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Evaluation of Traffic Noise on Selected Road Corridor in Lokoja, Nigeria

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ABSTRACT: Unpleasant sound is known to be a solemn menace to life and social existence, the relevance of this research work is in the application of neural network to real time traffic data from road traffic sound measurement. Traffic data were collected with the aid of sound meter of a high accuracy grade. The peak traffic sound level that causes disturbance to human beings known as L_{10} was measured in (dB(A)) which was sampled in Twelve (12) locations selected for the study in Lokoja, Kogi State Nigeria, and the associated noise levels were predicted by the application of neural network. The output obtained shows the highest value of L_{10} to be 86 dB(A) while the lowest value is 73 dB(A) in the sites considered. The results of the Neural Network output show a strong connection between the results obtained when calculation of road traffic noise model (CRTN) methodology was deployed.

Keywords: Neural Network; Noise pollution; Multi-layer perceptron; L_{10}.

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INTRODUCTION

Noise pollution in cities is a major concern to the well-being of man. This is because; unwanted sound is a risk to general wellbeing of people. Man's daily activities have not helped in curbing this dangerous trend. Noise causes cumulative adverse effects that impair health over a long period of exposure (Taeho, et al., 2018). It also reduces the productivity of man in his natural environment in terms of social and economic output. Not to mention the fact that it interferes with sleep and the ability to concentrate (Oluwaseun, Micheal, & Oladayo, 2015). The challenges that people face with noise pollution have not been acknowledged properly despite the fact that it is increasingly rising in both the unindustrialized and more advanced nations of the world (Odesanya, Okoko, & Stephens, 2018). A lot of studies throughout cities around the world have been carried out by several researchers (Su árez, & Barros, 2014; Oyedepo O. J., 2014; Baloye & Lobina, 2016; Manea, Manea, Florea, & Tarulescu, 2017).

There are several indications that noise pollution influences negatively on health of human beings, and this is why it becomes imperative for studies on noise pollution to be conducted so as to better understand the nature of noise pollution problems and how they can be managed (Dave, Toner, & Chen, 2018). City noise levels can be investigated using four different sources of noise; road traffic, industrial activities, marketing activities and entertainment facilities (Dursun, Ozdemir, Karabork, & Kocak, 2006). Numerous studies report that noise level in metropolitan cities exceeds specified standard limits. Mostert, Caris, & Limbourg (2017) ascribe noise to be part of the negative effects generated by the operations of road transport. Mathematical and computer software models were used for the analyses of road traffic noise by Fedorko, Heinz, Molnár, & Brenner (2020). Lopez & Souza (2020) in their study did a comparison of mathematical means of measurement which they deployed for traffic noise indices in pedestrian routes in a south American city; they compared different mathematical methods used for road traffic noise analysis and found out that the Calculation of Road Traffic Noise model (CRNT model) was the best one. This work therefore uses the CRNT model to analyse road traffic noise by using artificial neural network for the analysis. The problem of noise pollution is an increasing one in Nigeria especially in growing cities like Lokoja. Odesanya, *et al.,* (2018), Oyedepo, Ekom, & Ajala, (2013) and Anomohanran, Iwegbue, & Oghenerhoro, (2008), have conducted studies on road traffic noise in different Nigerian cities. Odesanya *et al.,* 2018 in their study of Akure metropolis describe the noise generated to be above the required threshold in most of the corridors used for their study.

The noise pollution situation in Lokoja is similar to that of many growing cities in Nigeria. The city is relatively large and is a transit town connecting most states in the southern part of Nigeria to the north. The population of Lokoja is steadily increasing. Its population increased from 423, 340 in 1980 to 902,131 in 2006 (NPC, 2006) which has led to the generations of more traffic streams on most road corridors for commuters. The city has witnessed continuous expansion in all directions in the past two decades.

The major aim for this research is to assess the road traffic noise levels in some selected road locations within Lokoja city, by deploying Neural Network to analyse data from the selected traffic junctions. Since neural network is mostly a predictive, clustering, classification, function approximation tool, its usefulness in this research cannot be overemphasized. The predictive component of neural network was deployed and some corridors were highlighted, data were collected and analysed in these selected corridors in order to validate the use of neural network.

MATERIALS AND METHODS

This investigation is based on the output of an outdoor measurement of sound levels carried out in August 2019 at 12 various locations in Lokoja, capital of Kogi State, Nigeria. Table 1 highlights the selected location in Lokoja in Kogi State.

Standard Operation Procedure for Sound Measurement

The apparatus consists of Sound level meter, Tripod stand, Measuring tape and Stop watch. High grade standardize sound meter was used to obtain the noise level in the corridor selected.

Table 1: Selected locations for the study

S/N	Selected sites	Junction Type
1	International market junction	T-Junction
2	Market road junction	Y-Junction
3	Feather strong road junction	T-Junction
4	Habson petroleum point 1	U-Turning Point
5	Beach road junction	T-Junction
6	Obasanjo amusement park	Roundabout
7	Ganaja junction	T-Junction
8	Galilee road junction	T-Junction
9	Cummins road junction	T-Junction
10	Zone 8 junction	Roundabout
11	Gen Hospital Road junction	U-Turning Point
12	RCCG city of grace junction	U-Turning Point

Source: Author's Field work, 2019

The sound meter is made up of precision guided microphone with a one third inch filter that can measure sound waves in the frequency range of between 31.5Hz to 8kHz, producing sound in the range of 35db to 130db in compliance with the standard of International Electro technical commission (IEC). Required adjustment was made to the instrument by calibrating it with the calibrator before using it on each selected corridor so as to maintain the precision of the data obtained.

Measurements were taken at the selected road junctions for this study in Lokoja Local Government Area (LGA) of Kogi State. The sound metre was held in a comfortable manure on the tripod stand in such a manner that the microphone of the sound metre points at the direction of the noise source. The distance of tripod should not be more than a metre from the source of the noise. In order to achieve this, reflective walls that could hamper the reading on the sound level metre were avoided. A corridor used for this study and a relative section of the result obtained are shown in Table 2 for the international market junction area in Lokoja. Measurements were made at intervals of ten seconds (10s) each for a period of thirty minute (30 min) to give one hundred and eighty (180) sampling readings per location. This process was also repeated for all the sessions which are, Morning session (7:30 – 8:00 am), Afternoon session (12:30 – 1:00 pm) Evening session (5:30 – 6:30 pm) and Night session (9:30 – 10:00 pm). By convention, equations (1) to (4) were used to evaluate the various traffic noise levels

$$.L_{Aeq} = 10\ log_{10}\left[\frac{1}{n}\sum_{i=1}^{N}\left(antilog\ \frac{L_{Ai}}{10}\right)n_i\right] \quad (1)$$

$$L_D = 10log_{10}\left[\frac{1}{2}\left(antilog\frac{L_{AeqM}}{10} + antilog\frac{L_{AeqA}}{10}\right)\right] \quad (2)$$

$$L_{DE} = 10\ log_{10}\left[\frac{1}{24}\left(15 \times anti\ log\frac{L_D}{10} + 9 \times anti\ log\frac{L_N+10}{10}\right)\right] \quad (3)$$

$$L_E = 10log_{10}\left[\frac{1}{2}\left(anti\ log\frac{L_{AeqE}}{10} + anti\ \log\frac{L_{AeqN}}{10}\right)\right] \quad (4)$$

The symbol $L_{Aeq}, L_D\ L_{DE}, L_{E,}$N, Lai and LAeq (M, A, E, N) represents:

L_{Aeq} = the average weighted equivalent sound pressure level

L_D = day-time sound level,

L_{DE} = day/evening sound level,

L_E = evening-time sound level,

N = total number of reading

L_{ai} = Average-weighted noise pressure level reading measured in dB,

LAeq(M, A, E, N) = equivalent sound pressure for the morning reading, afternoon reading, evening reading and night reading.

Table 2: A Section of Real Time Measured Noise Data from the International Market Junction, Lokoja

S/N	Reading (dB)	Data/time
1	72.6	2019-07-08 07:14:34
2	81.7	2019-07-08 07:14:44
3	81.1	2019-07-08 07:14:54
4	83.2	2019-07-08 07:15:04
5	78.7	2019-07-08 07:15:14
6	74.1	2019-07-08 07:15:24
7	83.8	2019-07-08 07:15:34
8	78.0	2019-07-08 07:15:44
9	73.1	2019-07-08 07:15:54
10	76.0	2019-07-08 07:16:04
11	70.3	2019-07-08 07:16:14
12	69.7	2019-07-08 07:16:24

Source: Author's Field work, 2019

Neural Network Model

Neural network (NN) as a tool employs mathematical models in its applications. As such, NN has the ability to make input and output data in a non-linear plotting sequence (Kashaninejad, Dehghani, & Kashiri, 2009). Applications of Artificial Neural Network (ANN) models include classification, clustering, function approximation, prediction, etc. Connection type NN is either static (feed-forward) or dynamic (feed-back). Neural networks consist in general of three foremost layers (input, hidden, output) and several modest computational basic elements known as neurons, which are basically organized in layers rather than operate in parallel (Mehdizadeh & Movagharnejad, 2011). In this work, multilayer perception, which relies on neural network based on feed forward and back propagation learning regulation, was adopted to predict the equivalent sound pressure levels in the areas considered.

Multilayer Perceptron (MLP) Network

Neural network in Multilayer perceptron consists of an input and an output layer, with an-hidden layer and information moves on from the one (1) input layer, through the layer that are hidden and then to the required output for interpretation (Mehdizadeh & Movagharnejad, 2011). Figure 1, shows Multilayer Perceptron (MLP) network with one hidden layer.

The input layer consists of LAeq(M, A, E, N) which stands for LAeqM, LAeqA, LAeqE and LAeqN respectively for the measurement in the international market junction; that is, the equivalent sound pressure for the morning reading (LAeqM), afternoon reading (LAeqA), evening reading (LAeqE) and night reading (LAeqN). The output layer (L10) stands for the noise-level which exceeded 10% for which the average time of the cumulated sound reading is collected and takes account of the associated infuriating levels of noise which people experience on hectic roads (Gracey & Associates, 2018). The model used in ascertaining the noise level in this area is called calculation of road traffic noise model (CRTN). CRTN has been deployed in some countries to determine road traffic noise effect on a surrounding area. L10 in the course of this research was determined by the CRTN model.

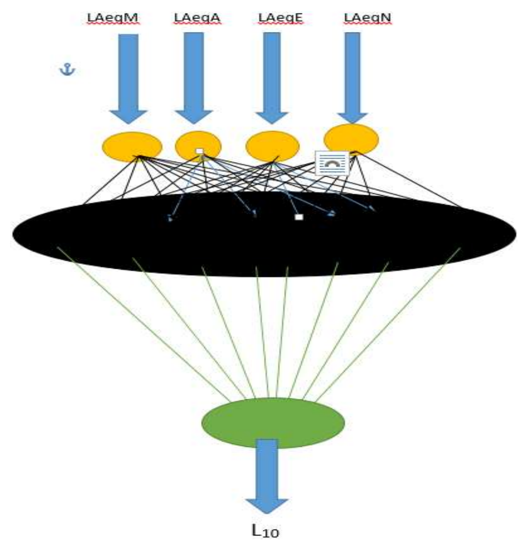

Figure 1: Multilayer Perceptron (MLP) Network Architecture

Source: Author's Field work, 2019

RESULTS AND DISCUSSION

The MLP training algorithm is the back propagation method. In training the network, the input vector is applied to the layer containing the input data. The training sought to reduce the associated errors. In predicting the noise pollution level from the measurement, the data were processed and coded before training. After training, validation and testing were done. The mean squared error (MSE) is plotted against the number of epochs made during the training. Figure 2 shows the performance having a mean squared error of 2.646 10−9 at epoch 13.

Each of the networks was trained beginning with different initial biases and weights. The division of the data set into training, validation and testing was done to get a good generalization measure of each network. The neural network having the lowest performance value generalizes best. The training, validation and testing output of the network shows a regression value of 1. This means that there is a close relationship between the target input and the output of the network training vindicating the fact that a relationship exists between road traffic flow and noise in the area selected for the study.

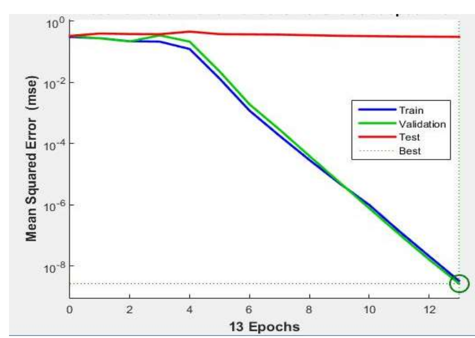

Figure 2: Validation Performance of the Network International Market

Source: Author's Field work, 2019

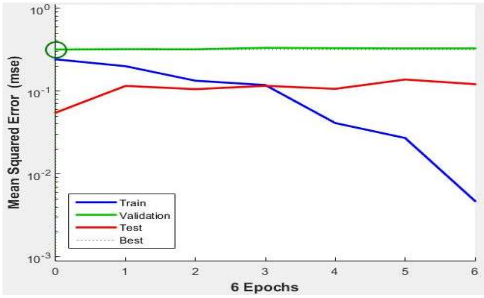

Figure 3: Validation Performance of the Network Zone 8
Source: Author's Field work, 2019

The measurements obtained by the sound meter from the 12 locations were used to train the network. Each sites' data were trained, validated and tested by the network for the prediction of the noise-level that had an average level that exceeded 10% of time otherwise known as L10. L10 is the threshold frequency of sound that most people react to. Hence, there is a need for the NN prediction. Figure 3, is the validation performance of the network in the zone 8 junction sound meter measurement. The results of the neural network analysis of the 12 locations are captured in Table 3.

The results obtained show NN to be a good tool that could be used to analyse data which relate to traffic noise level and the disorder that people close or around such traffic junctions experience. L10 was predicted for each location and using NN to analyse it shows that the highest value of 86 dB(A) was obtained in Location 3 while location 7 has the lowest value of 73 dB(A). The network output at Market road junction shows the least MSE of 0.216 while Zone 8 junction has the highest MSE of 0.317; the results further strengthen the resolve that NN is a good tool for analyses of road traffic noise.

Table 3: Neural Network (NN) Outputs of the Training

S/N	Sites	L_{10} (dB)	MSE
1	International Market Junction 1	82	0.264
2	Market Road Junction	81	0.216
3	Feather Strong Road Junction	82	0.3
4	Habson Petroleum Point 1	80	0.309
5	Beach Road Junction	86	0.298
6	Obasanjo Amusement Park	85	0.304
7	Ganaja Junction 1	73	0.302
8	Galilee Road Junction	80	0.285
9	Cummins Road Junction	81	0.299
10	Zone 8 Junction	75	0.317
11	Gen Hospital Road Junction	79	0.314
12	RCCG City Of Grace Junction	74	0.29

Source: Author's Field work, 2019

CONCLUSION

This work predicted the traffic noise level in some selected road locations in Lokoja, Kogi State, Nigeria using NN. The results of NN's prediction of L10 in each of the location, show an average of 79.8 d (A) which is on the high side compared with standard agreed by the World Health Organization (WHO) of 55 dB(A) for outdoor traffic noise level.

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