CHARACTERIZATION OF THE VULNERABILITY OF SCHOOL CHILDREN EXPOSED TO ROAD TRAFFIC NOISE IN SOME SELECTED SCHOOLS IN ZARIA, KADUNA STATE, NIGERI

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Abstract: Noise is considered as an environmental pollutant to which man is subjected to throughout his life. It has been reported to cause cardiovascular diseases, annoyance, aggression, impairment of cognitive performances and productivity. This study therefore investigated the impacts of traffic noise on the outdoor noise in an academic environment. The outdoor and traffic noise were quantified using a sound level meter. The collected data were used to evaluate noise parameters such as noise pollution level (LNP), equivalent continuous noise level (Leq.), traffic noise index (TNI), and Noise climate (NC). The traffic volumes around the schools were also evaluated which indicated high frequencies of road users particularly motorcycles. The outdoor noise levels ranged between 75.7-98.5dBA which exceeded the WHO standard of 55dBA and the traffic noise indices for the schools ranged between 56.2-122.7dBA. The Traffic Noise Indices were positively correlated (r=0.279) with the outdoor noise levels. The planting of trees around the schools and installation of noise barriers should be encouraged to reduce the high outdoor noise levels.
Keywords: Acoustics, noise pollution, outdoor noise, school, traffic noise, Zaria

Introduction

With the continuous growth of population, the urbanization of several cities in Nigeria is at a quick and fast pace. The population of Nigeria was estimated at 182.2 million people in 2015 and Zaria was said to have 975,200 inhabitants. The rapid growth of urban population results in increased demands for transport and as such in turn result into vehicle induced noise which contributes to problems of high noise levels (Ayaz and Rahman, 2011). Environmental challenges and opportunities vary considerably among schools around the world, across countries and within communities (World Health Organization, 2004). Nowadays, children experience a key part of their childhood in their school and it forms one of their principal social activities and setting (Alusiabe, 2014). The Ottawa Charter for Health Promotion stated that "health is created and lived by people within the settings of their everyday life; where they learn, work, play and live" (WHO, 1987).

WHO defines a health-promoting school as "one that constantly strengthens its capacity as healthy setting for living, learning and working" (WHO, 2014). The American Academy of Pediatrics defines a "healthful school environment" as "one that protects students and staff against immediate injury or disease and promotes prevention activities and attitudes against known risk factors that might lead to future disease or disability" (America Academy of Pediatrics, 1993). The school environment encompasses the social, physical and biological factors. Learning in classrooms is mainly facilitated through verbal and auditory communication between teachers and students (Flexer and Long, 2003). High noise levels in the classroom impair oral communication, causing students to become tired sooner more often, and this premature fatigue tends to have a negative effect on their cognitive skills (Hagen *et al.*, 2002).

Environmental pollution becomes more severe and widespread due to population growth, urbanization and industrialization in the cities (Ralte *et al.*, 2013). There are many factors which cause the environment to be polluted and one of those undesired and unpleasant factor is 'noise' which affects the quality of life (Haq *et al*., 2014). Noise pollution is one of the major problems for developing countries. There is a need to control the noise exposure levels in sensitive areas as hospitals, schools, and kindergartens (Amin *et al*., 2014).

Noise pollution has become an important environmental problem in that it has negative impacts on public health both physically and psychologically (Stansfeld and Matheson, 2003). Due to urbanization and industrialization, noise pollution has gained attention and as an environmental hazard rated third to air and water pollution (Singh and Davar, 2004). Besides the psychosocial effects of community noise, there is concern about the impact of noise on public health, particularly regarding cardiovascular outcomes (Stansfeld, 2000). Several attempts have been made to study the detrimental effects of chronic exposure to external noise in the several communities. But few studies have been carried out to examine the effects of road noise on outdoor noise in primary schools. The present study has been carried out to assess the traffic noise levels around some schools with close proximity to the road sides in Zaria.

Materials and Methods

This study was a cross-section survey which involves the quantification of environmental noise levels at some specific geographic coordinates of the city of Zaria. The selected nine schools used in this study were situated close to the road sides and as such exposed to different types of vehicular noise. This study therefore tends to focus on noise pollution which causes health hazards and cognitive impairment of the pupils in the course of learning. The quantification were carried out twice per day on a 2-day assessment along the roadsides and on the corridor of the classrooms between the hours of 8:00-10:00 a.m. and 11:00-12:45 p.m.The meter was held at an angle 45º to avoid deflection of sound waves by the body of the researcher. Sound level measurements were made for 40 min. The manual count of the number of automobiles like buses, cars, trunks, motorcycles (bikes) around the schools was measured during the study period. The geographic coordinates of the schools were determined using GPS (Extrex Legend Garmin, Made in Taiwan).

An EXTECH 407732 sound level meter which meets ANSI and IEC 65 Type 2 Standards, with high and low measuring ranges with basic accuracy of ±1.5 dB, fast and slow response was used to quantify the noise levels. The sound level meter was set to A-weighting and slow response. The quantified instantaneous noise levels (L_{AI}) was used to determine the different noise level percentiles values L_{10}, L_{50}, and L_{90} which were used for the evaluation of the Noise Climate (NC),

equivalent noise level (Leq), the traffic noise index (TNI), and the noise pollution level (LNP). The Leq is defined as the total energy response by human ear and indicator of physiological disturbance to the hearing mechanism. The L_{10} and L_{90} are both instantaneous noise levels that exceeded 10% and 90% of the time, while L_{50} is said to constitute the background level in the absence of nearby noise sources. And the NC is the range over which the sound levels are fluctuating in an interval of time.

$L_{NP} = L_{Aeq.} + (L_{10}-L_{90})$

$NC = L_{10} - L_{90}$

$LAeq. = 10Log\frac{1}{T}\sum_{i=1}^{n} 10^{\frac{Li}{10}} * ti$

$TNI = 4*(L_{10}-L_{90}) + L_{90} - 30dB\ (A)$

Where 30 is the correction factor;

(Essandoh and Armah, 2011).

A correlation analysis was performed to determine the relationship between the outdoor noise level and the traffic noised index. SPSS version 20 was used for the data analysis and the results were described using descriptive statistics both in tabular and graphical forms.

Results and Discussion

Variation of outdoor noise levels (LNP) and the continuous equivalent noise level (L_{Aeq}) from morning to afternoon

Figs. 1, 2, & 3 present the variations of the outdoor noise pollution level, Continuous equivalent sound energy and the average outdoor noise level quantified on the corridors of the classrooms in the morning and afternoon. It was observed that the variations from morning to afternoon were not greatly different as the highest variation was observed in ALHCZ with 15.06 dB (A) (as shown in Fig. 1) higher in the afternoon. However, in all the nine surveyed schools, the noise pollution level exceeded the World Health Organization Standard of 55 dB (A) (Fig. 2) in an academic environment. This could be as a result of the closeness to the road, surrounded by residential buildings, shops and other business centers which make use of electronic devices to enhance the sale of their goods and services. It was observed likewise that majority of the schools have fewer or no trees planted within and around the schools which could have served as noise intensity absorber. Kamal and Abd El-Rahman (2010) reported that noise levels affecting schools in Cairo-Egypt showed that all these schools suffered from the outdoor noise sources, where the average monthly outdoor noise levels for the majority of schools exceeded the permissible limits by approximately (13-18) dB (A) in the day period. Also, Kamal *et al.* (2010) have reported that the noise levels in schools outdoor ranged between 73-78 dB during the daytime. It was concluded that the façades most exposed to road traffic noise are subjected to values higher than 55.0 dB(A), and noise levels inside the classrooms are mainly due to the schoolyard, students, and the road traffic (Silva *et al.*, 2016). The report of Ozer *et al.* (2014) on the noise pollution in the Ataturk University, Turkey has also revealed the average noise level of 62.70 dB (A) which also exceeded the permitted value.

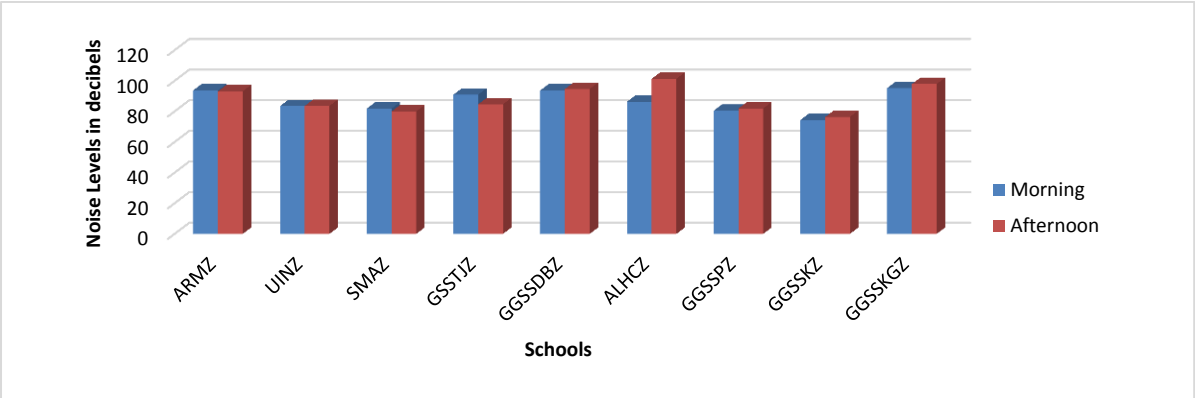

Fig. 1: Variation of outdoor noise level (LNP)in schools with period of the day

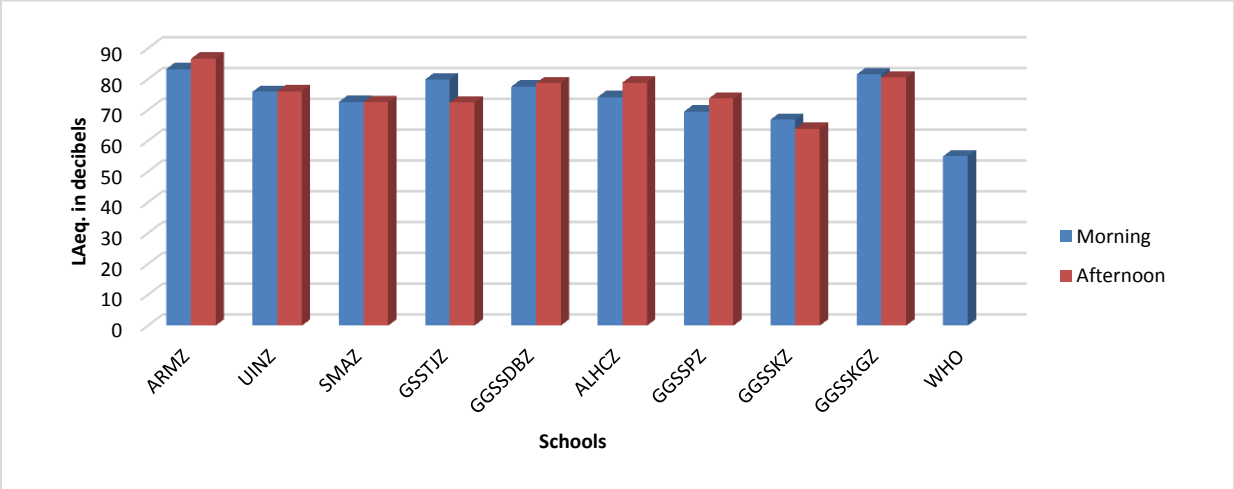

Fig. 2: Variation of outdoor L_{AeqMA} in schools with period of the day

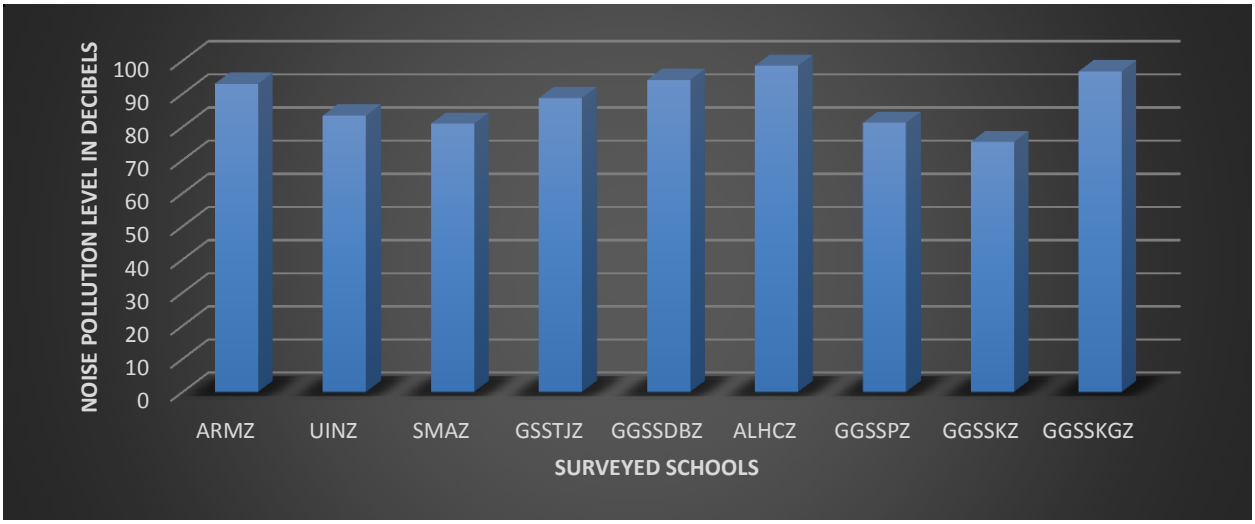

Fig. 3: Average noise pollution level of the surveyed schools

Table 1: Average traffic noise level around the schools

S/N	SCHOOL	L_{10}	L_{50}	L_{90}	L_{EQ}	LNP	TNI	NC
1.	ARMZ	83.3	70.8	67.7	74.5	92.6	122.7	14.3
2.	SMAZ	71.9	64.5	58.6	68.1	83.7	109.6	13.5
3.	UINZ	80.1	72.6	69.1	74.7	86	88.6	11.1
4.	ALHCZ	75.9	73.5	68.3	74.7	83.5	74	8.1
5.	GGSSPDZ	71	64	60.6	66	78.9	87.4	12.7
6.	GGSSKZ	65.3	62.6	58.8	63.4	70.3	56.2	5.9
7.	GSSTJZ	71.6	62.9	58.8	66.2	83.7	104	16.7
8.	GGSSDB	79.9	71.5	66	75.2	90.2	95.7	11.4
9.	GGSSKGZ	77.4	70.3	65.8	72.6	62.3	90	11

ARMZ – Abdul Rahman Mora L.G.E.A. Primary School, Zaria; SMAZ – Sarki Musa L.G.E.A. Primary School, Zaria; UINZ – U.B.E. Isan Nabawa Primary School, Zaria; ALHCZ – Al Huda Huda College, Zaria; GGSSPDZ – Government Girls' Secondary School, Pada, Zaria; GGSSKZ – Government Girls' Secondary School, Kongo, Zaria; GSSTJZ – Government Secondary School, Tundun-Junkun, Zaria; GGSSDBZ – Government Girls' Secondary School, Dogo-Bauchi, Zaria; GGSSKGZ – Government Girls' Secondary School, kofa-Gayan

Average traffic noise level around the schools

The results in Table 1 indicated the average traffic noise around the surveyed schools. The traffic noise index was observed to range between 56.2-122.7 dBA. ARMZ was observed to have the highest TNI owning to the fact that the road that passed the school was a collector road having so many arterial roads connected to it, and as such experienced high volume of traffic. Rajiv *et al.* (2012) have reported a high Leq value of 63.71 dBA in the educational zone of Kolhapur, India. Marathe (2012) reported TNI value of 77.4-92.6 dBA along four streets in India. Paunovic *et al.* (2013) had earlier reported that Leq near homes with public transport were 5-12 dBA higher than noise levels measured near homes without public transport. Goswami *et al.* (2011) investigated traffic noise levels along a road connecting two university campuses in Balasore City. They reported that the sources of noise along the area were predominantly due to vehicular traffic with heavy vehicles being the major emitters. The study reports that headache, bad temper, hearing problem, and loss of concentration were some of the significant effects due to high noise levels. Road traffic noise is a possible risk factor for arterial hypertension among adults (Belojevic *et al.*, 2008a). The exposure to road traffic noise increases blood pressure levels in preschool children (Belojevic *et al.*, 2008b) and school children (Paunovic *et al.*, 2009). The presence of public transport near schools correspond to a slight increase in children's systolic pressure (by 1.3 mmHg), independent of children's age, gender, family history of hypertension, physical activity, and eating habits.

Traffic volume around the schools

The Figs. 4-12 show the results of manual count of traffic density around the surveyed schools. Around all the visited schools, it was observed that the highest frequency was motorcycles (bikes). This shows that a large percentage of traffic noise is mostly generated by the motorcycles owing to the fact that it can access nook and cranny, population of people making use of it is much. Ana *et al.* (2009) earlier said the noise generated by mobile sources on nearby primary roads could be partially or completely responsible for the various environmental and health and learning related measurements obtained in their pilot study's secondary schools in Ibadan.

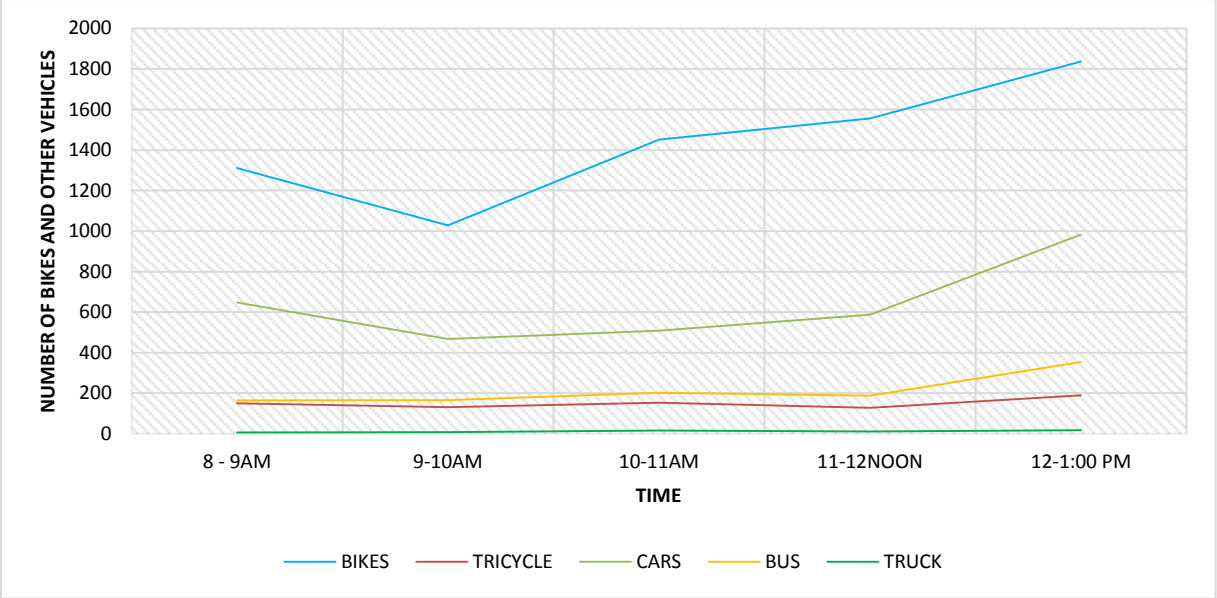

Fig. 4: Mean observed 2-day traffic density on the main roads near ARMZ by hour during school hour

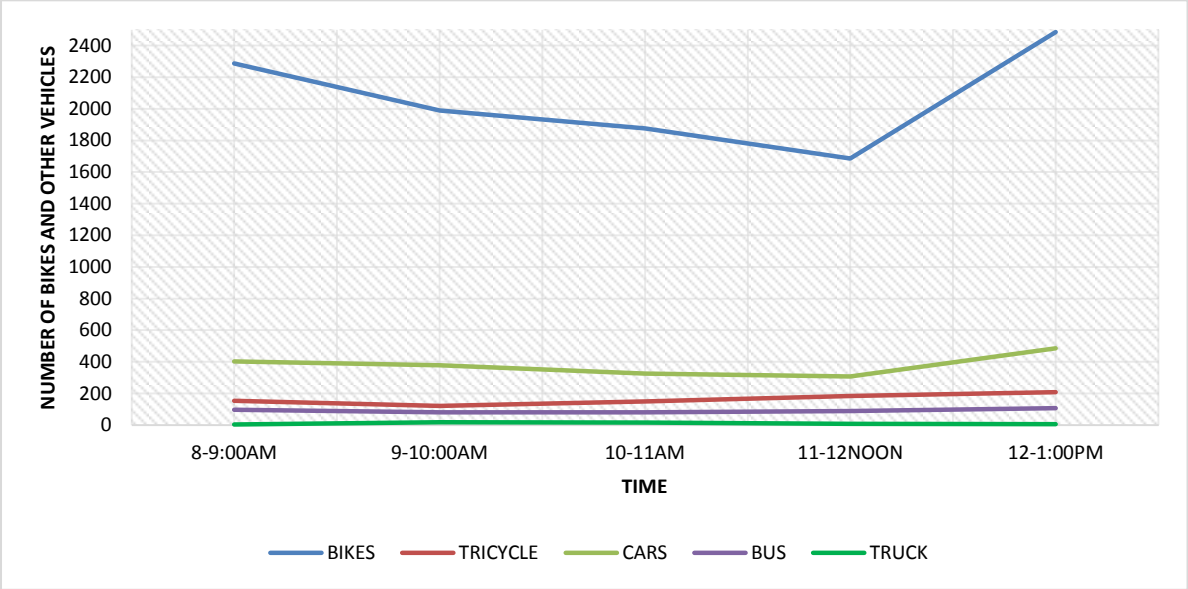

Fig. 5: Mean observed 2-day traffic density on the main road near GSS, Tundun-Junkun, Zaria, Nigeria, by hour during School hours

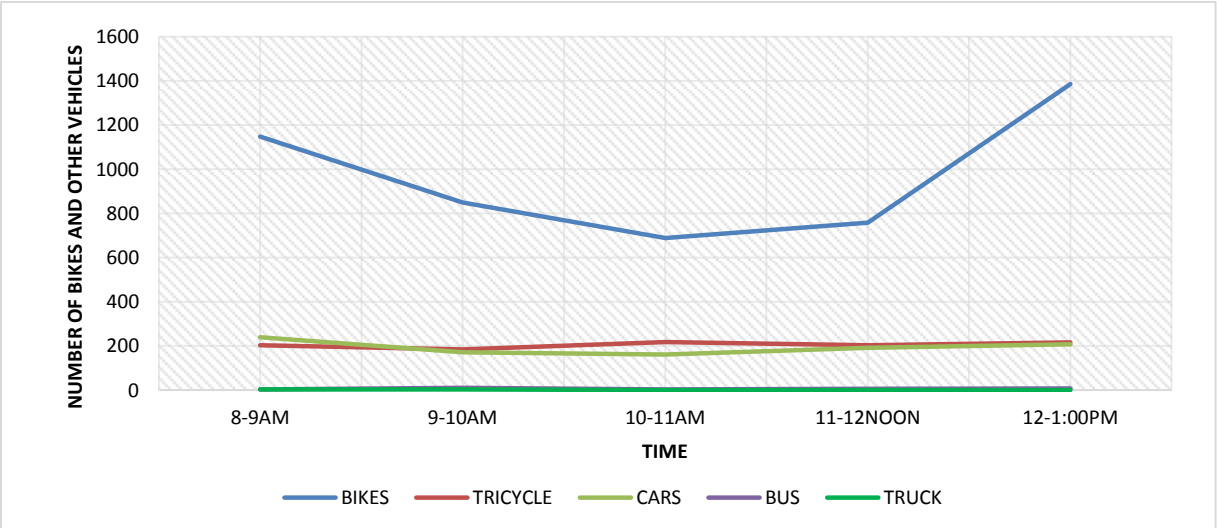

Fig. 6: Mean observed 2-day traffic density on the main road near UBE Isan Nabawa Primary School along Gangare, Zaria, Nigeria by hour during School hours.

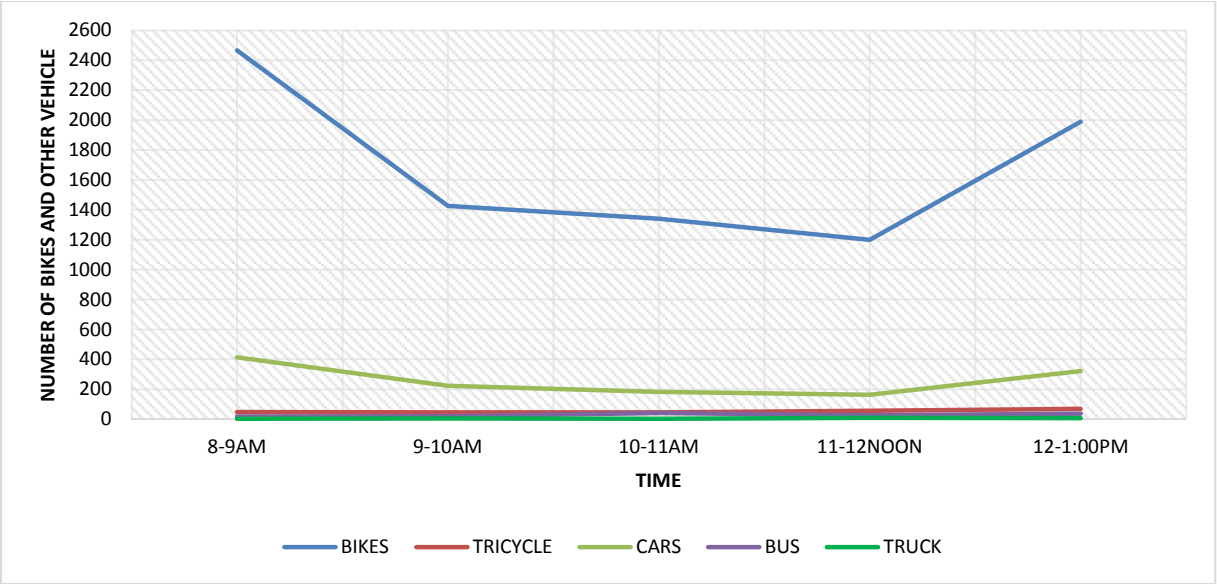

Fig. 7: Mean observed 2-day traffic density on the main road near GGSS Dogon-Bauchi, Sabon-Gari, Zaria, Nigeria by hour during school hours

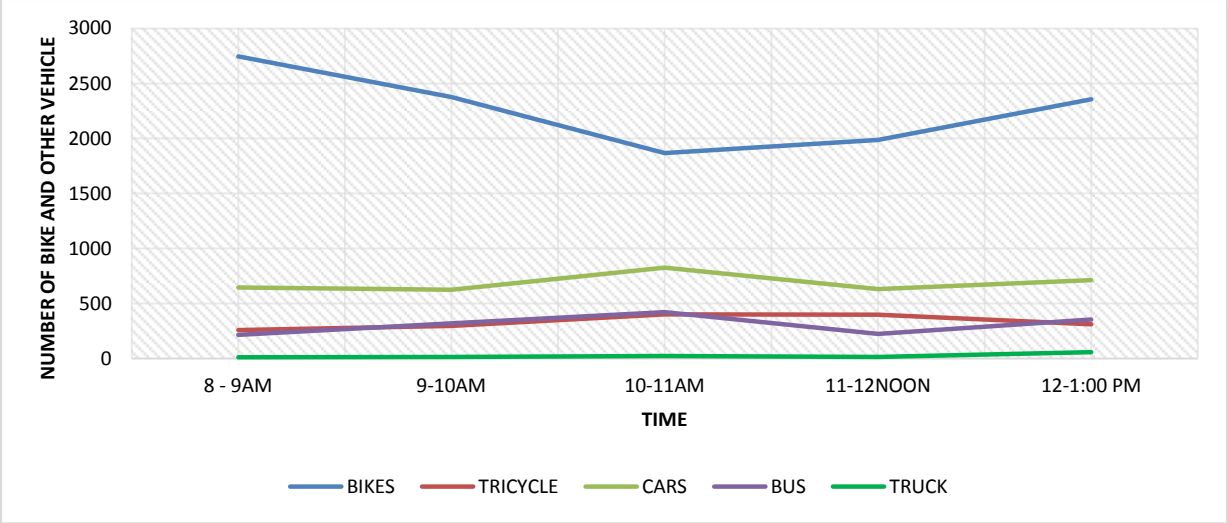

Fig. 8: Mean observed 2-day traffic density on the main road near Alhuda Huda College, Zaria, Nigeria by hour during school hours

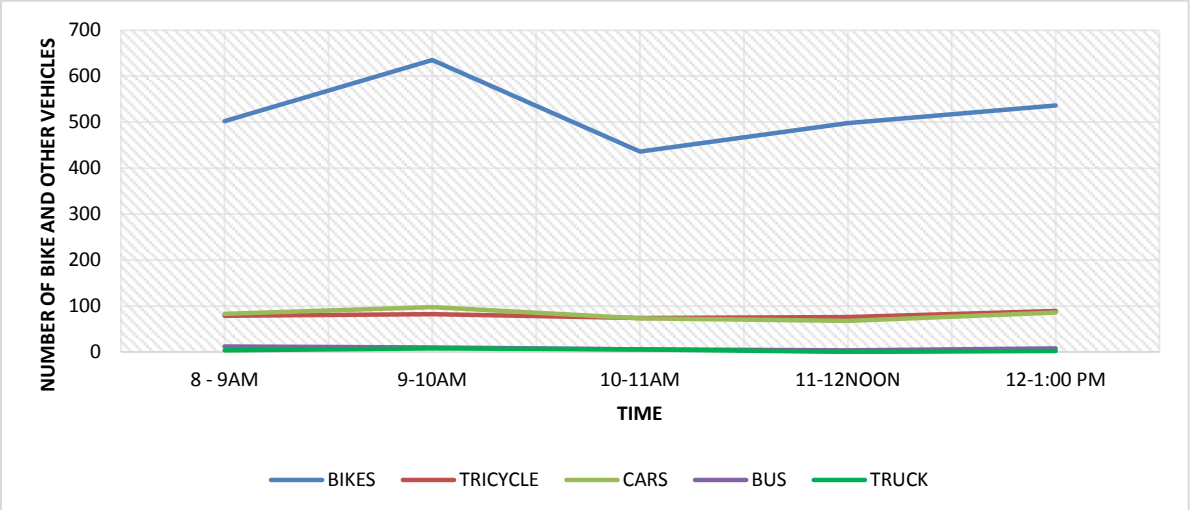

Fig. 9: Mean observed 2-day traffic density on the main road near GGSS, Pada, Zaria, Nigeria by hour during School hours.

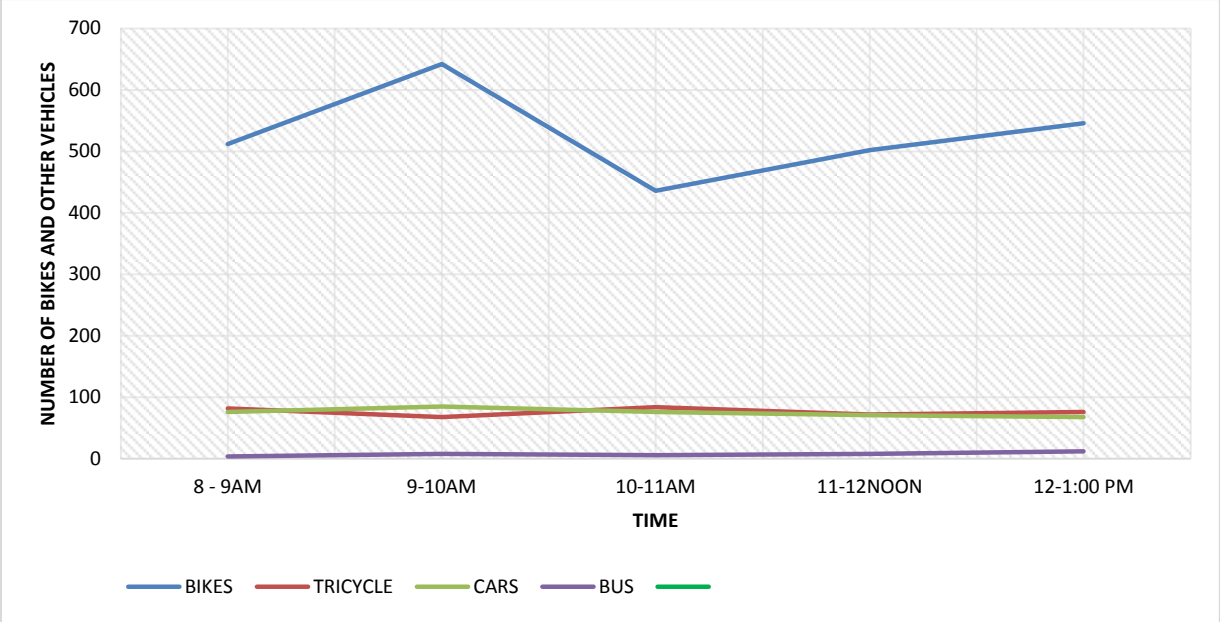

Fig. 10: Mean observed 2-day traffic density on the main road near Sarki Musa L.G.E.A. Primary School, Kwarbai, Zaria, Nigeria by hour during School hours.

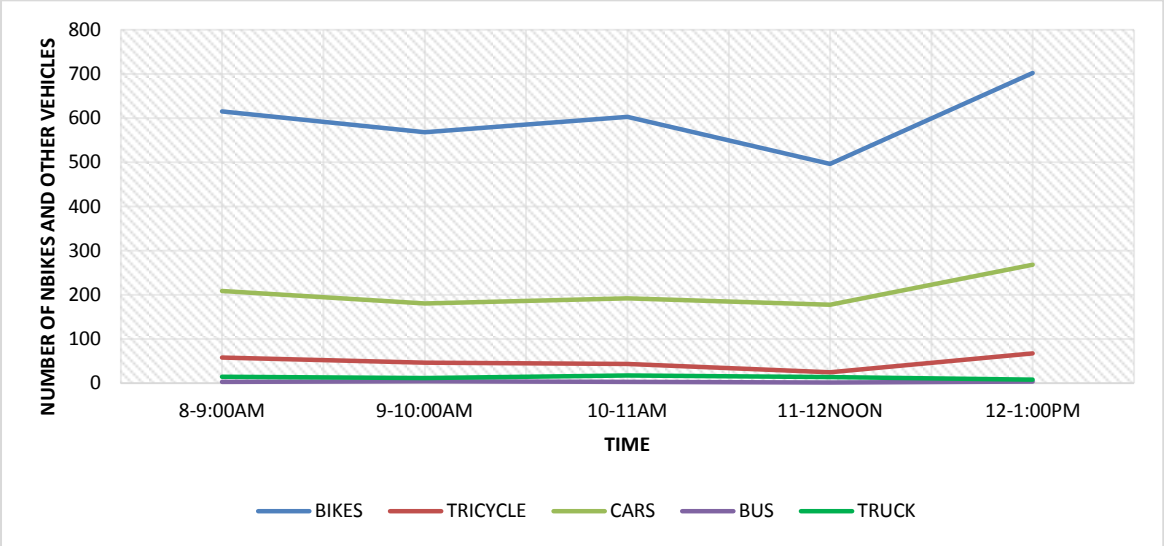

Fig. 11: Mean observed 2-day traffic density on the main road near Government Girls Secondary School, Kongo, Zaria, Nigeria by hour during School hours.

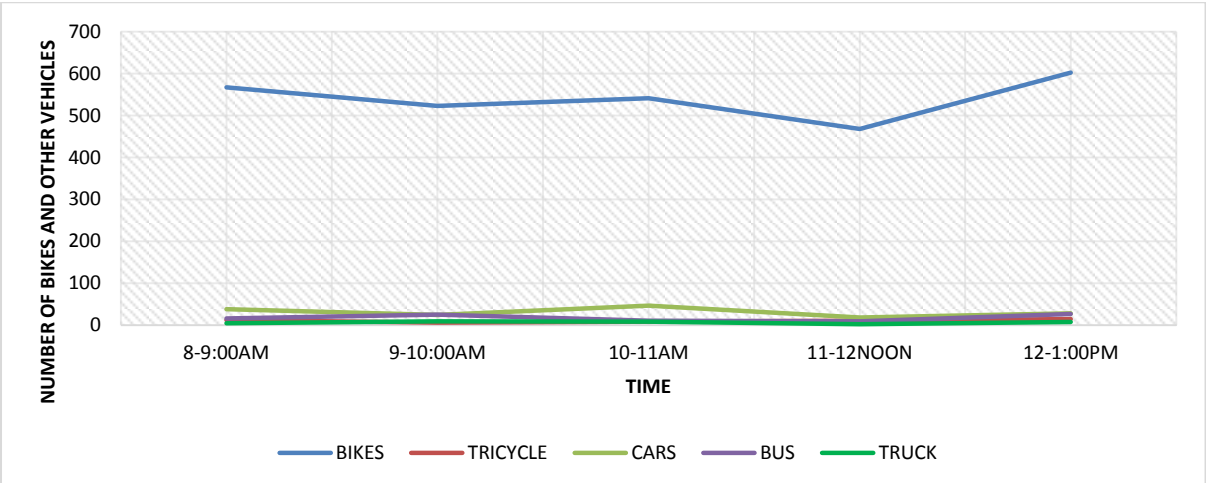

Fig. 12: Mean observed 2-day traffic density on the main road near Government Girls Secondary School, Kofa-Gayan, Zaria, Nigeria by hour during School hours

Relationship between outdoor noise level and traffic noise index

The Table 2 presents the relationship between outdoor noise and traffic noise. The Pearson correlation was positively low correlated. However, the correlation is statistically significant because the p-value (0.467) is less than the significance level which indicates that the correlation is different from zero. The result simply means that the increase in traffic noise does not indicate higher outdoor noise on the corridor of the classrooms whereby the increased outdoor noise might be as a result of classroom congestion and students activities. However, Pritam *et al.* (2014) reported that the outdoor noise levels are influenced by traffic volume and congestion.

Table 2: Relationship between outdoor noise level and traffic noise index

		Outdoor Noise Pollution Level	Traffic Noise Index
Outdoor LNP	Pearson Correlation	1	0.279
	Sig. (2-tailed)		0.467
TNI	Pearson Correlation	0.279	1
	Sig. (2-tailed)	0.467	

Conclusion

This work showed that the variation in outdoor noise levels in schools are greatly higher than the international standard, and as such can act as agent for cardiovascular diseases among students and teachers. That the outdoor noise levels range between 75.5 - 98.5 dB (A) where there recommended standard by WHO is 55 dB (A). The traffic noise index around the schools range between 56.2 - 122.7 dB (A) with a large noise climate (NC) which range between 5.9 - 16.7 dB (A) indicating that the prevalence of annoyance in individuals will be high in such areas. The research has also shown that the larger percentage of the noise generated outdoor is due to large frequency of motorcycles. However, the impact of traffic noise was poorly correlated with the noise levels on the corridor of the classrooms.

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Conflict of Interest

There is no conflict of interest.

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