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EVALUATION OF VEHICULAR NOISE POLLUTION IN ONITSHA METROPOLIS, NIGERIA

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ABSTRACT
Noise pollution, a by-product of urbanization and industrialization, is widely recognized as a major problem for the quality of city life. The 10 selected areas of study are 2 commercial centres, 2 road junctions/busy roads, 2 passenger loading parks and 2 high-density and 2 low density residential areas. Noise measurements are done in the morning (8.am – 9.00am), at noon (11.00 – 12.00pm), during afternoon (2.00pm – 3.00pm) and in the evening (5.00pm – 6.00pm); to determine noise pollution all over the metropolis. Noise descriptors such as L_{10}, L_{50}, L_{90}, L_{Aeq}, TNI, NPL (LNP) and NC were assessed to reveal the extent of noise pollution due to heavy traffic and failures of some mechanical systems in the metropolis. The road junctions had the highest noise pollution levels, followed by commercial centers, passenger loading parks, high density residential area and finally low density residential area. Noise threshold were found to be much beyond the permissible limit (70dB during the day time).Comparison of predicted equivalent noise level with that of the actual measured data showed that the model used for the prediction has the ability to calibrate the multi-component traffic noise and yield reliable result close to that by direct measurement.

Keywords: Noise, Pollution, Evaluation, Modeling

1 INTRODUCTION

The word “noise” is derived from the Latin “nausea” meaning sickness. Noise can be defined as the level of sound that exceeds the acceptable threshold; and creates an annoyance. Noise is any sound independent of loudness which can produce an undesired physiological or psychological effect in an individual group. Noise is a major source of friction between individuals living in semi-detached apartments (Jobair, *et al*., 2001).

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Noise has three major categories; viz., industrial noise, community noise and traffic noise. Traffic or vehicular noise has more inconveniencing effects than the other two categories. Vehicle noise emanates from the following sources: car engines, exhaust systems, tyres interaction with the road, horns, aerodynamic friction and by the interaction between vehicles, sounds of cooling fans, gear boxes and brakes.

In general, Figure 1 schematically illustrates the magnitude of noise pollution, sources and its influence in human beings .The most important factors raising noise pollution in urban areas include inter alia: vehicular traffics, neighborhood electronic appliances, TV and music systems, public address systems, railway and air traffic, and generating sets. Everyone, in one way or the other, is guilty of this menace; and falls prey to the noise generated by the household equipment used by us (Singh and Daver, 2004; Nwaeto and Placid, 2018).

As a result of urbanization and industrialization, the human environment is overly polluted; and the quality of life in urban centres has been on a recline. The increase in the population and in the number of circulating vehicles has led to an increase in noise pollution, but noise pollution has been considered less than other contaminants in the environment (Mansouri, *et al*., 2006). Existing evidence indicating that noise pollution may have negative impacts on human health has justified this research; and has provided better understanding of noise pollution problems and control (Georgiadou, *et al*., 2004). It was reported that the measurements of noise levels in residential, industrial, and commercial areas have gone so high in New Delhi, India; with commercial areas having the highest noise levels, followed by industrial and residential areas (Braj and Jain, 1995). Similarly, experience shows that noise pollution, particularly road traffic noise, is severe in rapidly expanding cities, such as those of Southeastern Nigeria, where insufficient control is exercised in urban expansion; and cities are poorly planned (Onuu, 1992). Noise pollution constitutes a serious health hazard. Noise related ailments ranges from annoyance to insomnia and high blood pressure (Ugwuanyi *et al*., 2004; Saadu *et al*., 1998; Ahmad *et al*., 2006; Schwela & Zali, 1999).

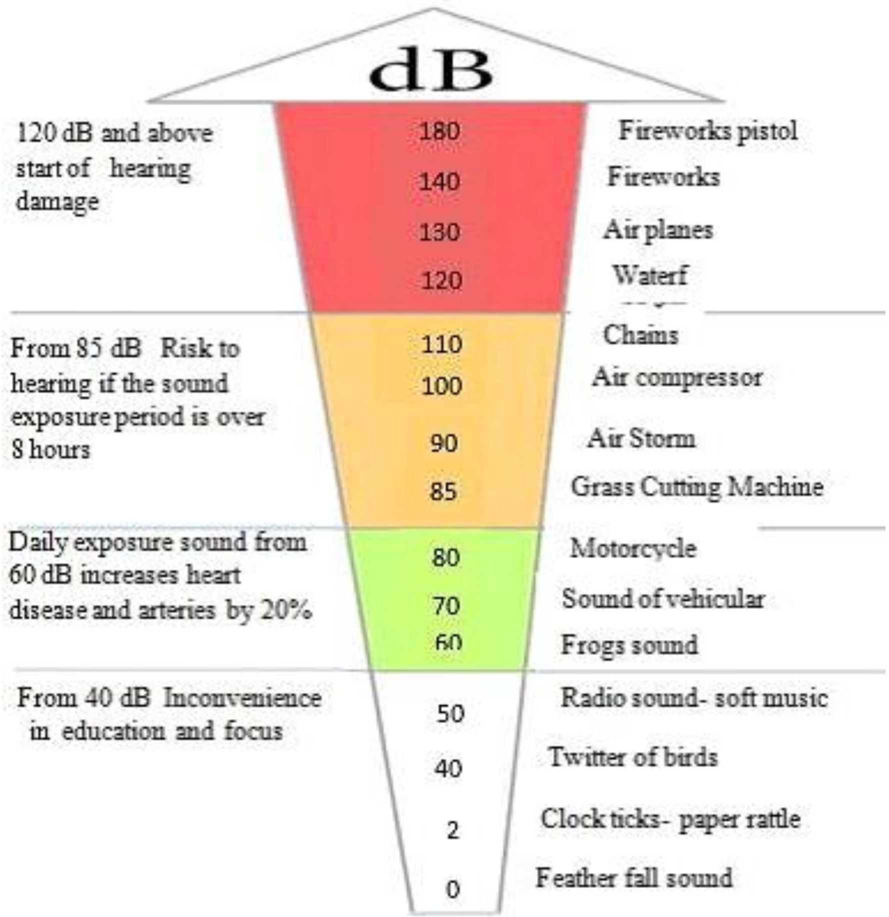

Figure 1: Noise Pollution; its Magnitude, Sources, and Effect
Source: Wael, 2008

Despite efforts by government agencies to clear Onitsha roads of rickety vehicles, one notices each day the influx of such decrepit "death-traps" in every nook and cranny of the metropolis. It becomes expedient to undertake the present study. The road junctions have the highest noise pollution level, followed by market areas, passenger loading parks, high density residential area and finally low density residential area. Comparison of predicted equivalent noise level with that of the actual measured data demonstrates that the model used for the prediction has the ability to calibrate the multi-component traffic noise and yield reliable result close to that by direct measurement (Uyaelumuo *et al*., 2017). The noise pollution situation in Onitsha metropolis is similar to that in many urban areas. The city is relatively large, having rapid increase from 163,032 people in 1963 to 261,604 in 2006 (NPC, 2006). A major hallmark of the city is expansion in terms of urbanization, industrialization, and modern road network and infrastructures. As a sequel, there is congestion across the city due to bloated commercial activities and deadlock road traffic.

2 MATERIALS AND METHOD

Materials

Instrumentation for the field measurement consisted of precision grade sound level meter (according to IEC 651 AWSI 51.4 type), ½ inch condenser microphone, and octave filler with frequency range and measuring level range of 31.5Hz – 8KHz and 35 – 130dB, respectively. Materials utilized include recording sheets, pen, pencil, graph paper and mathematical sets.

Methods: The research is based on the result of outdoor sound level (dB) meter measurements carried out at 12 different locations (2 commercial centers, 2 road junctions and busy roads, 2 passenger loading parks, 2 high density residential areas and 2 low density residential areas.

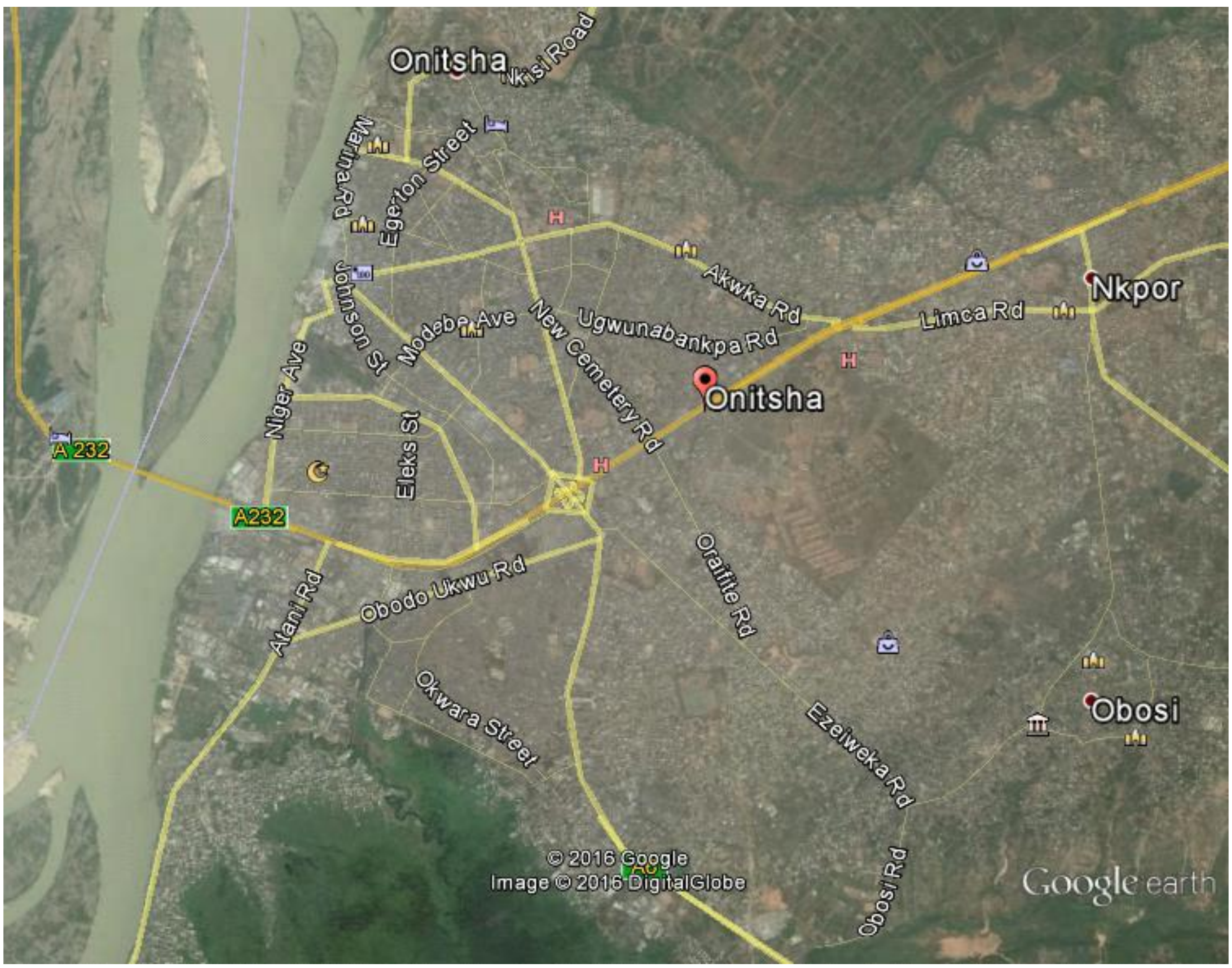

Figure 2: Satellite Earth Map of Onitsha Metropolis Nigeria

The instruments were calibrated by the internal sound level calibrator before making measurement at each site. All the instruments comply with IEC standards. The measurements were made at street level (of road junctions, market centers, passenger body parks, and residential areas). The

instrument was held comfortably in hand with the microphone pointed to the noise source at a distance not less than 1m away from reflecting object. LAI (A-weighed instantaneous sound pressure level) measurements were made and recorded at intervals 1 minute or 60 seconds for a period of one hour, giving 60 measured readings per sampling location. This procedure was carried out for morning (8.00am – 9.00am), at noon (11.00 noon – 12.00pm), afternoon (2.00pm – 3.00pm) and evening (5.00pm – 6pm).
The noise monitoring was done in a good climatic condition, where there was no sign of rainy cloud. Also the monitoring was done in all working days excluding Sunday and Public holidays in order to get good result.

The noise levels of different squares in different time intervals were assessed along with their *equivalent noise level* (leq). Leq represents the equivalent energy sound level of a steady state and invariable sound. It includes both intensity and length of all sounds occurring during a given period (Piccolo *et al.*, 2005 & Ozer *et al.*, 2009). Noise descriptors such as L_{10}, L_{50}, L_{90} were also assessed to calculate the value of Leq using the formula $L_{eq} = L_{50} + (L_{10} - L_{90})^2/56$ as Leq is an insufficient descriptor of the annoyance caused by fluctuating noise. Noise pollution level (NPL) expressed in dB is also calculated by using the formula ($NPL = L_{eq} + a(L_{10} - L_{90})$ where a =1.0 (constant in the equation). NPL takes into account the variation in the sound signal and hence serves as better indicator of the pollution in the environment for physiological and psychological disturbances of the human system. Noise Climate (NC) is the range over which the sound levels are fluctuating in an interval of time and is assessed using the formula ($NC = L_{10} - L_{90}$).

Traffic Noise Index (TNI) is another parameter, which indicates the degree of variation in a traffic flow. This is also expressed in dB (A) and can be computed using the relation [$TNI = 4\{(L_{10} - L_{90}) + L_{90}$ -30dB (A)}. Traffic volume is defined as the total number of vehicles passing through a fixed point on the road was counted. The ratio of heavy truck and buses to total traffic is called *truck traffic mix ratio*. This was computed in terms of percentage. Traffic volume count was manually done by counting the two and three wheelers (OKADA and KEKE-NAPEP), light motor vehicle (LMV) and heavy motor vehicle (HMV). An increase in this ratio will increase the noise level. The noise level was computed by using the model of Griffiths and Landon, i.e. $L_{eq} = L_{50} + 0.018(L_{10} - L_{90})^2$. Where, the statistical percentile indicators were calculated with the following formula

$$L_{10} = 61 + 8.4\log(Q) + 0.15p - 11.5\log(d)$$
$$L_{50} = 44.8 + 10.8\log(Q) + 0.12p - 9.6\log(d)$$
$$L_{90} = 39.1 + 10.5\log(Q) + 0.06p - 9.3\log(d)$$

Where, Q is the vehicles flow, P is the percentage of heavy vehicles and d is the distance (1m in this study) of source receiver. The analysis of the measured noise level generally depicts that there are existence of variations of noise with variables, as to time of the day, and locations among others. In order to determine the existence and statistical significance of these variations and trends, a cross classification analysis along with ANOVA test was assessed on the data.

3. RESULTS AND DISCUSSION

Table 1: Noise descriptors (TNI, NPL, NC) variations at 10 different selected areas of Onitsha Metropolis at different time intervals

S/N	Name of selected area	8.00 am - 9.00 am			11.00 am - 12.00 pm			2.00 pm - 3.00 pm			5.00 pm - 6.00 pm		
		TNI	NPL	NC	TNI	NPL	NC	TNI	NPL	NC	TNI	NPL	NC
1	Ochanja	106	93.6	18.9	106.8	93.7	18.8	110.5	95.1	19.7	109.8	95.9	19.1
2	Relief	106.9	93.2	19.1	114.2	96.3	21.0	110.8	95.2	19.8	118.2	101.9	21.5
3	Upper Iweka	106	93.7	19.1	98	88.8	16.6	106.6	92.7	18.3	105.3	96.3	17.5
4	Oguta	112.1	94.3	20.4	105.4	93.6	19.0	112.9	96.3	20.4	107.3	96.4	18.2

5	RTC	106.6	92	19.2	97.5	91	16.6	98.2	89.7	16.5	106.6	95.7	18.3
6	Peace Mass	100.9	90.5	17.7	107	92.0	19.1	110.4	95.5	20.0	105.4	97.7	18.2
7	Fegge	105.4	91.2	18.7	108.7	93.5	19.6	109.5	94.5	19.6	107.7	96.6	18.7
8	Iweka	103.5	90.3	18	95.7	89.0	15.9	101.3	92.0	17.2	108.4	96.1	17.9
9	Obodoukwu	107.8	89.3	16.8	117.2	98.6	21.7	110.9	95.6	20.1	109.1	95.7	18.9
10	Modebe	101.5	88.4	17.5	103.1	89.7	17.9	111.8	95.7	20.1	105.8	94.9	17.9

Table 2: Prediction of noise level of 10 different selected areas of Onitsha Metropolis

S/N	**Name of selected area**	**8.00 am -9.00 am**		**11.00am-12.00 pm**		**2.00pm -3.00 pm**		**5.00pm -6.00 pm**	
		Predicted noise level (L_{eq})	Actual noise level (L_{eq})	Predicted noise level (L_{eq})	Actual noise level (L_{eq})	Predicted noise level (L_{eq})	Actual noise level (L_{eq})	Predicted noise level (L_{eq})	Actual noise level (L_{eq})
1	Ochanja	74.7	76.4	74.9	76.8	75.4	78.5	76.8	79.1
2	Relief	74.1	76.7	75.3	78.3	75.4	78.4	80.4	79.6
3	Upper Iweka	74.6	74.3	72.2	74.5	74.4	77.2	78.8	77.6
4	Oguta	73.9	74.3	74.6	75.4	75.9	76.4	78.8	77.1
5	RTC	72.8	73.8	74.4	73.9	73.2	75.8	77.4	77.7
6	Peace Mass	72.8	74.4	72.9	75.1	75.5	76.0	79.5	76.9
7	Fegge	74.7	75.8	74.9	76.8	75.4	78.5	76.8	79.1
8	Iweka	72.2	73.4	73.1	75.8	74.8	76.1	78.2	78.7
9	Obodoukwu	72.5	74.6	76.9	79.5	75.5	79.5	76.8	80.2
10	Modebe	70.9	75.0	71.8	76.7	75.6	76.7	77.0	78.8

Table 3: Q (Traffic volume) and P (Truck – Traffic Mix Ratio) at 10 different selected areas of Onitsha metropolis at different time interval.

S/N	**Name of selected area**	**8.00am - 9.00 am**		**11.00 am - 12.00 pm**		**2.00 pm - 3.00 pm**		**5.00 pm - 6.00 pm**	
		Q	P (%)	Q	P (%)	Q	P (%)	Q	P (%)
1	Ochanja	625	1.01	480	2.68	497	1.54	860	1.59
2	Relief	568	1.11	488	2.69	495	1.28	571	2.25
3	Upper Iweka	524	1.84	472	2.67	501	1.79	417	2.43
4	Oguta	558	2.1	493	2.69	517	2.93	596	2.12
5	RTC	553	1.02	445	2.65	491	0.95	672	2.43
6	Peace Mass	554	1.92	515	2.71	556	2.46	647	2.32
7	Fegge	531	1.94	501	2.70	523	1.78	532	1.91
8	Iweka	529	1.26	472	2.67	497	1.61	612	2.10
9	Obodoukwu	580	1.1	491	2.69	517	1.48	595	2.13
10	Modebe	582	1.83	476	2.68	492	1.08	607	1.98

Table 4: Total number of vehicles passing the road in unit time at 10 different times of a day in and around Onitsha Metropolis

S/N	Name of selected area	8.00 am - 9.00 am				11.00 am - 12.00 pm				2.00 pm - 3.00 pm				5.00 pm - 6.00 pm			
		2 & 1 W	LMV	HMV	Total	2 & 1 W	LMV	HMV	Total	2 & 1 W	LMV	HMV	Total	2 & 1 W	LMV	HMV	Total
1	Ochanja	744	112	11	867	302	116	18	436	344	124	13	481	483	157	11	651
2	Relief	557	128	11	696	338	109	12	459	349	117	19	485	538	135	8	681
3	Upper Iweka	421	122	19	562	275	114	17	406	357	119	27	503	692	114	15	821
4	Oguta	512	127	15	654	343	117	11	471	403	118	10	531	613	137	13	763
5	RTC	534	108	17	659	207	112	16	335	341	118	14	473	839	128	10	977
6	Peace Mass	496	134	12	642	407	106	12	525	513	114	11	683	761	135	15	911
7	Fegge	448	114	11	573	346	129	8	483	413	128	18	559	581	141	14	736
8	Iweka	446	121	8	575	277	115	14	406	349	118	14	481	562	136	18	716
9	Obodoukwu	396	126	12	534	335	120	11	466	396	132	10	538	402	146	8	556
10	Modebe	276	118	6	400	286	116	6	408	338	122	6	466	340	147	4	491

Discussion

The noise levels in all the location surveyed except at low residential areas are higher than the recommended level of 60 (A) for commercial areas and residential area (1S0:12 1996/1-1992 2004). The noise level is about 1-27 DB (A) above the recommended limit of 82dB (A) (Ramalingeswara and Rao, 1992) in all the locations surveyed except for the residential are

A graph of TNI, NC and NPL against four different times for the (10) different locations shows the average TNI range from(74.1 to80.4) dB (A) at commercial centers (72.2 to 78.8) dB (A) at road junction/ busy roads, (72.8 to 79.5) dB (A) at passenger loading parks (70.9 to 77.0) dB (A) at low-density residential area. Road junctions/busy roads and low- density residential area have the highest and lowest annoyance response due to traffic noise respectively. It should be noted that the world health organization recommends a noise level of less than 35 dB (A) based on the continuous equal energy concept for the restorative process of sleep (Mufuruku, 1997).

The prediction of noise pollution levels at different selected areas of Onitsha by using the model of Griffiths and Langdon (Griffiths & Langdon, 1968). It is observed that the value of assessed predicted noise level is close to respective actual equivalent noise level measured (Table 3). Such comparison depicted that the model used for prediction in the present study has the ability to calibrate the multi-component traffic noise and yield reliable results close to that by direct measurement. The correlation (R^2) value for observed Leq versus calculated Leq for the present model is 0.95, 0.98, 0.94, and 0.99 for different time intervals of the afore-said selected areas. Using the given data, a calibrated model has been checked for validation by R^2 value and ANOVA test, which have given good results.

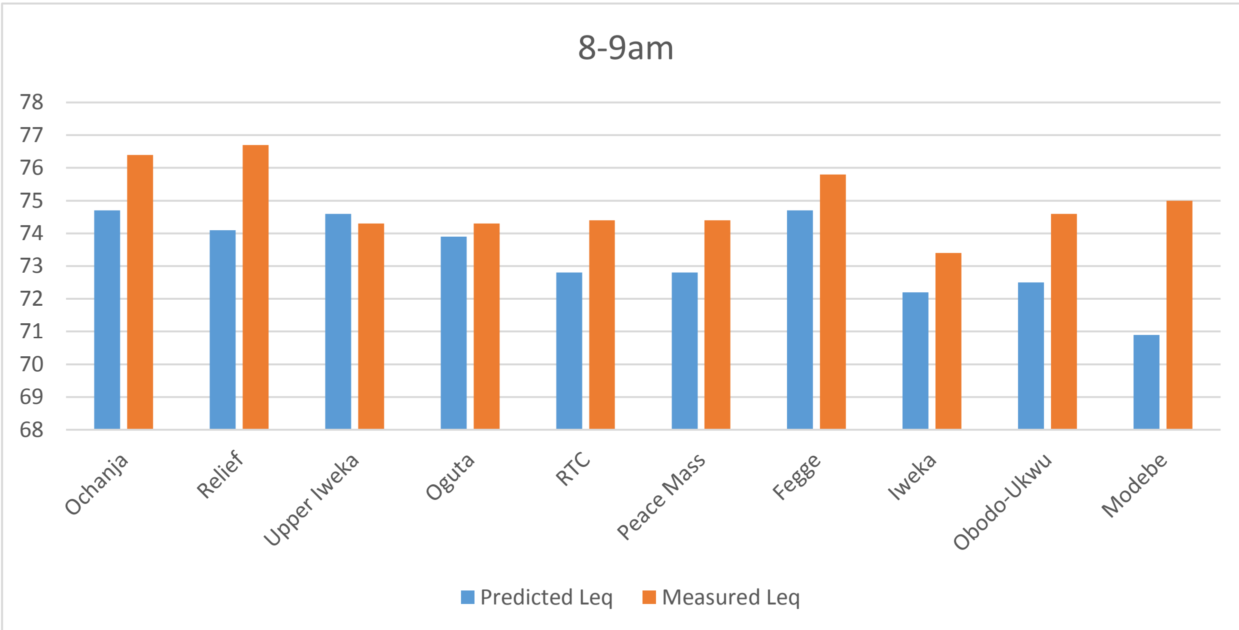

Figure 3: A Bar chart of predicted Leq against Measured Leq for the 10 locations between 8-9am

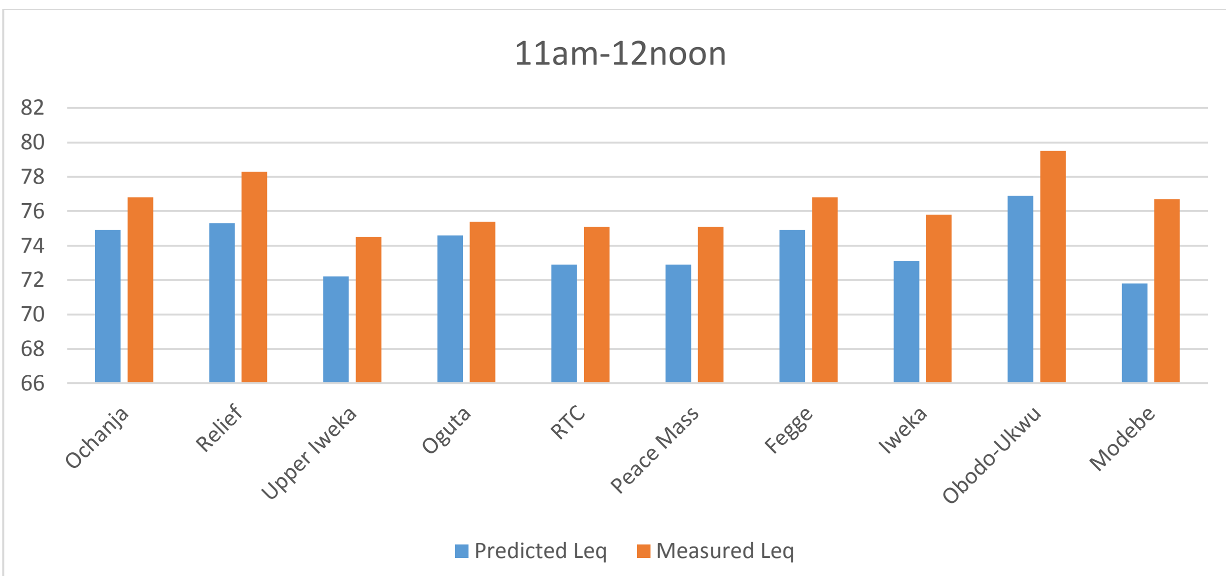

Figure 4: A Bar chart of predicted Leq against Measured Leq for the 10 locations between 11-12noon

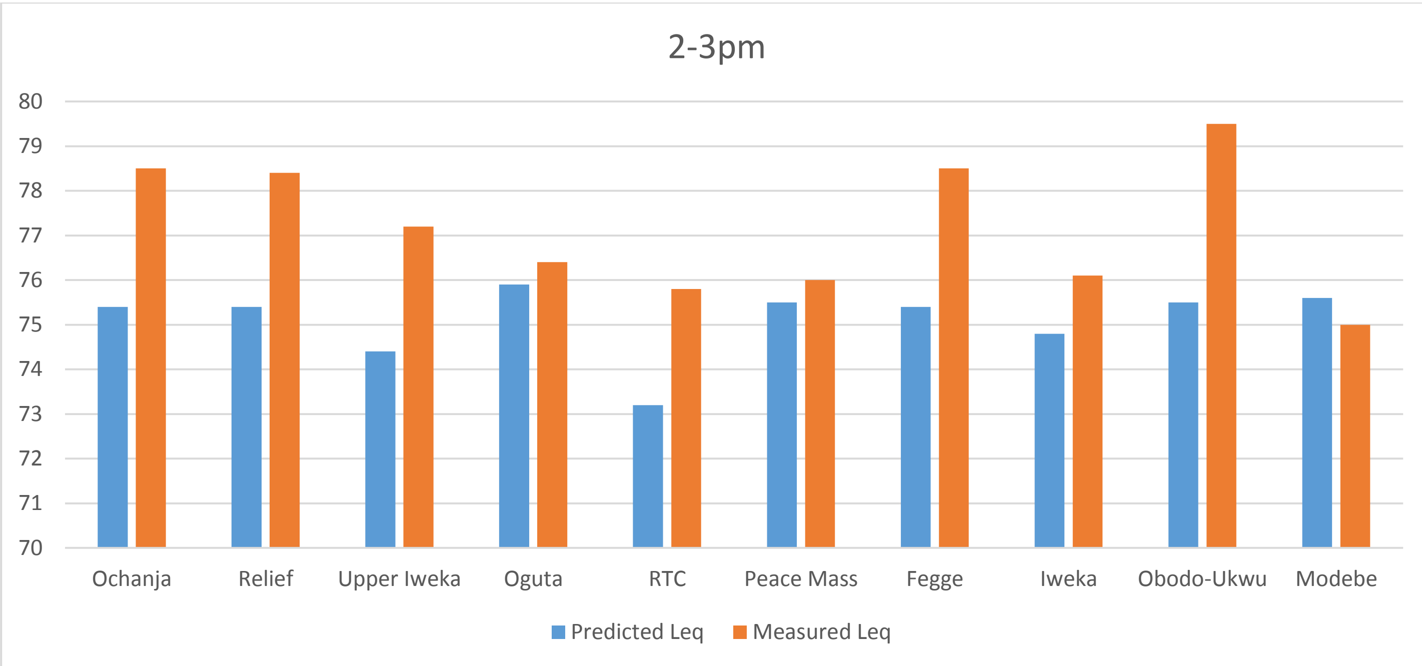

Figure 5: A Bar chart of predicted Leq against Measured Leq for the 10 locations between 2-3pm

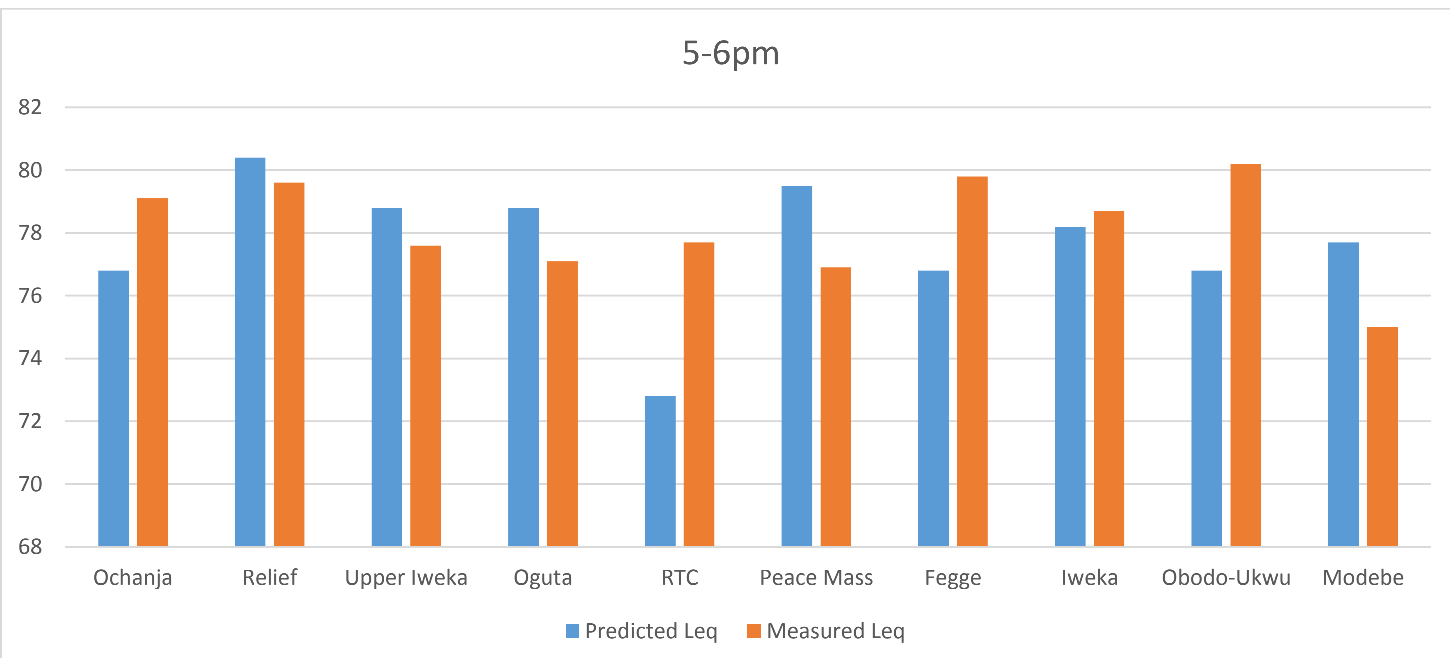

Figure 6: A Bar chart of predicted Leq against Measured Leq for the 10 locations between 5-6pm

The nucleus of the metropolis is characterized by a high noise exposure level. The noise pollution level is (88.4 to 101.9) dB, the NC is (17.7 to 21.7) dB and the TNI is (97.5 to 118.2) dB. The RTC, Chisco, Iweka junction and street, Fegge Street, relief market all comprise the nucleus of the metropolis as they are close to flyover. At the centre of the metropolis, there are concentration of shops, markets, and clustered buildings with high population and traffic volume. All these are responsible for high noise exposure level; therefore, the residents living or trading in these areas are exposed to noise levels of 80-90 dB (A) or more every day. This is very dangerous to the health of the people in these areas. (Uyaelumuo, *et al*., 2017)

The noise level at Onitsha metropolis is similar to those reported for other cities around the world in Jordan, Spain, Brasil, Greece, and India (Ahmed *et al.*, 2006, Amando and Jose 1998, Zannin *et al*., 2002, Mufuruki, 1997 Georgiadon *et al.*, 2004; & Panadya, 2003). According to the World Health Organization (WHO) generally 60dB (A) sounds can result in temporary hearing impairment and 100 dB (A) sound can cause permanent impairment (Kiely, 1998).

5. Conclusion

This study was carried out to measure the noise levels in the metropolis. The focus was on five selected areas of ten locations: commercial centers, road junctions/busy roads, passengers loading parks, high-density residential areas, and low-density residential areas. Possible technical controls include changes in road profiles; low -noise pavement (porous or porous elastic) types; effective repairs to the silencers and vehicle suspensions so as to reduce exhaust and rolling stock noise: reductions, limitations, or restrictions on traffic (types of vehicles, speed, hours of access, and so on); and building of acoustic barriers along the sides of heavily travelled highways running through residential areas. Transportation and land planning (private vs public transportation, bus lanes, parking areas, shuttle buses and pedestrian areas) are important components of the plan. The measure reveals that noise levels at 8 of 10 selected areas exceed the recommended limit of 82dB (A) by values of 1-27 dB (A). Hence the present value of noise pollution in Onitsha metropolis poses a severe health risk to the residents.

Furthermore, discomfort and irritation being caused by the pollution can drastically reduce productivity, both in public service and private sectors. In addition some areas may soon reach the threshold of pains and lead to permanent loss of hearing and death.

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APPENDIX I

Noise level (dB) visualized at 10 different selected areas at different time intervals of Onitsha metropolis.

S/N	Name of selected area	8.00 am - 9.00 am							11.00 am - 12.00 pm							2.00 pm - 3.00 pm							5.00 pm - 6.00 pm						
		Min	Max	Mean+SD	L_{10}	L_{50}	L_{90}	L_{frq}	min	max	Mean+SD	L_{10}	L_{50}	L_{90}	L_{frq}	min	max	Mean+SD	L_{10}	L_{50}	L_{90}	L_{frq}	Min	Max	Mean+SD	L_{10}	L_{50}	L_{90}	L_{eq}
1	Ochanja	55.7	104.8	76.4±7.7	79.3	68.4	60.4	74.7	57.5	105.6	76.8±7.7	80.4	68.6	61.6	74.9	58.6	106.5	78.5±8.0	81.4	68.5	61.7	75.4	59.7	107.2	79.1±8.7	82.5	70.3	63.4	76.8
2	Relief	56.1	104.3	76.7±7.6	79.6	67.6	60.5	74.1	56.3	105.7	78.3±7.3	81.2	67.5	60.2	75.3	58.2	101.6	78.4±8.2	81.4	68.4	61.6	75.4	59.1	108.3	79.6±8.8	83.7	72.2	62.2	80.4
3	Upper Iweka	57.2	106.7	74.3±8.6	78.7	68.1	59.6	74.6	57.6	105.4	74.5±8.0	78.2	67.3	61.6	72.2	56.1	104.4	77.2±7.3	81.7	68.5	63.4	74.4	60.4	106.2	77.6±8.0	82.8	73.4	65.3	78.8
4	Oguta	55.1	106.2	74.3±8.4	80.9	66.5	60.5	73.9	56.4	107.7	75.4±8.2	78.4	68.2	59.4	74.6	57.3	101.2	76.4±8.1	81.7	68.5	61.3	75.9	60.5	102.3	77.1±8.1	82.7	72.3	64.5	78.8
5	RTC	55.4	106.6	73.8±8.5	79.0	66.3	59.8	72.8	56.5	108.4	73.9±8.1	77.7	69.5	61.1	74.4	57.2	101.6	75.8±7.2	78.7	68.4	62.2	73.2	60.6	109.9	77.7±7.7	81.7	71.5	63.4	77.7
6	Pea	5	1	7	7	6	6	7	5	1	7	7	6	6	7	5	9	7	8	6	6	7	5	1	7	8	7	6	7

	ce Mass	7.6	08.2	4.4±7.9	7.8	7.3	0.1	2.8	7.2	06.3	5.1±8.9	9.7	6.4	0.6	2.9	6.4	9.3	6.0±8.7	0.4	8.4	0.4	5.5	9.7	08.7	6.9±9.7	0.8	3.6	2.6	8.9
7	Fegge	54.1	105.2	75.8±8.5	79.3	68.4	60.4	74.7	57.5	105.6	76.8±7.7	80.4	68.6	61.6	74.9	58.6	106.5	78.5±8.0	81.4	68.5	61.7	75.4	59.7	107.2	79.1±8.7	82.5	70.3	63.4	77.4
8	Iweka	59.5	105.1	73.4±7.1	79.5	66.5	61.5	72.2	58.7	102.6	75.8±8.2	78.0	68.6	62.1	73.1	57.3	104.9	76.1±7.7	79.7	69.6	62.5	74.8	62.3	106.1	78.7±8.1	84.7	72.5	66.8	79.5
9	Obodoukwu	55.4	106.2	74.6±7.6	77.4	67.5	60.6	72.5	56.1	108.6	79.5±7.7	82.4	68.5	60.4	76.9	56.4	103.4	79.5±8.3	80.6	68.3	60.5	75.5	58.2	109.3	80.2±9.0	82.4	70.5	63.5	76.8
10	Modebe	56.3	100.8	75.0±8.1	79.0	65.5	61.5	70.9	55.6	104.3	76.7±8.0	79.4	66.1	61.5	71.8	57.6	102.5	76.7±8.3	81.5	68.4	61.4	75.6	61.1	107.6	78.8±8.0	82.1	71.3	64.2	78.2