

EVALUATION OF TRAFFIC NOISE POLLUTION LEVELS IN JIMMA CITY, ETHIOPIA

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Abstract. This study aims to assess the environmental traffic noise pollution levels in Jimma city, especially in market area where mini-bus, trucks, tricycles, buses, motorbikes, and loudspeakers are the major sources of noise. Ten different sites were selected randomly for the noise level measurements along the left and right edge of the roads. The measurements were taken from March 04–19, 2021 at morning 8:00 – 12:45 AM, and afternoon 2:30 – 6:45 PM after every 5 minutes interval. Results showed that the rate of minimum noise in Jimma city, market area in the morning L_{10} , L_{50} , and L_{90} were 84.02 ± 3.59 dB, 82.05 ± 3.84 dB, and 81.12 ± 3.08 dB, respectively, whereas in the afternoon L_{10} , L_{50} , and L_{90} were 87.55 ± 2.07 dB, 82.95 ± 3.70 dB, and 83.73 ± 1.79 dB, respectively. The mean traffic noise index in the morning and afternoon were 94.63 dB and 91.39 dB, respectively. The mean continuous sound equivalent level (L_{Aeq}) in the morning and afternoon were 86.42 dB and 80.04 dB, respectively. The noise level obtained in this study was higher than the acceptable levels compared to another study done in the country. Therefore, noise mitigation strategy and other different preventive countermeasures such as increasing public awareness through educational programs and technical controls for the future development of Jimma city are crucial.

Key words: Traffic noise level, noise climate, street traffic noise, noise pollution.

INTRODUCTION

Noise is an unwanted sound with random intensity of signals that bears no information [9]. Noise pollution (also termed as sound pollution) refers to undesirable levels of noise caused by human activity especially the urbanization and the development of transport and industry that disrupt the standard of living in the affected area. Noise pollution is a problem not only in developed countries, but also in developing countries like Ethiopia nowadays. According to WHO [19], noise pollution in big cities is considered to be the third hazardous environmental pollution after air and water pollution [14]. Moreover, recent research done in Dire Dawa city by Goshu *et al.* [10] and Mesfin *et al.* [13] shows that it was a serious problem. Moreover, similar research done in Nigeria [3] and in Addis Ababa [2] shows that noise pollution has an adverse effect on the life of citizens.

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Industrialization and urbanization have made people migrate to cities from nearby rural areas [14]. This increases the human activities that have major contribution to noise pollution. Markets attract people from every corner of the surrounding area for commercial economic and social transactions, resulting in high noise emission. Road traffic noise is considered the main source of noise in large cities and the most worrisome when it comes to annoyance.

According to WHO [19], exposure to noise for a long duration according to occupational safety and health act, may result to physical, physiological, and even psychological problems [3]. These problems may include permanent or temporary loss of hearing, interference with speech clarity and intelligibility, reduced productivity, increase in blood pressure and lack of concentration.

Recent research done in Dire Dawa city [10] has pointed out that traffic is the major source of noise pollution in the city. Another study performed in Germany [7] has shown that traffic noise pollution increased the incidence of heart diseases [4].

The present study sought to assess the level of noise pollution in Jimma city, Ethiopia, in the market area.

MATERIALS AND METHODS

STUDY AREA

This is a study of the environmental equivalent noise levels within Jimma city in the market area, commonly called Merkato, conducted between March 4–19, 2021. The study area included the main road to the market area, on both sides of the road, located at a distance of 1.5 m from reflecting surfaces.



Fig. 1. Map of Jimma city [5].

Jimma city is a fast-growing city located between latitudes 8.250 to 9.250 North and longitudes 36.450 to 37.390 East. Although the official population according to 2006 censuses stood at 776, 298, the rapid migration of internally displaced citizens as a result of insurgency and terrorism in the North-East, and

daily migration of people into the city from the surrounding area for business is believed to have doubled this number. The map of the city is shown in Figure 1.

INSTRUMENTATION

Analogue sound level meter PCE318 (PCE Instruments UK. Ltd, United Kingdom) was used to measure the sound intensity. This instrument has the range from 20 dB to 130 dB, a resolution of 0.1 dB, frequency range 31.5 Hz, time weighting of fast and slow, accuracy 1.5 dB, and weight of approximately 260 g. The instrument was calibrated to measure average noise level. The instrument is comfortably held in hand at 1 m above the ground with a microphone pointed to the suspected noise source: the three-wheeled cars, minibuses, taxies, trucks, motorcycles, and loudspeakers, the sources which generated noise in the market areas.

The instantaneous sound levels were recorded every 5 minutes for a period of 720 minutes. The total number of recorded data, carried out daily from 8:00 AM to 12:45 PM in the morning, and 2:30 to 6:45 PM in the afternoon, was 961 for 15 days from March 04 – 19, 2021. Based on the collected data, the weighted equivalent sound level pressures were computed. The average weighted sound level L_{Aeq} and the daytime average sound levels were computed using the equation [10, 11, 17]:

$$L_{Aeq} = 10 \log_{10} \left| \frac{1}{N} \sum_{i=0}^N 10^{\frac{L_i}{10}} \right| \quad (1)$$

where L_{Aeq} is the weighted values of equivalent continuous noise level in dB over a given period. It is measured continuously at a particular point [10, 11, 17]. L_i is the recorded intensity levels in each time intervals, N is the total number of observations and n_i is the recorded time.

The ambient noise pollution level was calculated as

$$LNP = L_{Aeq} + ks \quad (2)$$

where k is a constant which is provisionally given the value 2.56 and s (dB) is the standard deviation of the instantaneous level in time [7, 11, 15, 16].

Various noise pollution indices were calculated using Gaussian percentile to obtain the noise pollution levels. Different percentile statistical values like L_{10} , L_{50} and L_{90} were computed from the sampled data and these parameters were used for the evaluation of noise climate (NC), traffic noise indices [17]. Noise indices like, noise climate (NC) and traffic noise index (TNI) were computed according to the following equations [6, 12]:

$$NC = L_{10} - L_{90} \quad (3)$$

$$TNI = L_{90} + 4 \times NC - 30 \quad (4)$$

where, L_{10} and L_{90} is the traffic noise level exceeded for 10 % and 90 % of the sampling time, respectively.

RESULTS AND DISCUSSIONS

RESULTS

The study area is noisy due to the rapidly increasing number of vehicles in the city. The roads in the study area have been overflowed with heavy traffic throughout the day.

The intensity of noise levels recorded during the study time is shown in Table 1. The results show that the highest mean noise intensity, 82.74 dB, was recorded on March 09, 2021. On that day, the maximum intensity, 90.04 dB, was recorded in the morning. The minimum intensity was recorded 49.57 dB with the standard deviation of 11.2 dB. Similarly, in the afternoon, the highest mean intensity noise recorded was 73.77 dB on March 11, 2021, while the maximum intensity was 81.22 dB. The minimum intensity, 52.34 dB, with the standard deviation 7.72 dB, was recorded on March 13, 2021.

Table 1

The average, maximum, minimum and standard deviation of continuous intensity emitted from Jimma market area from March 4–19, 2021 in the morning and afternoon

Date (March, 2021)	Morning				Afternoon			
	Average (dB)	Max (dB)	Min (dB)	Std (dB)	Average (dB)	Max (dB)	Min (dB)	Std (dB)
04	72.45	81.25	62.45	5.26	69.13	79.85	59.75	5.91
05	71.85	85.30	56.78	6.43	67.62	79.12	55.56	7.05
06	73.09	84.56	60.25	8.22	74.51	79.76	69.45	3.34
07	70.87	86.54	57.25	9.00	65.22	76.98	59.75	4.44
08	70.11	85.67	49.57	11.2	72.98	78.54	54.76	5.41
09	82.74	90.04	55.45	8.64	70.87	78.45	62.45	4.31
10	73.3	75.71	69.9	2.09	73.15	81.22	61.23	6.01
11	71.78	72.38	71.15	0.51	73.77	79.77	70.24	2.98
12	76.57	80.54	73.25	3.54	66.33	69.87	60.77	3.00
13	81.11	86.47	75.96	4.29	68.07	78.76	52.34	7.72
14	75.02	76.1	74.55	0.43	72.43	78.74	58.43	5.66
15	74.53	74.55	74.49	0.02	64.54	69.76	60.23	2.94
16	66.25	76.1	63.58	2.82	67.09	78.76	60.23	5.1
17	75.59	77.25	74.08	1.12	69.26	78.76	60.45	5.58
18	69.77	73.77	66.98	2.29	73.85	78.72	70.05	2.66
19	74.48	76.29	71.5	1.55	72.6	79.45	69.22	2.56

The results shown in Table 2 revealed that the average sound level (L_{Aeq}) in the morning and afternoon were 77.00 and 75.67 dB, respectively.

The equivalent continuous noise level in Jimma city in the market area lies between 64.11 dB to 86.42 dB in the morning; in the afternoon, it was between 63.9 dB and 80.04 dB shown in Table 2.

The noise pollution level in the market area, calculated using Eq. 2, is shown in Table 2, in columns 3 and 5. The results indicate that the noise pollution level is between 64.16 dB and 92.21 dB in the morning; in the afternoon it lies between 77.32 dB and 89.52 dB.

Table 2

The equivalent and the average noise levels

Date [March, 2021]	Morning		Afternoon	
	L_{Aeq} (dB)	LNP (dB)	L_{Aeq} (dB)	LNP (dB)
04	78.8	85.05	63.9	85.05
05	81.07	92.21	77.53	92.21
06	84.58	90.34	80.04	90.34
07	66.07	89.11	73.26	89.11
08	65.95	80.21	79.18	80.21
09	74.39	83.40	77.01	83.40
10	79.89	85.24	79.1	85.24
11	77.5	78.81	79.48	78.81
12	84.56	88.53	71.42	88.53
13	86.42	92.13	75.99	92.13
14	70.85	71.95	79.56	71.95
15	64.11	64.16	69.8	64.16
16	68.48	75.70	73.76	75.70
17	82.69	85.56	75.24	85.56
18	82.06	87.92	78.47	87.92
19	84.72	88.69	76.94	88.69

Table 3 lists the traffic noise level and annoyance perceived during this study. From the measurements, the maximum, minimum and the mean noise levels and traffic annoyance in the morning and afternoon were evaluated for each day. The result shows that the minimum the ambient noise levels for L_1 , L_{10} , L_{50} and L_{90} were 62.45 dB, 84 dB, 82.05 dB, 81.12 dB, respectively.

The annoyance response to traffic noise level was estimated in terms of NC and TNI . The noise climate and traffic noise indices depend on ambient noise levels of L_{10} and L_{90} , the minimum value of NC and TNI were 0.5 dB and 55.5. dB respectively, while the maximum values for NC and TNI were 7.73 dB and 88.21 dB in the morning. The maximum TNI value was 88.21 dB. This implied annoyance in response to traffic noise in the morning time in Jimma city, which was higher than the results mentioned in [6].

The average noise distribution measurements for morning time for L_1 , L_{10} , L_{50} , and L_{90} were 77.29 dB, 83.08 dB, 88.96 dB and 84.52 dB, respectively. The

average noise climate and traffic noise indices were 4.36 dB and 73.10 dB, respectively.

Similarly, the traffic noise level and annoyance response were evaluated in the afternoon, as shown in Table 4. The average maximum levels L_1 , L_{10} , L_{50} and L_{90} were 92.99 dB, 73.06 dB, 84.52 dB and 70.32 dB, respectively.

Table 3

Traffic noise level and annoyance response in the morning
from March 04–19, 2021 from 8:30 AM –12:30 PM

Parameters	Min	Max	Mean	Std
L_1 (dB)	62.45	85.46	77.29	7.03
L_{10} (dB)	64.16	92.21	83.08	7.79
L_{50} (dB)	82.05	94.13	88.96	3.84
L_{90} (dB)	77.32	89.52	84.52	3.61
NC (dB)	0.81	9.13	4.36	2.47
TNI (dB)	54.1	91.37	73.1	11.25

Table 4

Traffic noise level and annoyance response in the afternoon
from March 04–19, 2021 from 2:30–6:30 PM

Variables	Min	Max	Mean	Std
L_1 (dB)	79.32	102.74	92.29	7.17
L_{10} (dB)	54.1	91.37	73.06	11.25
L_{50} (dB)	77.32	89.52	84.52	3.61
L_{90} (dB)	52.12	94.63	70.32	10.33
NC (dB)	0.1	10.84	3.62	2.75
TNI (dB)	52.12	94.63	69.94	10.33

DISCUSSION

The maximum value of L_{Aeq} measured in Jimma city, market area, shown in Table 2, is above the minimum limit mentioned by WHO [19]. This can affect the acoustic comfort of the residents in the city. During the measurement time, the residential area located near the market and the people who work in this area were highly affected by the noise. Moreover, the peak noise pollution level in Jimma city market was above Dire Dawa Kefera market area evaluated in refs. [10, 11, 19].

The annoyance response to traffic noise in the morning time in Jimma city, shown in Table 3, was higher than the results mentioned in ref. [6]. Similarly, the average maximum noise climate and traffic noise index were 3.62 and 69.94, respectively, whereas the traffic noise index was 94.63 dB in the afternoon of March 8, 2021, which is above the maximum recommended noise level specified by the WHO guideline [19]. According to WHO [19], in developed countries, noise from transportation, as the main environmental noise pollution, can potentially affect the public health. Therefore, the results obtained in this study demonstrate

that traffic-related noise level on the main road of the market area Jimma city is unacceptably high. The exposure rate is hazardously high when people are exposed to such noise levels for more than 8 hours.

CONCLUSIONS AND RECOMMENDATIONS

The main aim of this study was to assess environmental noise pollution levels in Jimma city. The findings of this study, as well as from other studies [1, 10, 20], identify traffic as a major source of noise pollution [10, 11]. Since excessive noise appears unavoidable in Jimma city's market area, it may be appropriate for noise exposure assessment to be taken as a requirement for environmental impact statements in this area. This study shows the noise pollution levels was high. Therefore, as legislators protect people from tobacco smokers, they should protect citizens from noise pollution as well. Regional leaders and other stakeholders involved in noise emission should implement the existing laws, policies, guidelines and directives regarding environmental pollution by raising people's awareness of noise pollution and its health hazards by conducting regular public health campaigns.

In summary, the following conclusions can be drawn from the current study:

1. The levels of noise in the study area (Jimma city, market area, Ethiopia) are greater than Ethiopian national standard for commercial areas mentioned in refs. [8, 13].
2. Equivalent average noise levels, traffic noise index, noise pollution level and noise climate were mainly determined by traffic volume and market activities.

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