pp 122 - 128

Investigating urban Traffic noise pollution carried out at three Institutions of Higher Learning in Windhoek, Namibia

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Abstract

Noise pollution adversely affects human health. Higher institutions of learning situated in urban areas can be affected by noise pollution. In this study, noise pollution levels were measured in three institutions of higher learning in Windhoek [International University of Management-(IUM), Triumphant College-(TC) and International Training College LINGUA-(ITC)]. The mean noise pollution values were higher than the World Health Organisation (WHO)'s, United States Environmental Protection Agency (USEPA)s' recommended limit of 45 dB (A) for silence zones. The mean noise level equivalent (L_{eq}) variation and the mean percentile noise indices of the three institutions were all above the recommended standards for educational institutions. The mean value of noise climate (NC) was found to be 18.4, 17.9 and 16.3 (IUM, TC and ITC-Lingua) and the traffic noise index (TNI) for all the locations were higher than the WHO's traffic noise recommended limit of 45 (dB). The results of the research indicate that the higher institutions of learning studied are noisy particularly because of vehicle noise. In order to reduce noise pollution within the campuses some useful suggestions were presented.

Key words: Noise Pollution, Learning Institutions, Noise Climate, Traffic Noise Index

Introduction

Noise pollution is one of the most significant environmental challenges in many parts of the globe (Pinto *et al.,* 2009; Li *et al.,* 2002; Balashanmugam et al., 2013). Although noise pollution adversely affects human health, its effects on human health have not attracted much attention like water and air pollution (Ebeniro and Abumere, 1999; Goswami *et al.* 2011). Noise pollution may lead to loss of work performance and various hearing and psychological problems (Mutasem *et al.,* 2002; Akgungor and Demirel, 2008). Noise generated from vehicular activities in urban areas has become a major problem to educational environment not only to those located at large business districts but also those located at relatively small suburbs. Earlier studies have reported that prolong exposure to excessive noise may lead to premature delivery of babies, permanent hearing loss to workers in such areas, nausea, vomiting, pain, high blood pressure, hypertension, depression, fatigue, allergy, mental stress and annoyance (Vidya and Nageswara, 2006; Oyedepo and Saadu, 2010; Wazir, 2011; Bhabananda and, Kalita, 2013).

Many studies have looked at the problems of noise pollution in educational institutions around the world (Ikenberry, 1974; Debnath et al., 2012; Bhabananda and Kalita, 2013). All the studies are in good agreement that noise pollution affects teaching and learning process.

In Namibia, almost all educational institutions are situated near busy places like bus stops, busy roads and market areas. Therefore, these learning environments are exposed to noise levels which disturb teaching and learning activities.

This study looked at noise pollution levels affecting three different higher institutions of learning (International University of Management-IUM, Triumphant College –TC and International Training College (ITC) LINGUA in Windhoek, which formed a baseline report for noise monitoring in educational institutions in Namibia.

Methods

Study Site

Windhoek is the capital city of the republic of Namibia located on latitude 22.5609° S, and longitude 17.0658° E within the Khomas Highland plateau area. It is situated 1700 metre (5,600 ft) above sea level, almost exactly at the country's geographical centre (NPC, 2011). The human population in Windhoek is about 325,858 according to the 2011 national census (NPC, 2011). It has over 300 sunny days per year, with annual average high and low temperatures of 31^{O}C and 17^{O}C respectively. The coldest month of Windhoek is July, while its hottest month is December. There are several universities and higher institutions of learning situated in Windhoek. In this study, we looked at the environmental noise pollution in the three higher institutions of learning namely: the International University of Management-IUM; Triumphant College-TC and International Training College-Lingua–ITC-Lingua. Figure 1 shows the locations of the institutions.

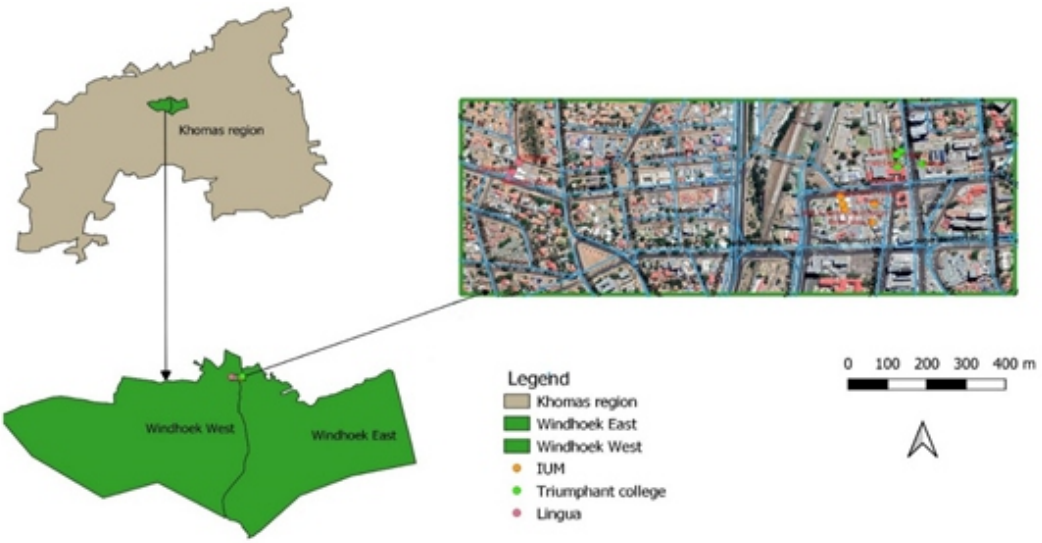

Figure 1: Aerial view of the locations of the three higher institutions of learning in Windhoek.

Data Collection

The material used for the measurement are the 3M™ 2200 integrating-averaging sound level meter, which contains a range of 30-140 dB, a weighting method of A, C, Z, a stopwatch and a mobile phone. The noise pollution measurement was carried out in different locations, within the three institutions. The measurement locations for the international university of management-IUM was carried out at the main campus at the following points; the entrance, Block A (library), Block B (admin and reception), behind block D and Block F lecture halls. At the Triumphant College, the monitoring points were; the entrance, photocopy centre, lecture rooms, parking lot and at the reception. For the international training college-lingua, the readings were collected at the entrance to the institution, the business school section and around the classroom. These measurements were conducted during the daytime at a particular time interval of 8:00-10:00, 10:00-12:00, 12:00-14:00, and 14:00-16:00 hours Universal Time (UT).

Noise Measurement Modelling

There are several models developed by different researchers to analyse equivalent environmental noise pollution levels (Quartieri *et al*., 2014; Stjepan and Vesna, 2008; Domenico, 2013; and Asheesh *et al*., 2011). In this study, we used Griffiths and Langdon method (Quartieri *et al*., 2014) to calculate the equivalent noise levels of the three higher learning institutions. Equation 1 was used to evaluate the noise equivalent levels and the statistical percentile indicators expressed in equations 2-4.

$$L_{eq} = L_{50} + 0.018(L_{90} - L_{10})^2 \quad \text{.....1}$$

$$L_{10} = 61 + 8.4log(Q) + 0.15P - 11.5log(d) \quad \text{.....2}$$

$$L_{50} = 44.8 + 10.8log(Q) + 0.12P - 9.6log(d) \quad \text{.....3}$$

$$L_{90} = 39.1 + 10.5log(Q) + 0.06P - 9.3log(d) \quad \text{.....4}$$

where L_{10}, L_{50}, and L_{90} are the percentile noise indices respectively. Q represents the total vehicles, P is the percentage of heavy vehicles and d is the distance from the source of noise to the receivers (Quartieri *et al*., 2014).

The noise pollution variation and the degree of change of traffic flow around the higher learning institutions were calculated using the Noise Climate (NC) and Traffic Noise Index (TNI) as shown in equation 5 and 6 (Bijay & Shreerup, 2013).

$$NC = L_{10} - L_{90} \quad \text{.....5}$$

$$TNI = 4(L_{10} - L_{90}) + (L_{90} - 30) \quad \text{.....6}$$

where L_{10}, and L_{90} are the percentile noise indices respectively.

L_{10} and L_{90} are the noise levels exceeded for 10% and 90% respectively of the measurement duration. L_{10} gives upper limit while L_{90} gives the lower limit (ambient or background noise).

Results and Discussion

Table 1 presents the noise standards as given by the United State of America Environmental Protection Agency, U.S. (E.P.A.), World Health Organisation (WHO) and the European Commission (E.C). The major sources of noise identified in all the learning institutions monitored can be characterized as both outdoor and indoor noise sources. These sources include vehicular traffic noise, train emission, noise from construction sites, laboratory noise, photocopy and machines. Educational institutions fall under the silence zone and the permissible noise limits for this category zone are maximum 45 dB(A) during day time (6am to 9pm) (Table 1). Figure 2, 3 and 4, shows the noise levels recorded from the International University of Management (IUM), Triumphant College (TC) and International Training College (ITC) – LINGUA, Windhoek. Clearly, the results for noise levels for all the institutions monitored exceeded the maximum allowed levels of 45 dB(A) as recommended by US EPA and WHO & EC (Table 1).

Table 1: Noise Standards as given by the United State of America Environmental Protection Agency U.S.(E.P.A.) and World Health Organization (W.H.O) & European Commission (E.C)

Country	Industrial Area Day/Night	Commercial Area Day/Night	Residential Area Day/Night	Silence Zone Day/Night
U.S. (E.P.A.)	70 / 60	60 / 50	55 / 45	45 / 35
W.H.O. & E.C.	65	55	55 / 45	45 / 35

Sources: USEPA (1974); WHO (2018); and EC (2002).

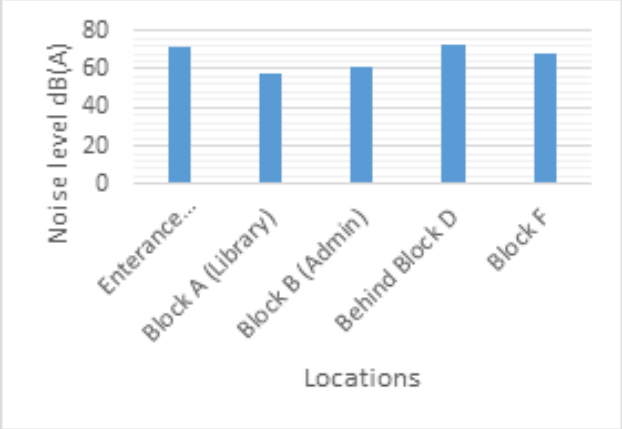

Fig. 2: Average noise pollution level at International University of Management

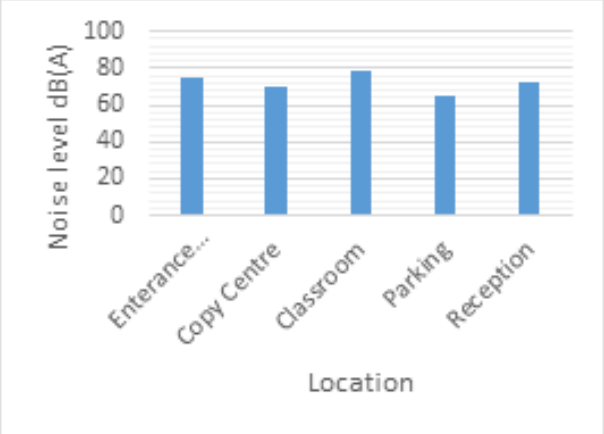

Fig: 3: Average noise levels in dB (A) at Triumphant College, Windhoek

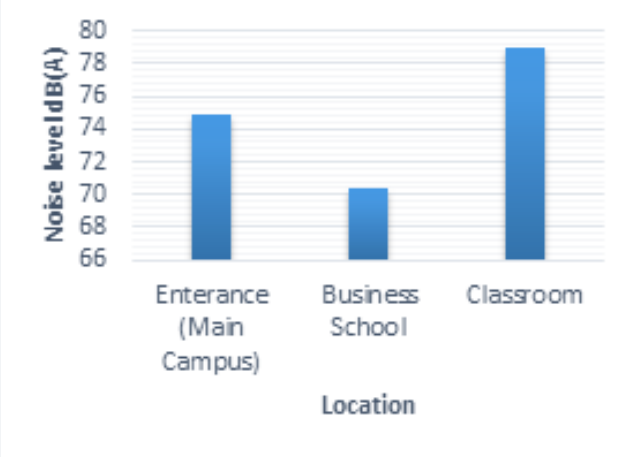

Fig. 4: Average noise levels in dB (A) International Training College-Lingua

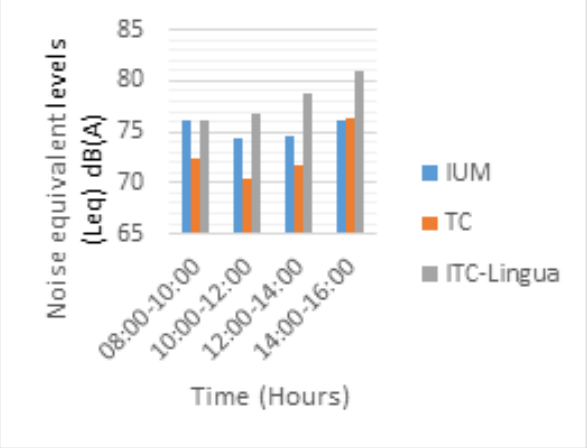

Fig. 5: Noise equivalent levels across sampling locations

Institutional Equivalent Noise Level

The results of the noise equivalent values obtained for IUM, TC, and ITC-Lingua were found to range from 74.3-76.2 dB (A) for IUM, 70.4-76.3 dB(A) for TC and 76.1-81.0 dB(A) for ITC-Lingua respectively (Figure 5). The values obtained were not in accordance with the prescribed noise equivalent limit in respect of silence zone. The noise equivalent levels L_{eq} and the percentile of 10^{th}, 50^{th} and 90^{th} of the noise indices were obtained by using the model proposed by Griffiths and Langdon (Quartieri *et al.*, 2009). The total traffic flow of vehicle data, Q, obtained during measurement at IUM, TC, and ITC are 370, 318 and 326 respectively. The average percentage of heavy vehicle P obtained are 25.3, 25.9 and 25.1 percent respectively. The distance from the source of noise to the sound level meter were 9.4m, 13.4m, and 12.3m respectively.

Table 2: L_{10} percentile noise indices variation

Time interval (Hour)	IUM	TC	ITC Lingua
08:00-10:00	70.0	66.7	72.1
10:00-12:00	68.5	65.2	72.3
12:00-14:00	54.6	66.3	73.9
14:00-16:00	69.9	69.5	75.3
Min	54.6	65.2	72.1
Max	70.0	69.5	75.3
Mean	65.8	66.9	73.3

Table 3: L_{50} percentile noise indices variation

Time interval (Hour)	IUM	TC	ITC Lingua
08:00-10:00	59.2	56.0	62.7
10:00-12:00	58.0	55.1	62.9
12:00-14:00	47.6	55.9	64.1
14:00-16:00	59.2	58.7	65.3
Min	47.6	55.1	62.7
Max	59.2	58.7	65.3
Mean	56.0	56.4	63.8

Table 4: L_{90} percentile noise indices variation

Time interval (Hour)	IUM	TC	ITC Lingua
08:00-10:00	45.2	42.2	57.1
10:00-12:00	44.0	41.5	56.5
12:00-14:00	46.6	35.6	57.1
14:00-16:00	45.2	44.8	57.6
Min	44.0	35.6	56.5
Max	46.6	44.8	57.6
Mean	45.3	41.0	57.1

Noise Indices

The various ambient noise parameters or noise indices, such as L_{10}, L_{50}, L_{90} NC and TNI were also computed and the results shown in Tables 2, 3, 4, 5, and 6 respectively. The results obtained for L_{10} for the three campuses ranged from 54.6-70.0 with an average value of 65.8 for IUM, 65.2-69.5 with an average value of 66.9 for TC and 72.1-75.3 with an average value of 73.3 for ITC-Lingua. L_{50} values varied from 47.6-59.2 with an average value of 56.0 for IUM, 55.1-58.7 with an average value of 56.4 for TC and 62.7-65.3 with an average value of 63.8 for ITC-Lingua. The evaluated result for L_{90} ranges from 44.0-46.6 with an average value of 45.3 for IUM, 33.6-44.8 with an average value of 41.0 for TC and 56.5-57.6 with an average value of 57.1 for ITC-Lingua. A comparison of the noise indices for the three institutions showed that ITC-Lingua has the highest values of noise indices, which may be because of the impact of traffic speed around the institution. The Noise Climate (NC) varies between 17.8–18.8 during 08:00-10:00 and 10:00-12:00noon 10:00-12:00 noon and 14:00-16:00 hours with an average of 17.9 for TC and 15.0–17.7 during 08:00-10:00 hours and 12:00-14:00 hours with an average value of 16.3 for ITC Lingua. Traffic Noise Index (TNI) calculated ranged from 91.6-115.0 with an average value of 99.5 for IUM, 96.2-97.3 with an average value of 90.4 for TC and 87.1-98.4 with an average value of 92.4 for ITC-Lingua. The result show that IUM has more traffic related noise than the other institutions.

Table 5: Average Noise Climate of the three institutions

Time interval (Hour)	IUM - dB(A)	TC- dB(A)	ITC Lingua – dB(A)
08:00-10:00	18.6	17.7	15.0
10:00-12:00	18.8	17.0	15.8
12:00-14:00	17.8	17.5	16.8
14:00-16:00	18.5	19.3	17.7
Min	17.8	17.0	15.0
Max	18.8	19.3	17.7
Mean	18.4	17.9	16.3

Table 6: Average Traffic Noise Index of the three institutions

Time interval (Hour)	IUM	TC	ITC Lingua
08:00-10:00	95.8	89.2	87.1
10:00-12:00	91.6	86.2	89.7
12:00-14:00	115.0	88.9	94.3
14:00-16:00	95.4	97.3	98.4
Min	91.6	86.2	87.1
Max	115.0	97.3	98.4
Mean	99.5	90.4	92.4

Conclusion

The present study reveals that all the educational institutions monitored are affected by noise as these noise levels are higher compared to the standards of the United State of America Environmental Protection Agency and those recommended by the World Health Organization and the European Commission for silence zone. The minimum values of noise equivalent levels recorded for the three institutions were 74.3, 70.4 and 76.1 for IUM, TC and ITC-Lingua respectively. The calculated values of noise indices were higher compared to the recommended standards prescribed for silence zones. A comparison of noise traffic index showed that IUM was exposed to traffic noise more than the other institutions. The following recommendations were provided to minimise the impacts of noise around the educational institutions: (1) Creating a bypass road for vehicles outside the educational institutions, (2) Ban on the use of horns, (3) Planting of trees especially shrubs along the roadside to reduce noise, (4) The implementation of technical measures for noise levels.

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