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ARTICLE

Mapping Vehicular Noise Pollution in Port Harcourt Metropolis, Rivers State, Nigeria: Implication for a Sustainable Urbanization

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ABSTRACT

This study aims to investigate geo-referenced vehicular noise pollution in the Port Harcourt metropolis of Rivers State, Nigeria. Three types of data were gathered for this study. Data from vehicular traffic noise were measured in decibels (dB) using Noise Dosimeter (ND); data from vehicular traffic counts were carried out by observing and counting traffic flow at junctions and roundabouts as well as vehicular traffic noise location map was established by using Global Positioning System (GPS) instrument processed in the Geographic Information System (GIS) environment. The findings indicated that in the northern segment, Igwurita (99.5 dB) and New road roundabout (96 dB), generated the highest vehicular noise in the spatial distribution. In the eastern road segments, Eleme Flyover (98.1 dB) and Artillery Junction (95.5 dB) contributed the highest vehicular noise levels. In the northern segment, New Road (2311 vehicles) and Igwuruta (1566 vehicles) at the roundabouts, generated the highest vehicular traffic counts in the spatial distribution. Thus, among the eastern roads, Eleme Flyover (6735 vehicles) and Artillery Junction (5539 vehicles) contributed the highest vehicular counts in the area. The results showed that the northern and eastern segments of the Port Harcourt metropolis had the highest level of vehicular traffic noise and traffic flow. Thus, the vehicular noise level values have exceeded the recommended 75 dB national and international health standards. The study recommended the construction of more road networks in the southern and western parts of the Port Harcourt metropolis to decongest traffic flow and noise pollution in the northern and eastern segments of the city.

1. Introduction

Globally, noise pollution has caused serious public health to a great number of people. According to World Health Organization (WHO), an estimated 466 million (5% global population) are troubled by hearing loss and over 1.1 million of the affected people are between the ages of 12 to 35 years with global spending of $750 billion annually [1]. The greatest of hearing-impaired people

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are in South Asia, Asia Pacific, sub-Saharan Africa. Thus, noise is drawn from a Latin word called "nausea" which means sea sickness or quarreling. Noise is any sound level can create anger or annoyance with physiological and the psychological impact on an individual [2]. Noise pollution has been greatly contributed to by vehicles. Resultantly, there are 1.2 billion vehicles in the world, WHO estimated 16% a rise in vehicles between 2010 to 2013 globally [3,4]. This suggests that there is an expectant increase in noise pollution resulting from vehicular traffic.

In the United States of America (USA), 104 million people suffer serious health problems related to inducing noise levels of over 70 dBA per day resulting from alteration of the natural environment by human activities and vehicular flow [5]. In Asia, the country of Turkey has recorded tremendous effects of noise pollution due to the greater number of vehicles in the urban areas such as Tokat city which recorded over 65 dBA in residential areas [6]. In Europe, deaths of young people involving children of about 12,000 have been recorded, causing 48,000 ischemic heart disease in the continent [7]. It is estimated that road traffic noise has affected 113 million people, 22 million people are affected by railway traffic and 4 million are affected by aircraft, 12,500 school children have poor learning impairment due to noise pollution [8]. An estimated 18% of city dwellers are exposed to dangerous noise and 14.5% of these people affected are caused by road traffic. Also, 7% of European rural dwellers are affected by road traffic noise [8,7]. In African countries such as Egypt, noise pollution has reached 75 dB ~ 85 dB by exceeding the recommended limit of 60 dB (daytime), 55 dB (evening) and 50 dB (nighttime) which was accelerated by vehicle traffic and poor urban planning [9]. In Nairobi, the capital city of Kenya, Public Service Vehicles (PSVs) generated a noise limit of about 95.9 dBA with the minimum noise level in the northern part recording 92.2 dBA, the western part having 88.7 dBA, the southern part having 83.1 dBA and the eastern part having 81.2 dBA respectively thereby causing serious Noise-Induced Hearing Loss (NIHL), physiological as well as psychological restlessness [9]. In the city of Windhoek, Namibia, vehicular and industrial activities contributed to noise pollution ranging between 64 dBA ~ 72 dBA thereby exceeding the WHO standard of 70 dBA in residential areas [10,11].

Serkan, Hasan, Murat and Pervin (2009) studied the evaluation of noise pollution caused by vehicles in the city of Tokat in Turkey using noise level meters at 65 sample points. Statistical relationships showed that vehicular noise pollution on the streets of Tokat varies significantly with some areas exceeding 65 dB above the national recommendation of the Turkish noise control regulation for residential areas. The study recommended proactive reduction of noise pollution sources especially vehicular traffic noise [6]. However, Stansfeld, Haines and Brown (2000), Passchier-Vermeer and Passchier (2000), Quis, (2001), Job (1996), Evans and Hygge (2000) studied the effects of noise in cities using an experimental approach. Findings showed that noise pollution affects sleeping, social behavior, hypertension, cardiovascular disease, psychological symptoms, psychiatric disorders, raised catecholamine secretion, disrupts reading and understanding, long-term memory and high blood pressure as well as causes annoyance [12-16]. Thus, Dancan, Christopher and James (2015) assessed the effects of noise pollution on 60 randomly selected Public Service Vehicles (PSVs) in Nairobi City, Kenya using digital noise level meters. The study analyzed the differences in noise levels and sources across various routes using statistical techniques and student t-tests. Findings showed that noise generated by vehicular traffic was accelerated by the giant speakers and amplifiers of the vehicles especially Public Service Vehicles (PSV) which was a great source of noise pollution in the urban area [9].

Nowadays, more people are dwelling in the cities more than ever before because of the underdeveloped nature and high-level insecurity of most rural dwellings especially the current situation of insecurity in Nigeria. However, over 4.2 billion were already residing in the cities in 2018 [17]. Thus, this population is commuted by vehicles which top-up the already existing noise level in the cities. The increased urbanization is making people and vehicles denser resulting in more noise pollution. Urbanization has caused contemporary global problems that involve greater number of the population buying more vehicles for the movement of people and commodities as well as services. Vehicular noise pollution is a by-product of the Industrial Revolution in Europe. Thus, the population of people and vehicles are rapidly increasing day by day and as such, noise pollution is increasing as vehicle volumes rise [18].

Vehicular traffic noise pollution occurs from the sound of vehicles and commuter passengers. Vehicular noise levels can increase with bad vehicle conditions and congestion of vehicles at bottleneck roads and roundabouts. It can also occur due to over-throttling of the acceleration pedal of the vehicle in motion [7]. Many variables have contributed to the increased noise level pollution in the cities. These factors include bad roads, uncontrolled traffic, high vehicular loudspeakers, shouting of passengers, bad exhaust of vehicles, the bad engines and others [19]. The rapid population of vehicles and people has resulted in serious noise pollution with its attendant health effects that are making the cities very uncomfortable to live [20].

In this vein, this study is aimed at geo-referencing vehicular noise pollution in Port Harcourt Metropolis of Rivers State, Nigeria.

2. Methodology

Port Harcourt area is located within latitudes 04° 30N and 05° 30N as well as longitudes 06° 30E and 07° 30E in the Tropical country of Nigeria (Figures 1 and 2). Port Harcourt is situated in the coastal environment, close to the Atlantic Ocean in the south-south zone of Nigeria. Port Harcourt city experience the harmattan wind that takes place from December to January of every year. The city experiences land-to-sea breezes due to its location close to the Atlantic Ocean. Port Harcourt has an average relative humidity of 80% which is at its peak from April to September but experiences low relative humidity during the dry season from January to March [21,22]. The city has a rainfall range of 2000 mm to 2500 mm [23]. It has an average temperature of 32 °C especially during the dry season from January to March and 26 °C July [24]. The thickness of the cloud is 6 oktas during the wet season with a wind velocity of 0 ~ 3 m/s [21,22]. The calm climatic features of Port Harcourt characterizes the thick vegetation cover and rapid urbanization that has resulted in high traffic volumes in the city area.

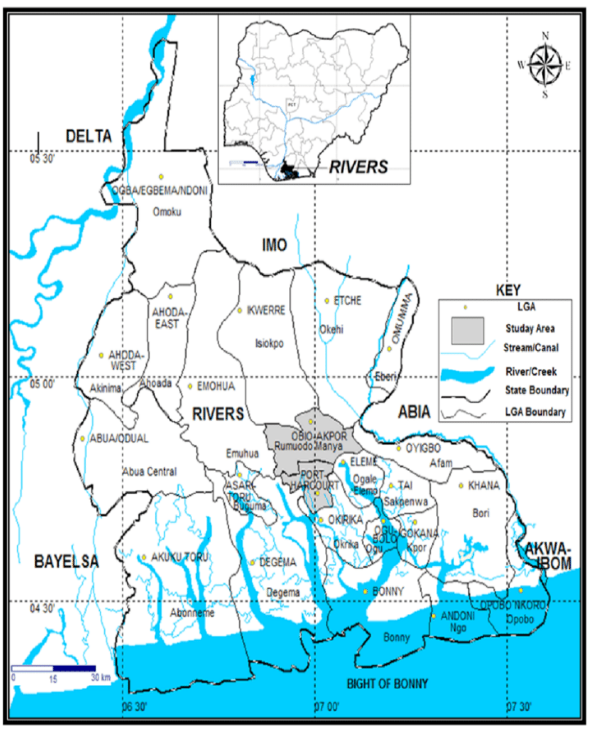

Figure 1. Study Area of Port Harcourt metropolis in Rivers State

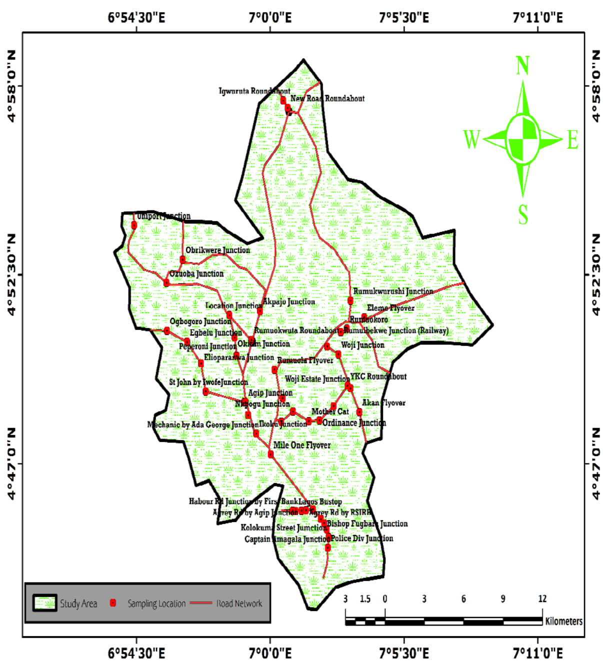

Figure 2. Road Network Locations of Port Harcourt Metropolis

The sampled roads, GPS coordinates, traffic counts and vehicular traffic noise are as in Table 1. Three types of data were gathered for this study: Data from vehicular traffic noise (in decibel dB) using Noise Dosimeter (ND) known as Noise Level Meter (NLM); data from vehicular traffic counts by observation and counting as well as vehicular traffic noise location map data using Global Positioning System (GPS) instruments. The field data collection took place from January 17th to February 27th, 2021 (one month and two weeks). In the first week (January 17th to January 23rd) field assistants were trained for data collection. In the second week (January 24th to January 30th) field reconnaissance survey and sample location mapping were carried out. Thus, from the third to sixth weeks (January 31st to February 27th) one month, data observation and measurements were undertaken. This period is expected to have the highest traffic flow due to the reason that people make many returning trips from their end-of-year travels. Also, the beginning of the year is one peak period with vehicular traffic flow in the cities. The vehicular traffic noise level data were measured using the Noise Level Meters placed at different purposively selected locations of the road such as junctions and roundabouts (a total of 9 roads and 5 sample points per road summing it to 45 sample points) at a height between 1.20 m and at a distance 2 m ~ 3 m from traffic noise sources [27-29]. Another work has used the sound level meter placed on the pavement of the streets at about 1.2 m height and a distance of about 7.5 m from the existing road level [31].

However, data for vehicular traffic counts and noise levels were randomly collected at different roundabouts and junctions across the various road segments. The reasons for choosing roundabouts and junctions were because of observed high traffic volumes and the resultant noise level due to vehicular speeds, high traffic jams, the hooting of passengers to board vehicles and the bottle-neck nature of their intersections [34].

The Septa Square 15-minute measurement period was used where the number of vehicles was counted and vehicular traffic noise level was recorded every 15 minutes for an hour in the morning (7:00-8:00 a.m.), afternoon (2:00-3:00 p.m.) and evening (5:00-6:00 p.m.). Thus, the mean noise levels of the hourly vehicular traffic noise were calculated and recorded. The nose levels in the morning, afternoon and evening were divided by three to give the average noise level for each day for the period under study. This was done for all the sampled roads across the city. The counted vehicles were identified as Cars, Vans, Lorries and Tricycles [30,27,32]. The GPS instruments were used to establish the locations of all the sample points of the vehicular traffic counts and noise (Table 1). The evaluation and combination of the generated GPS coordinate data and vehicular traffic noise were used to produce the vehicular noise traffic map of the study area.

Table 1. Sampled Roads, GPS Coordinates, 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	7º 03’ 26”	4º 51’ 14”	6735	98.1
	Artillery Junction	7º 02’ 20”	4º 50’ 23”	5539	95.5
	Rumuola Flyover	7º 00’ 16”	4º 49’ 43”	5200	98.6
	Waterlines Junction	7º 00’ 31”	4º 48’ 33”	5424	95.8
	Mile One Flyover	7º 00’ 00”	4º 47’ 15”	6252	97.4
Airport/Ikwerre Road	Igwuruta Roundabout	7º 00’ 32”	4º 57’ 33”	1566	96
	New Road Roundabout	7º 00’ 43”	4º 57’ 20”	2311	99.5
	Rumuokwuta Roundabout	6º 59’ 22”	4º 50’ 18”	1859	92.6
	Agip Roundabout	6º 58’ 56”	4º 48’ 46”	1616	98
	Ikoku Junction	6º 59’ 25”	4º 47’ 51”	1654	92.8
East-West Road	Uniport Junction	6º 54’ 24”	4º 53’ 56”	258	80.6
	ObiriKwerre Junction	6º 57’ 14”	4º 52’ 28”	268	82.3
	Rumuokoro	7º 03’ 02”	4º 50’ 54”	180	76.5
	Rumukwurushi Junction	7º 03’ 18”	4º 51’ 43”	288	82.2
	Akpajo Junction	7º 01’ 16”	4º 51’ 28”	478	95
Trunk B (State Roads)					
Aggrey Road	Lagos Bustop	7º 01’ 02”	4º 45’ 36”	5168	90.9
	Habour Rd Junction by First Bank	7º 00’ 55”	4º 45’ 36”	6108	92.5
	Aggrey Rd by Agip Junction	7º 01’ 17”	4º 45’ 36”	5388	92.8
	Aggrey Rd by RSIRB	7º 01’ 28”	4º 45’ 37”	4219	88.1
	Aggrey Rd by Post Office	7º 01’ 46”	4º 45’ 39”	5558	88.3
Trans-Amadi Road	Garrison Junction	7º 00’ 27”	4º 48’ 12”	383	77.8
	Nkpogu Junction	7º 00’ 55”	4º 48’ 30”	333	73.9
	Mother Cat	7º 01’ 35”	4º 48’ 13”	344	75.2
	Ordinance Junction	7º 02’ 01”	4º 48’ 14”	354	75.7
	Slaughter Roundabout	7º 02’ 36”	4º 48’ 39”	388	77.8

Table 1 continued

Road Trunks (A, B, C)	Name of Roundabout/Junction	GPS Coordinate Easting	GPS Coordinate Northing	Vehicular Traffic Count	Noise
Ada-George Road	Location Junction	6º 57' 56"	4º 51' 06"	328	72.5
	Okitim Junction	6º 58' 24"	4º 50' 39"	203	62.1
	Peperoni Junction	6º 58' 36"	4º 50' 07"	317	72.6
	Agip Junction	6º 58' 58"	4º 48' 46"	422	78.0
	Mechanic by Ada George Junction	6º 59' 05"	4º 48' 23"	441	79.7
Trunk C (Neighborhood Roads)					
Borokiri Road	Thumson Numbere Junction	7º 02' 04"	4º 45' 22"	3304	87.0
	Police Div Junction	7º 02' 22"	4º 44' 32"	4835	87.9
	Kolokuma Street Jumction	7º 02' 24"	4º 44' 49"	3250	85.8
	Captain Amagala Junction	7º 02' 19"	4º 45' 03"	4292	87.4
	Bishop Fugbara Junction	7º 02' 13"	4º 45' 14"	5432	82.7
Woji Road	Woji Junction	7º 02' 48"	4º 50' 10"	280	79.7
	RumuibekweJunction (Railway)	7º 02' 54"	4º 50' 49"	401	86.9
	YKC Roundabout	7º 03' 10"	4º 49' 14"	455	90.5
	Woji Estate Junction	7º 03' 18"	4º 49' 10"	170	69.8
	Akan Flyover	7º 03' 40"	4º 48' 28"	325	80.2
Rumuolumeni-Ogbogoro-Ozuoba Road	St John by Rumuolumeni Junction	7º 57' 21"	4º 49' 05"	328	73.2
	Elioparanwa Junction	6º 57' 09"	4º 49' 54"	297	74.4
	Ogbogoro Junction	6º 55' 45"	4º 50' 51"	351	76.1
	Egbelu Junction	6º 56' 34"	4º 50' 31"	350	75.3
	Ozuoba Junction	6º 55' 44"	4º 52' 14"	407	80.2

3. Results and Discussion

The spatial distribution of noise across the space of Port Harcourt indicated that the northern and eastern roads of the metropolis had the highest noise pollution as well as those of the southern roads respectively (Figure 3). In the northern segment, Igwurita (99.5 dB) and New road roundabout (96 dB), generated the highest vehicular noise in the spatial distribution. Thus, among the eastern roads, Eleme Flyover (98.1 dB) and Artillery Junction (95.5 dB) contributed the highest vehicular noise levels in the series. However, Ikoku Junction (92.8 dB) and Habour Road Junction by First Bank (92.5 dB) generated the highest vehicular noise among the roads located in the southern segment of the Port Harcourt metropolis. The part with the least vehicular noise pollution was the western segment with the UNIPORT junction (82.3 dB) and Rumuokwuta Roundabout (92.6 dB) having the highest. The spatial distribution of vehicular noise in the metropolis of Port Harcourt showed that they were not evenly dispersed in space.

Vehicular noise pollution is a product of vehicular counts on the road network. In the northern segment, New Road (2311 vehicles) and Igwuruta (1566 vehicles) Roundabouts generated the highest vehicular counts in the spatial distribution. Thus, among the eastern roads, Eleme Flyover (6735 vehicles) and Artillery Junction (5539 vehicles) contributed the highest vehicular counts in the area. However, Mile One Flyover (6252 vehicles) and Habour Road Junction by First Bank (6108 vehicles) generated the highest vehicular counts among the roads located in the southern segment of the Port Harcourt metropolis. The part with the least vehicular counts was the western segment with Rumuokoro (180 vehicles) and Uniport Junction (258 vehicles). The spatial distribution of vehicular counts in the metropolis of the Port Harcourt showed that they were not evenly distributed in space (Figure 4).

The spatial distribution of vehicular noise pollution across the space of Port Harcourt showed that the northern and eastern roads of the metropolis had the highest noise pollution. The roads with the highest noise in the northern segment were Igwurita (99.5 dB) and New Road roundabout (96 dB). In the eastern section of the metropolis, Eleme Flyover (98.1 dB) and Artillery Junction (95.5 dB) generated the highest vehicular noise level.

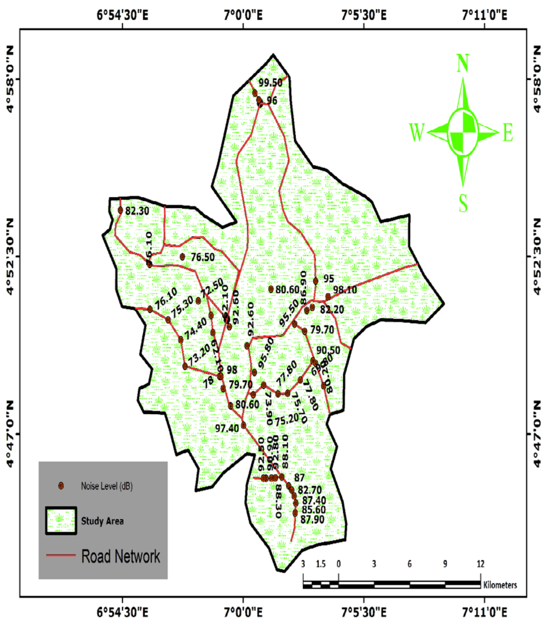

Figure 3. Spatial Distribution of Vehicular Noise Pollution in Port Harcourt Metropolis

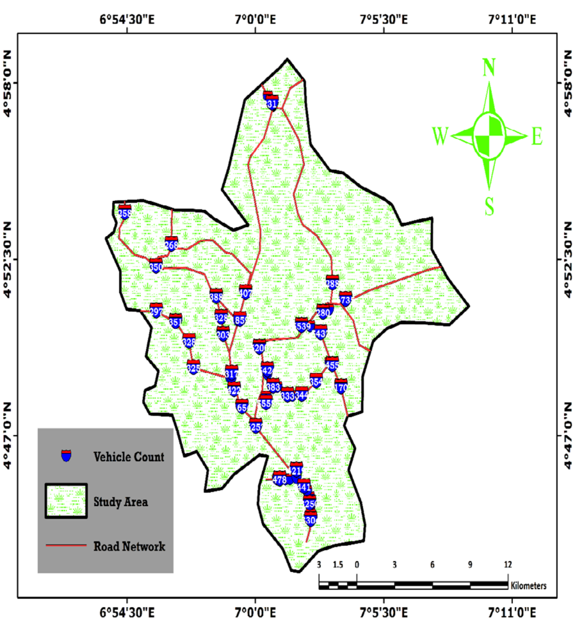

Figure 4. Spatial Distribution of Vehicular Counts in Port Harcourt Metropolis

In this vein, Evans and Hygge (2000) investigated the spatial distribution of traffic-induced noise exposures in a US city: An analytic tool for assessing the health impacts of urban planning decisions using a simple GIS-based noise model. The study discovered that urban noise was found to increase by 6.7 dB resulting from a rise in vehicular traffic on the streets. The spatial distribution of noise indicated that noise along arterial streets increased annoyance by 40%. Also, traffic noise pollution increased in the city's fastest-growing neighborhoods such as the Southern Market Area and those found in Chinatown and Downtown Civic Center. Thus, the study estimated that 17% of the city's population was at risk of high annoyance from vehicular traffic noise in different quarters of the city [16]. Similarly, a study was conducted on the traffic noise pollution assessment of Tehran, the capital city of Iran using the GIS-based spatial distribution map. The result indicated that the maximum equivalent sound level (Leq) was recorded on Basij Highway that is connecting the Central Business District (CBD) of the city at a maximum vehicular noise pollution level of 84.2 dB(A). But the roads around Fajr Hospital had minimum vehicular traffic noise of 59.9 dB(A). These studies, therefore, showed that spatial distribution of vehicular noise pollution can spread differently across the various roadways and in different segments of the city area using the GIS approach [17]. However, noise pollution has been studied in several cities of the world using the Geographic Information System (GIS) with data captured by the Global Positioning System (GPS) and noise level meter. A study was carried out on noise pollution in the city of Nairobi in Kenya. The researchers used the GPS to identify noise spots in CBD and applied the noise level meter to collect noise data. The findings showed that the average noise levels ranged between 61 dB to 78 dB which rose from the western part to the eastern segment of the CBD and was caused mainly by vehicular traffic noise on hot spots found more in the eastern city area [18]. Accordingly, a study has conveniently used the GIS to generate and analyzed data by applying deterministic and statistics models [19]. Furthermore, they spatially examine the dynamics of traffic-induced noise in the city of Tehran by using the Federal Highway Administration Traffic Noise Model (FHWA-TNM) and Iranian Traffic Noise Predictor (ITNP) and presented them in a GIS platform. Measurements were carried out during low and high traffic times within a time frame of six months. The results showed that the commercial areas had the highest noise level which was caused by poor regulation of traffic noise in the study area.

4. Conclusions

This study examined the georeferencing of vehicular noise pollution in the Port Harcourt metropolis. Many cities across the world are faced with noise pollution problems emanating from urbanization, industrialization and overpopulation which have resulted in serious psychological and physiological discomfort to the city dwellers. Thus, the study reviewed that there is a high risk of vehicular noise pollution across the cities of the world. The study used purposive and systematic approaches to investigate the spatial spread of noise pollution in the city area by employing the GIS techniques in capturing locations of roundabouts and junctions, traffic count and noise level measurement. The vehicular noise level values have exceeded the recommended 75 dB national and international standards thereby exposing 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 city dwellers who are more affected by vehicular noise pollution are those located in the northern and eastern segments of the Port Harcourt metropolis with noise levels above 75 dB indicating that they are at risk of a psychological and physiological disorders. This study has empirically established that vehicular traffic counts vary across the selected roads; and that there is a strong relationship between vehicular counts and noise pollution. This implies that the higher the vehicular volume at roundabouts and junctions the greater the vehicular noise pollution across the roads in the metropolis. It therefore concludes that some cities have exceeded their vehicular noise pollution and environmental comfort threshold. This study recommends the expansion of more roads to the southern and western segments of the city to reduce traffic flow in the norther and eastern sections. Furthermore, there is a need to develop and implement a road-safety management framework targeting improving the attitude of road users and the environment for a sustainable city free from annoying noise levels.

Conflict of Interest

There is no conflict of interest.

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