4
Airport/Ikwerre Road	Igwuruta Roundabout				⌵	96
	New Road Roundabout				⌵	99.5
	Rumuokwuta Roundabout				⌵	92.6
	Agip Roundabout				⌵	98
	Ikoku Junction				⌵	92.8
East-West Road	Uniport Junction				⌵	80.6
	ObiriKwerre Junction				⌵	82.3
	Rumuokoro				⌵	76.5
	Rumukwurushi Junction				⌵	82.2
	Akpajo Junction				⌵	95
Trunk B						
Aggrey Road	Lagos Bustop				⌵	90.9
	Habour Rd Junction by First Bank				⌵	92.5
	Aggrey Rd by Agip Junction				⌵	92.8
	Aggrey Rd by RSIRB				⌵	88.1
	Aggrey Rd by Post Office				⌵	88.3
Trans-Amadi Road	Garrison Junction				⌵	77.8
	Nkpogu Junction			⌵		73.9
	Mother Cat			⌵		75.2
	Ordinance Junction			⌵		75.7
	Slaughter Roundabout				⌵	77.8
Ada-George Road	Location Junction			⌵		72.5
	Okitim Junction		⌵			62.1
	Peperoni Junction			⌵		72.6
	Agip Junction				⌵	78.0

	Mechanic by Ada George Junction				⌵	79.7
Trunk C						
Borokiri Road	Thumson Numbere Junction				⌵	87.0
	Police Div Junction				⌵	87.9
	Kolokuma Street Jumction				⌵	85.8
	Captain Amagala Junction				⌵	87.4
	Bishop Fugbara Junction				⌵	82.7
Woji Road	Woji Junction				⌵	79.7
	RumuibekweJunction (Railway)				⌵	86.9
	YKC Roundabout				⌵	90.5
	Woji Estate Junction			⌵		69.8
	Akan Flyover				⌵	80.2
Rumuolumeni-Ogbogoro-Ozuoba Road	St John by Rumuolumeni Junction			⌵		73.2
	Elioparanwa Junction			⌵		74.4
	Ogbogoro Junction				⌵	76.1
	Egbelu Junction			⌵		75.3
	Ozuoba Junction				⌵	80.2

Table 3 Guideline Values for Community Noise in Specific Environments

(WHO Guidelines)		
Specific Environment	**Critical Health Effects**	**LAeq [Db(A)]**
Outdoor living area	Serious annoyance, day time and evening. Moderate annoyance day time and evening	55 50
Dwelling, indoors Inside bedrooms	Speech intelligibility and moderate annoyance, day time and evening Sleep disturbance, night time	35 30
Outside bedrooms	Sleep disturbance (windows open) (Outdoor values)	45
School classrooms & pre-school schools indoors	Speech intelligibility, disturbance of information extraction, message communication	35
Pre-school bedroom, indoors	Sleep disturbance	30
School playground, outdoor	Annoyance (external source)	55
Hospital, ward rooms, indoors	Sleep disturbance, night time Sleep disturbance, day time and evenings	30 30

Hospital treatment rooms, indoors	Interference with rest and recovery	#1
Industrial, commercial, shopping and traffic areas, indoors and outdoors	Hearing impairment	70
Ceremonies, festivals and entertainment events	Hearing impairment (patrons:<5 times/year)	100
Public Addresses	Hearing impairment	85

(Source: WHO, 1999)

Table 4 Maximum Permissible Noise Levels for General Environment in Nigeria

	Facility	**Noise Limits dBA (Leq)**	
		Day	**Night**
A.	Any building used as hospital, convalescence home, home for the aged, sanatorium and institutes of higher learning, conference rooms, public library, environmental or recreational sites.	45	35
B.	Residential buildings	50	35
C.	Mixed residential (with some commercial and entertainment)	55	45
D.	Residential + industry or small-scale production + commerce	60	50
E.	Industrial	70	60
	Time Frame: use duration Day: 6.00 a.m. - 10.00p.m. Night: 10.00p.m - 6.00a.m The time frame takes into consideration human activity.		

(Source: National Environment Regulations [NER], 2003)

The study indicated that vehicular noise pollution has exceeded the established health standards. According to [18, 19, 20) noise related ailments can cause or trigger annoyance, insomnia and high blood pressure. This indicated that people dwelling in Port Harcourt were at greater risk of psychological and physiological disorder. However, study carried out by [21] on the traffic noise pollution in Banepa, a semi urban town of Nepal showed that noise maximum levels range between 59.11dB to 121dB indicating that motor vehicles contributed the highest noise pollution surpassing the permissible limit. This study expressed that the City has exceeded the Nepal, WHO, OSHA and that of countries like Germany, Australia, Japan, Korea and the Philippines. Furthermore, [22] examined road traffic noise pollution, through sustainable planning approach. It concluded that in Larkana city of Pakistan, noise level ranges from 70dB and 101dB (A) which reflects the severe level of traffic noise in the city surpassing the National Environmental Quality standards of noise in Pakistan. These studies support the current investigation of Port Harcourt where noise pollution has 98.6dB, thereby causing public health challenges especially those contributed by influx of vehicles.

4. Conclusion

This research investigated the characterization of vehicular noise pollution and established health standards in Port Harcourt metropolis, Rivers State, Nigeria. The cause of urbanization, overpopulation and industrialization has immensely contributed to rapid growth of vehicular traffic and pollution across the cities of the world. The study reviewed in its literature that vehicular noise pollution has caused severe psychological and physiological health hazards to the city dwellers in terms of impaired hearing, cardiovascular disease, sleep disability, bad social conduct, loss of memory, interrupted reading and poor understanding, high catecholamine secretion, raised annoyance, hypertension and high blood pressure. The research has added new knowledge that vehicular noise pollution has exceeded the established health standards of 70dB across the roads in Port Harcourt metropolis. It therefore shows that

a good number of people are exposed to different physiological and psychological noise induced health hazards in the study area. It is recommended that there should be expansion and improvement of more road network especially in the southern and western part of Port Harcourt Metropolis. There is need to develop road-safety management framework that will improve the city's built environment and the attitude of road users in order to reduce vehicular noise pollution. The study has recommended that there is urgent need to implement the state and national laws on noise pollution offenders so as to reduce the effects of noise in Port Harcourt metropolis for the purpose of having a healthy and safe city.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that this research does not have any conflict of interest whether commercial or financial association that could be seen as a potential conflict of interest.

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