HIGHWAY TRAFFIC NOISE LEVEL IN DEVELOPING NATIONS: A CASE STUDY OF UNIVERSITY OF IBADAN, IBADAN, NIGERIA

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Abstract: The study dealt with the determination of highway traffic noise levels in the main campus of the University of Ibadan, Ibadan, Nigeria. Noise measurements were obtained with the TECPEL Model 331 Data Logger portable sound level meter, set to compute sound level distributions on a second-by-second basis. The temperatures were measured by outside weather thermometer, while the local traffic counts were done manually. In all, ten (10) locations were considered for study while data were collected between 7.20 – 16.20 Hours daily and analyzed using Microsoft Excel 2007. The results were compared with World Health Organization (WHO) road traffic noise pollution standard. The road noise levels at the zones ranges from 53.8 and 65.2 decibels [dB (A)]. These were predominantly attributable to motor vehicular traffic. The temperature varied from 24 degrees C to 32 degrees C, and the total traffic count in the selected locations was 74,829 for the period of the survey. The permissible level for road traffic noise is 50 - 55 dB (A) by WHO standard. In all the surveyed locations in the campus, the noise level surpassed the permissible limit except at Barth Road/Technology Drive 'T' junction [53.8dB (A)] and U.I./Poly gate [53.9dB (A)] that fell in the range of WHO permissible limit. In addition, the mean noise level in the University of Ibadan campus was 59.2 dB (A); this is also above the prescribed standard. The study showed that the observed departure of the noise levels from the standard specified by WHO in the campus may cause health problems in the area under study. Also the established baseline noise levels at selected locations in the University can be re-assessed at regular intervals for appropriate monitoring. The findings may require an urgent need by the institution to put in place immediate regulatory measures to minimize and control the high road traffic noise.

Keywords: Highway traffic noise, sound level meter, noise pollution standards, monitoring, health problems

I. INTRODUCTION

Noise, defined as unwanted or excessive sound, is an undesirable by-product of our modern way of life. It can be annoying, can interfere with sleep, work, or recreation, and in extremes may cause physical and psychological damage [1]. Whereas noise emanates from many different sources, transportation noise is perhaps the most pervasive and difficult source to avoid in society today [2] – [5]. The problems associated with traffic noise are receiving top priority attention and resources from governments, the private sector and the public all over the world [6]. Recent research indicates that in all major urban areas of India, for example, the mean noise level is more than twice the prescribed international limits [3]. Highway traffic noise is a major contributor to overall transportation noise. A broad-based effort is needed to control transportation noise. This effort must achieve the goals of personal privacy and environmental quality while continuing the flow of needed transportation services for a quality society.

In contrast to many other environmental problems, noise pollution continues to grow, accompanied by an increasing number of complaints from affected individuals. Most people are typically exposed to several noise sources, with road traffic noise being a dominant source. Population growth, urbanization and to a large extent technological developments are the main driving forces, and future enlargements of highway systems, will only increase the noise problem. Viewed globally, the growth in urban environmental noise pollution is unsustainable, because it involves not simply the direct and cumulative adverse effects on health. It also adversely affects future generations by degrading residential, social and learning environments, with corresponding economical losses [7]. Thus, noise is not simply a local problem, but a global issue that affects everyone [8] – [9] and calls for precautionary action in any environmental planning situation.

The objective of the World Health Organization (WHO) is the attainment by all peoples of the highest possible level of health. As the first principle of the WHO Constitution the definition of health is given as: “A state of complete physical, mental and social well being and not merely the absence of disease or infirmity”. This broad definition of health embraces the concept of well-being and, thereby, renders noise impacts as health issues, most especially in developing countries, where compliance with noise regulation is known to be weak [10].

In recent years, road noise as an environment pollutant, has been receiving increased attention. Concerns were expressed about the ill effects of noise and subsequently legislative regulations to control noises in western countries were enacted in the sixties and seventies of last century. But in the developing countries, the control exercise was initiated only in the eighties.

In recent years, the noise generated by traffic on the nation's streets and highways has been of increasing concern to both the public and government. Research and information activities are important in promoting acceptance of and compliance with highway traffic noise regulations and to encourage changes in behavior. These can also be used in their own right to encourage noise abatement measures to be taken in the study area. Therefore, a similar study was undertaken in the University of Ibadan campus in order to assess the road traffic noise level in the environment.

The objectives of the research were: determination of the road traffic noise level in the University of Ibadan campus; evaluation of the results in comparison with World Health Organisation (WHO) road traffic noise pollution standard; and establishment of baseline noise levels at selected locations that can be re-assessed at regular intervals for appropriate monitoring.

The study covered all major zones of the campus such as the academic, business, administration, and residential areas of the community taking cognizance of the three major gates leading into the campus.

II. MATERIALS AND METHODS

a) Study Area

University of Ibadan is located 8 kilometers from the centre of the major city of Ibadan in Western Nigeria. It has over 12,000 students. The site covered over 1,032 hectares of land generously leased by the chiefs and people of Ibadan for 999 years. With equipment transferred from Yaba Higher College, the 104 foundation students (including 49 students in teacher training and survey courses) began their courses at Ibadan, on 18 January, 1948; the formal opening took place on 25 March, 1948. In February, 1948, London University allowed Ibadan its special relationship scheme, and then it was called the University College, Ibadan. Arthur Creech Jones, then Secretary of State for the Colonies, and an influential member of the Elliot Commission, turned the first head at the permanent site of the University College, on 17 November, 1948, which became the Foundation Day. The University of Ibadan became an independent university in 1962 [11].

b) Data Collection

The site for this study was purposely selected because of the high traffic volume of this area and accessibility to highway junctions and roundabout, which was considered appropriate for this research. The monitoring was carried out close to the source of the road traffic noise generation in all the ten (10) selected locations in the University of Ibadan, Campus, Nigeria. The Sound Level meter was placed on a tripod stand at a height of 1.5m from the ground level and 1m from the centre line of the road. The data on noise was taken continuously for nine (9) hours (the peak period; between 7.20a.m – 4.20p.m) at an interval of 1sec. The traffic counts and the temperature were also recorded.

The locations considered were: U.I main gate, Oduduwa/Chapel road intersection (Central Administration junction), Social Sciences junction, Barth road/Technology drive ‘T’ junction (Tech junction), U.I second gate (Atiba road), Emoton/sapara/Benue roundabout, Benue/Massaba road ‘T’ junction, U.I/Poly gate(Liard road) Manuwa/Emotonl/Niger road intersection (Bello hall junction), and Chapel/Atiba/Dina/Farm road intersection (Abadina junction). Measurement locations were selected so that there was a clear view of the sound source and so was the propagation of the sound to the microphone without any blockade; these form one of the bases of selecting the monitored locations.

c) Study Instrumentation

The noise levels were measured with the help of a portable precision digital sound level meter (Model-TECPEL-331 DATA LOGGER). This instrument is primarily designed for community noise surveys. Auto ranging measurement of 30dB to 130dB, working with window software, 32,000 records data logger, bar graph indication with back light, RS-232 real time display software for window 95/98/2000 frequency weighting: A,C; 4-digit display with updated cycle 0.5s, 0.1dB resolution max/min hold function. Having the standard fast and slow time weightings, AC/DC signal output, overload condition indication, auxiliary output jack IEC 651 TYPE II, ANSI S1.4 TYPE 2. Calibration potentiometer easy to adjust, back screw hole tripod connection, external power DC 9V input.

Measurements from 30 to 130 dB (A) can be carried out with this instrument. The instrument has a wide dynamic range data logging, time-stamp on all recorded data, huge storage capacity for data, all these was achieved using manufacturer supplied manual guide. It is capable of recording sound pressure levels, per seconds for 9-hours with ability to record and store 32,000 data. Road noise measurements were taken following the prescribed procedure stipulated in the manual of the manufacturer of Sound Pressure Level meter. The results were downloaded through the sound level meter software into a PC. (laptop) by which the analysis was carried out.

d) Field Survey

The field work was carried out for thirteen (13) official working days; readings were taking at each location per day for 9-hours; for the period between 7:20am – 4:20pm (the peak period of traffic volume within the metropolis). The first 10days was used for the main field data collection in all the ten (10) locations and the last 3days was used to consolidate the readings in each location again for maximum validation of the data already collected. In each monitoring location, thirty-two thousand (32,000) data of traffic noise level were recorded and through the data logger software, and were downloaded into the PC (laptop) in a Microsoft Excel format which was used to calculate average road noise levels for specific monitored locations. After each day's downloading the memory of the sound level meter was cleared, ready for the next monitoring station. These were repeated throughout the period of the field work survey and the data were collected for analysis to meet the objectives of this project. Simultaneously, traffic counts were carried out for better correlation of the results.

e) Method of Data Analysis

The techniques of analysis involved the use of Microsoft Excel 2007 [12]. This was to generate tables and formulate equations. At each location were download into PC (Laptop) with the aid of sound level meter data logger software into Microsoft Excel format. Content analysis was also adopted to explain the result. The 32,000 data were segmented into nine (9) parts of 3,556 data per/Hr. The noise levels per/Hr. at each location were calculated. Lastly, the average noise levels at each location and average noise levels per/Hr. were calculated. Content analysis was also adopted to explain the result.

III. RESULTS AND DISCUSSION

The results shown in Table 1 indicated that the road noise levels at the zones were 65.2, 62.9, 58.2, 53.8, 63.0, 60.3, 57.5, 53.9, 61.2, and 59.3 measured in decibels [dB (A)], respectively. The source is predominantly attributable to motor vehicular traffic. The temperature varied from 24 degrees C to 32 degrees C, and the total traffic count as shown in Table 2 in the selected locations was 74,829 for the monitored period of the survey. The permissible level for road traffic noise is 50-55 dB (A) by WHO standard [13] -[15] (WHO 1996). In all the surveyed locations in the campus, the noise level surpassed the permissible limit except at Barth Road/Technology drive 'T' junction [53.8dB (A)] and U.I/Poly gate [53.9dB (A)] that fell in the range of WHO permissible limit. In addition, the mean noise level in the University of Ibadan campus was 59.2 dB (A): which is also above the prescribed standard.

The hours between 7:20a.m – 9:20 Hours Nigerian Time have the highest noise level in all the locations and there was a decline in the noise level as the time period increased. This was due to the high traffic volume at this period: as workers were trying to get to the office in time and many parents wanted to take their children to school. Interestingly, the main gate has the highest noise level and the highest traffic count. It was the noisiest of all the monitored locations as it appeared from the study; this was due to an increase in the number of vehicles in the area as well as honking of horns at the car parks close to the main gate. The results showed observed departure of the noise levels in the campus from the standard specified by WHO may cause health problems in the area under study. In addition, basic relationships peculiar to the location under study were established through the means of linear, logarithmic, exponential, power and polynomial relationships using: (a) Traffic Count as function of Time; (b) Traffic Noise as function of Time; and (c) Traffic Noise as a function of Traffic count.

a) Traffic Count as function of Time

i) Linear Relationship

$y = -310.3x + 9865.8$ (1)

$R^2 = 0.3008$ (2)

ii) Logarithmic Relationship

$y = -1376Ln(x) + 10272$ (3)

$R^2 = 0.4081$ (4)

iii) Power Relationship (Traffic Noise expressed as a power of Traffic Count)

$y = 10249x^{-0.1577}$ (5)

$R^2 = 0.3825$ (6)

iv) Exponential Relationship

$y = 9791e^{-0.0357x}$ (7)

$R^2 = 0.2844$ (8)

v) Second Order Polynomial Relationship

$y = 91.396x^2 - 1224.3x + 11541$ (9)

$R^2 = 0.4348$ (10)

vi) Third Order Polynomial Relationship

$y = -32.536x^3 + 579.44x^2 - 3280.5x + 13689$ (11)

$R^2 = 0.5134$ (12)

vii) Fourth Order Polynomial Relationship

$y = -16.264x^4 + 292.74x^3 - 1592.9x^2 + 2179.4x + 9701.9$ (13)

$R^2 = 0.5944$ (14)

viii) Fifth Order Polynomial Relationship

$y = 3.5244x^5 - 104.37x^4 + 1101.4x^3 - 4911.7x^2 + 8040x + 6342$ (15)

$R^2 = 0.6079$ (16)

ix) Sixth Order Polynomial Relationship

$y = -10.491x^6 + 318.26x^5 - 3785.8x^4 + 22274x^3 - 66799x^2 + 92818x – 34573$ (17)

$R^2 = 0.9455$ (18)

b) Traffic Noise as function of Time

i) Linear Relationship

$y = -0.3483x + 61.286$ (19)

$R^2 = 0.587$ (20)

ii) Logarithmic Relationship

$y = -1.5417Ln(x) + 61.737$ (21)

$R^2 = 0.7931$ (22)

iii) Power Relationship (Traffic Noise expressed as a power of Traffic Count)

$y = 61.743x-0.0256$ (23)

$R^2 = 0.7906$ (24)

iv) Exponential Relationship

$y = 61.283e^{-0.0058x}$ (25)

$R^2 = 0.5856$ (26)

v) Second Order Polynomial Relationship

$y = 0.1248x^2 - 1.5962x + 63.574$ (27)

$R^2 = 0.9737$ (28)

vi) Third Order Polynomial Relationship

$y = 0.0077x^3 + 0.0099x^2 - 1.1121x + 63.068$ (29)

$R^2 = 0.9804$ (30)

vii) Fourth Order Polynomial Relationship

$y = -0.0045x^4 + 0.098x^3 - 0.5934x^2 + 0.4041x + 61.961$ (31)

$R^2 = 0.9901$ (32)

viii) Fifth Order Polynomial Relationship

$y = 0.0023x^5 - 0.0614x^4 + 0.6201x^3 - 2.7363x^2 + 4.1883x + 59.792$ (33)

$R^2 = 0.9988$ (34)

ix) Sixth Order Polynomial Relationship

$y = -5E-05x^6 + 0.0037x^5 - 0.0777x^4 + 0.7136x^3 - 3.0094x^2 + 4.5624x + 59.611$ (35)

$R^2 = 0.9988$ (36)

c) Traffic Noise as a function of Traffic Count

i) Linear relationship

$y = 0.0005x + 55.145$ (37)

$R^2 = 0.4335$ (38)

ii) Logarithmic Relationship

$y = 4.2435Ln(x) + 21.308$ (39)

$R^2 = 0.3908$ (40)

Time	Car	Bike	Jeep	Bus	Van/trk	Tak/tr	**Sum/hr.**
7:20 - 8:20	8244	1224	432	270	108	-	**10278**
8:20 - 9:20	8154	1746	720	90	72	-	**10782**
9:20 - 10:20	6462	522	396	216	72	-	**7668**
10:20 -11:20	5436	450	504	162	90	11	**6653**
11:20 -12:20	6876	846	432	234	90	-	**8478**
12:20 -1:20	6750	504	648	162	36	15	**8115**
1:20 - 2:20	5526	558	378	108	90	13	**6673**
2:20 - 3:20	7560	882	630	234	54	-	**9360**
3:20 - 4:20	5346	882	396	126	72	-	**6822**
TOTAL	**60354**	**7614**	**4536**	**1602**	**684**	**39**	**74829**

Table 2: traffic count/hour of different types of vehicle in the campus

Table 1

Measured road traffic sound level at each location dB (A)

TIME	U.I. Main Gate	Central Admin	Social Sci. Junction	Tech Junction	U.I. Second Gate	Emt/Sap/Roundab	Ben/Mas junction	U.I/Poly Gate	Bello Junction	Abadina Junction	dB(A)/HR
7:20 - 8:20	66.5	65.4	60.6	59.7	67.3	62.0	62.4	60.7	57.6	56.1	**61.8**
8:20 - 9:20	66.3	64.3	60.3	57.5	64.2	62.0	59.5	58.7	63.0	57.0	**61.3**
9:20- 10:20	65.0	63.0	57.9	56.0	61.8	61.1	58.7	53.0	62.8	60.3	**60.0**
10:2- 11:20	64.8	62.2	58.4	53.7	62.2	59.7	55.0	52.9	61.2	60.9	**59.1**
11:2- 12:20	64.2	61.6	57.8	51.3	61.9	58.9	55.2	50.4	61.7	62.5	**58.6**
12:20- 1:20	64.4	61.6	57.9	53.1	60.9	59.1	55.4	50.6	61.0	60.1	**58.4**
1:20 - 2:20	64.7	62.4	57.8	50.7	62.9	60.0	55.9	52.2	61.4	59.6	**58.6**
2:20 - 3:20	65.4	62.3	57.6	50.7	62.6	59.3	56.7	53.6	61.2	57.2	**58.7**
3:20 - 4:20	65.4	63.7	57.5	51.7	63.0	60.2	58.7	52.9	61.3	59.7	**59.4**
Avg. Traffic Sound	**65.2**	**62.9**	**58.2**	**53.8**	**63.0**	**60.3**	**57.5**	**53.9**	**61.2**	**59.3**	**59.5**

iii) Power Relationship (Traffic Noise expressed as a power of Traffic Count)

$y = 31.595x^{0.0703}$ (41)

$R^2 = 0.387$ (42)

iv) Exponential Relationship

$y = 55.347e^{9E\text{-}06x}$ (43)

$R^2 = 0.4296$ (44)

v) Second Order Polynomial Relationship

$y = 3E\text{-}07x^2 - 0.0052x + 79.153$ (45)

$R^2 = 0.6653$ (46)

vi) Third Order Polynomial Relationship

$y = 1E\text{-}10x^3 - 3E\text{-}06x^2 + 0.0193x + 10.9$ (47)

$R^2 = 0.6873$ (48)

vii) Fourth Order Polynomial Relationship

$y = -4E\text{-}13x^4 + 1E\text{-}08x^3 - 0.0002x^2 + 1.072x - 2218.9$ (49)

$R^2 = 0.9398$ (50)

viii) Fifth Order Polynomial Relationship

$y = -8E\text{-}17x^5 + 3E\text{-}12x^4 - 5E\text{-}08x^3 + 0.0004x^2 - 1.2361x + 1710.4$ (51)

$R^2 = 0.9524$ (52)

ix) Sixth Order Polynomial Relationship

$y = -2E\text{-}21x^6 + 2E\text{-}17x^5 + 1E\text{-}12x^4 - 2E\text{-}08x^3 + 0.0002x^2 - 0.7091x + 967.8$ (53)

$R^2 = 0.9524$ (54)

From equations (1) to (54), it appeared that sixth order polynomial relationships best illustrated mathematical equations on (a) Traffic Count as function of Time; (b) Traffic Noise as function of Time; and (c) Traffic Noise as a function of Traffic Count. The coefficients of determinations (R^2) obtained were 0.9455, 0.9988 and 0.9524 from equations (18), (36) and (54) respectively. Aside from the fact that these were the highest R^2 obtained, the values showed strong relationships between the variables.

IV. CONCLUSIONS

The study showed that the existing noise level in the University of Ibadan Campus is about 10dB (A) higher than the standard permissible by the WHO for road traffic noise in a community, hence noise pollution has become a challenge for the University to strategically proffer solutions through policy issues. In addition baseline mathematical relationships have been established using (a) Traffic

Count as function of Time; (b) Traffic Noise as function of Time; and (c) Traffic Noise as a function of Traffic Count. These may serve as a basis for future modeling of traffic noise in the University.

The present noise levels may pose as potential health treat in the community. Effects of these treats may include hearing impairment, startle and defense reactions, aural pain, ear discomfort speech interference, sleep disturbance, cardiovascular effects, performance reduction, and annoyance responses; these health effects, in turn, can lead to social handicap, reduced productivity, decreased performance in learning, absenteeism in the workplace and school, increased drug use, and accidents [1] & [16]. In addition to health effects of road traffic noise, other impacts are important such as loss of property value. Noise has a significant impact on the quality of life, and in that sense, it is a health problem in accordance with the World Health Organization's (WHO) definition of health: which includes total physical and mental well-being, as well as the absence of disease.

The University authority may consider the protection of its populations from road traffic noise as an integral part of its policy for the campus environmental protection through the implementation of action plans with short, medium and long terms objectives for reducing road noise levels in the campus.

The university and the relevant department may also collaborate on further research to update existing data on highway traffic noise to assist in formulation of policies and action plans in line with acceptable standards on greening the environment.

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