EVALUATION OF ENVIRONMENTAL NOISE POLLUTION OF KEFERA MARKET OF DIRE DAWA CITY, ETHIOPIA

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Abstract. The purpose of this work is to investigate the cause of the environmental noise pollution in the Kefera market and assess the noise pollution level. The data were collected for three consecutive days, from April 04 to 06/2019, in the morning and afternoon during 80 minutes. Data were collected every 5 seconds by moving to the center of the market from three different directions. The results revealed that the traffic noises were strongly time-dependent. The noises parameters were L_{10}, L_{50}, L_{90}, L_{Aeq}, L_D and L_{NP}, and determined the produced noise levels. Moreover, this work has tried to answer the main cause of noise pollution in the Kefera market and surrounding.

Key words: Noise pollution level, noise source, transient noise, market noise.

INTRODUCTION

Noise can be defined as a "disagreeable or undesired sound" or other disturbance. From the acoustics point of view, sound and noise constitute the same phenomenon of atmospheric pressure fluctuations around the mean atmospheric pressure. The differentiation between sound and noise is greatly subjective: a sound, for one person, can be noise for somebody else, depending of perception modality. The recognition of noise as a serious health hazard is a challenge of modern times. As it was documented by [22], the amplified music may be considered as sound for some of the listeners which gives pleasure to them, whereas for the others it is just the noise.

At home and at work or any other places, we often hear noise from ventilation or heating systems that is hardly noticeable because it has no prominent features. The noise never stops and has no tone, but if the fan suddenly stops or starts to whine, these changes may disturb or even annoy us. Our hearing recognizes information carried by the sounds that we hear. All the information that we do not need or want is considered as a noise. The noise features that make us listen and take notice are tones or changes in sound level.

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When measuring a noise, we need to know the type of it so that we can choose the parameters to measure, the equipment to use, and the duration of the measurement. Often, we need to use our ears to pinpoint the annoying features of the noise, before making objective measurements, analyzing and documenting them. As it was noticed by different scholars, the noise produces a series of physiological, psychological, and behavioral problems [6, 13, 22]. One of the main types of noise which produces displeasure is traffic noise. It is the main environmental pollutant encountered in the daily life of human being which directly affects his health [14].

Noise pollution in urban environment comes from numerous sources, e.g., sirens, loud music, neighbors, car and home alarms, religious temples, horns, motorcycles, trucks, passenger cars, buses, planes, trains, etc. [5, 8, 16, 21].

Noise pollution is a significant environmental problem in many rapidly urbanizing areas. One of the most undesirable side effects of the improperly planned city is the pollution of the environment and consequent degradation of the quality of life [7, 9]. Various works have also been done on the relationship between the extent of reaction of people and exposure to traffic noise in Dire Dawa city [13, 22]. However, more recent research has concentrated on the relationship between noise and non-auditory effects [15].

This work focuses only on a single area where most of the vehicles are going from every corner of the city toward it. The researchers have measured the noise level of Kefera market area because this biggest market of the town is found in the area where a lot of consumers, from every corner of the city, are coming here to get their daily food consumption. People are working here from early in the morning until later in the night. Therefore, the main purpose of this study was to investigate the cause of the environmental noise pollution in this market and assess the noise pollution level.

MATERIAL AND METHODS

STUDY AREA

The outdoor sound level measurements were carried out in May 2019 at 12 different locations, as shown in Figure 1 of Kefera market in Dire Dawa city (a very crowded area with busy road junctions, goods loading parks, and high-density residential in the surrounding areas). Kefera is one of the most important areas of the city and is located in the South of the city with the latitude between 9.580^{o} and 9.599^{o} and its longitude between 41.850^{o} and 41.866^{o}.

The map of the market, shown in Figure 1, depicts the main road and the link roads, too. Most of the houses, shops, and the open market are located along the main road. Besides, there is a large open market area located at the edge of the main road. On the other hand, there are two link roads passing through the residence of the city and connecting the market.

The data were collected from four sides of the market which are equidistant from the center of the market place. Each red point shown in the map represents the equidistant places where the data were taken. They were taken in three consecutive days, in the morning and afternoon, for 80 minutes.

Fig. 1. Selected cites of Kefera market in Dire Dawa city. The stars indicate the points were data were measured. The arrow shows the direction of other roads which approaches to the center of the market.

INSTRUMENTATION

A digital sound level meter, Az8928, was used to measure the sound intensity level which ranges from 40 to 130 dB. The device has performed the measurements with an accuracy of ±2 dB. The instrument is calibrated to measure average noise levels.

The measurements were made at street level (at road junctions toward market center from each corner). The instrument was comfortably held in hand, at 1 m above the ground, with the microphone pointed to the suspected noise sources [1–3]. The three-wheeled cars and mini-buses are coming toward the market from three sides, all emitting noises. Moreover, people coming to the market to communicate with the sellers, rapidly raise the level of sound for communication. This loud conversation could be an additional noise source.

The instantaneous sound levels were recorded with the instruments for a period of 80 minutes every 5 seconds. The total number of recorded data, carried out daily from 8:30 to 9:50 AM in the morning, and 2:30 to 3:50 PM in the

afternoon, was 961. Based on collected data from survey, the weighted equivalent sound level pressures can be computed. The average weighted sound level L_{Aeq} and the day time average sound levels can be computed by the equation [17]:

$$L_{\mathrm{Aeq}} = 10\log_{10}\left[\frac{1}{N}\sum_{i=1}^{N} 10^{L_{\mathrm{A}i}/10} n_i\right] \tag{1}$$

where L_{Aeq} is the equivalent continuous noise level in dB over a given period of measuring. It is measured continuously at a particular point [17]. It is the average rate at which energy is received by the human ear during the mentioned period. L_{Ai} is the recorded intensity in each time intervals, N is the total number of observations and n_i is the recorded time.

The daytime noise level of the sound can be computed by the equation [10]:

$$L_{\mathrm{D}} = 10\log_{10}\left[\frac{1}{2}\left(10^{L_{\mathrm{AeqM}}/10} + 10^{L_{\mathrm{AeqA}}/10}\right)\right] \tag{2}$$

where L_{AeqM} is the weighted average sound level during morning, L_{AeqA} is the weighted average sound level in the afternoon measured and L_{D} is the daytime noise level [10].

As it was described in Eq. (1), the noise fluctuation depends on the average equivalent noise produced. Therefore, the noise pollution depends on the amount of the equivalent continuous noise. The level of this fluctuation of the sound levels is the noise pollution level, L_{NP}. It is given by [10] as

$$L_{\mathrm{NP}} = L_{\mathrm{Aeq}} + K\sigma \tag{3}$$

where K is a constant term and σ is the standard deviation of the sound level measured during the same period. The value of K is 2.56 for this work [10].

RESULTS AND DISCUSSION

The results of observation and field data are analyzed and discussed in this section. The study area was subjected to problems due to pressure of rapidly increasing number of people in the city and unplanned traffic volume. The roads and the market place in the study area have been observed to be overflown with voluminous traffic throughout the day especially, in the morning. The measurements were taken in the morning and afternoon from 8:00 AM to 9:20 AM and 3:00 PM to 4:20 PM, respectively.

The second data were recorded on the next day at the same time as of the first day, and the last data were recorded in the third day during the same time, both in morning and afternoon as mentioned.

Both in morning and in the afternoon session the main noise pollution is due to traffic noise and people conversation. The measurements show that the average equivalent noise level during morning and afternoon in the first day are 61.14 dB

and 60.76 dB respectively. In the second day the measurements show that the average equivalent noise levels during the morning is 57.7 dB and 60.7 dB in the afternoon. In the third day, the measurement shows that during the morning are 85.27 dB and 59.5 dB in the afternoon.

The major causes of noise pollution in the market area were three-wheeled cars, construction trucks, mini-buses, conversation, and amplifiers. The equivalent noise levels emitted from the sources can be arranged in MATLAB script in order to compute: the average equivalent noise levels, the daily average equivalent noise, and the noise pollution level described by Eqs. (1) – (3). The average equivalent noise variations at the given time intervals, in 04/04/2019, during the morning and afternoon, are shown in Figures 2 and 3. The results depict that peak L_{Aeq} is 121.64 dB, the minimum L_{Aeq} = 17.21 dB, with the standard deviation of 15.19 dB. During morning time, the average equivalent noise has a peak around 45 minutes. Moreover, throughout the time, the average equivalent noise fluctuates also with distance.

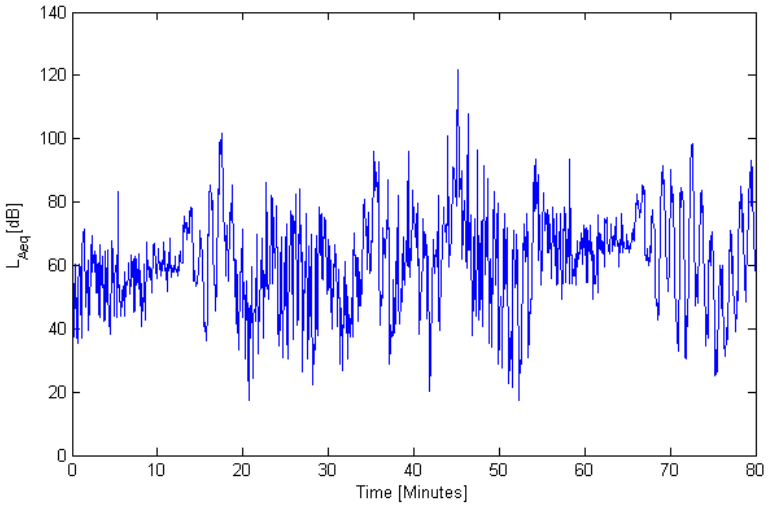

Fig. 2. The average equivalent sound intensity level in the morning, from 8:30 to 9:50 on 04/04/2019.

In the afternoon, the average equivalent noise variation shown in Figure 3, highly fluctuates with time and distance from the source. The maximum and the minimum average equivalent noise variation are 114.8 dB and 21.01 dB, respectively with the standard deviation of 15.72 dB. The average fluctuation varies from 25 to 95 dB in the time interval of 25 to 60 minutes. The rate of fluctuations from 30 to 50 minutes is very high. This is due to the high traffic volume in the market areas. The criterion that was adopted by [19], was the noise risk zone. The first risk zone observed from 0 to 15 minutes is that of the average noise levels of 80 dB. Around 20 minutes, there is a tolerable zone whose noise level was below 65 dB. Similarly, we can further classify the risk zone by observing the fluctuations of average equivalent noise levels.

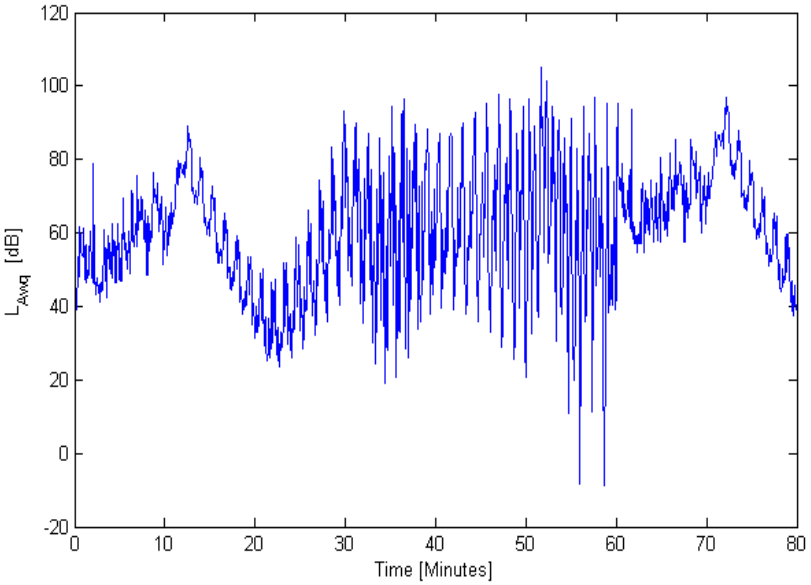

Fig. 3. The average noise equivalent during the afternoon from 2:30 to 3:50 PM on 04/04/2019.

For the sake of comparison of the average noise equivalent daily noise level in each day, we have plotted three independent Figures using Eq. (2). Figure 4 shows the average daily noise equivalent of 04/04/2019; Figure 5 depicts the average daily noise equivalent on 05/04/2019, and Figure 6 shows the average daily noise levels on 06/04/2019. The nature of fluctuations in these three days is not the same. Since the place is the market area, the goods coming from different corners of the country were unloaded here. Moreover, the date also had its own impact on the production of noise. This is because, in the city, the days 04, 05 and 06 of each month, were the days when most of the workers received their salary.

As we noted from Figure 5, in the second day of recording, the average daily equivalent noise pollution fluctuated raising it output noise levels as compared to the first-day fluctuations, shown in Figure 4. Moreover, in Figure 4, at the last minutes of observation, the average daily noise level is below 50 dB, whereas in Figures 5 and 6, the average daily noise levels were above 60 dB. This shows that at that particular time in these two days, there was a noise source which creates great noise in and around the market area. As we noted from Figure 6, in the time intervals between 50 and 60 minutes, there was a transient variation of noise levels in the gate of the market area, due to the fact that the variations of the noise levels move up and down rapidly near the corner of the road. Beyond 60 minutes, the variation of the noise levels moves up in the positive direction instead of moving below 80 dB. As it was shown by [9], the transient variation of the source of the sound arises by traffic noise mainly.

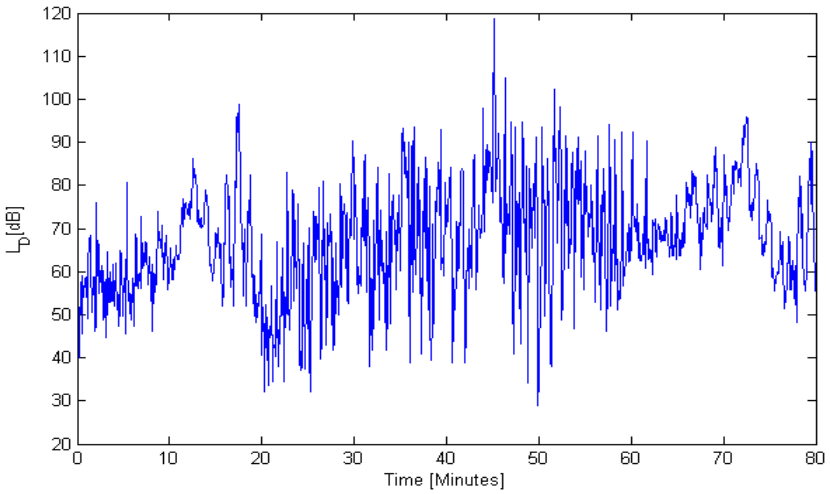

Fig. 4. Variation of daily noise with time on April 04, 2019.

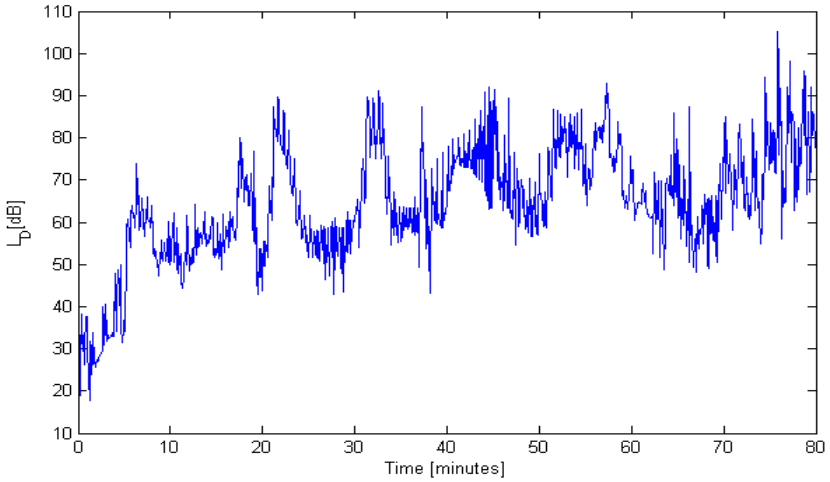

Fig. 5. Variation of daily noise with time on April 05, 2019.

The noise pollution level of the first day of recording is shown in Figure 7. It was calculated using Eq. (3) with the constant values K = 2.56 and the standard deviation of the recorded measurements. As we noted from the Figure 7, there is a high fluctuation of noise in the first 13 minutes, which oscillates between 40 to 62.5 dB. Transient noise levels come from the vehicle (like three-wheeled cars, trucks, mini-buses and loudspeakers) and passers-by. This is the reason why the noise pollution levels are high around 48 minutes shown in Figure 7. In addition, near to the Kefera market, there are different workshops which produced different

materials which are ready for selling. This has its own impacts on raising the noise pollution level of the market area. The other reason is the nature of the roads. The road, single and two ways, serves for all types of vehicles. In addition, the number of people surrounding this area is high. All these are added together to raise the noise pollution of the place. As we have noticed, in all open market types, people are selling their goods using microphones for advertising the buyers. Similar research done by [4] shows that the noise levels can rise and has a positive impact on raising the noise levels.

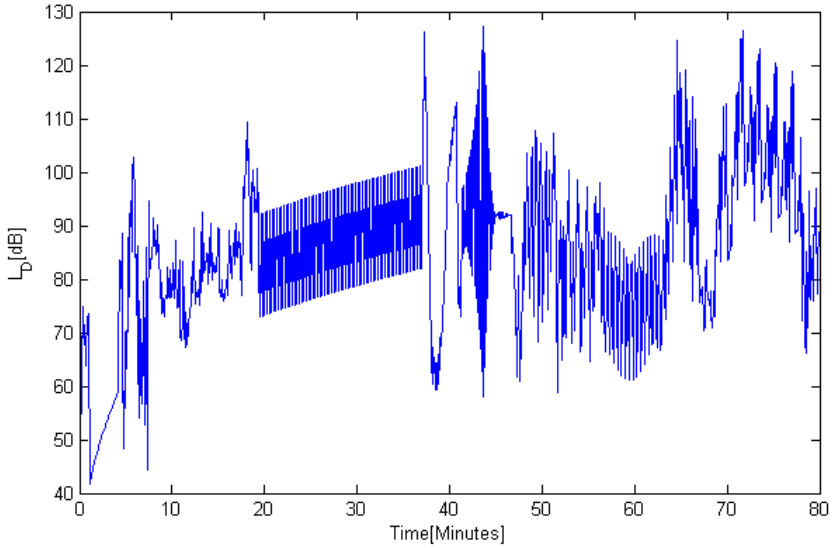

Fig. 6. Variation of daily noise with time on April 06, 2019.

L_n is a descriptor that identifies the sound level that is exceeded n percent of the time over a measurement period. The n-percent exceeded level, L_n, is the sound pressure level which exceeded n percent of the time. In other words, for n percent of the time, the fluctuating sound pressure levels are higher than L_n. L_n can be obtained by analysing a given noise by statistical means.

L_{10} is the level exceeded for 10% of the time (i.e., for 10% of the time, the sound or noise has a sound pressure level above L_{10}). For the rest of the time, the sound or noise has a pressure level at or below L_{10}. These higher sound pressure levels are probably due to sporadic or intermittent events.

L_{50} is the level exceeded for 50% of the time. It is statistically the mid-point of the noise readings. It represents the median of the fluctuating noise levels.

L_{90} is the level exceeded for 90% of the time. For 90% of the time, the noise level is above this level. It is generally considered to be representing the background or ambient level of a noise environment [1–4, 18].

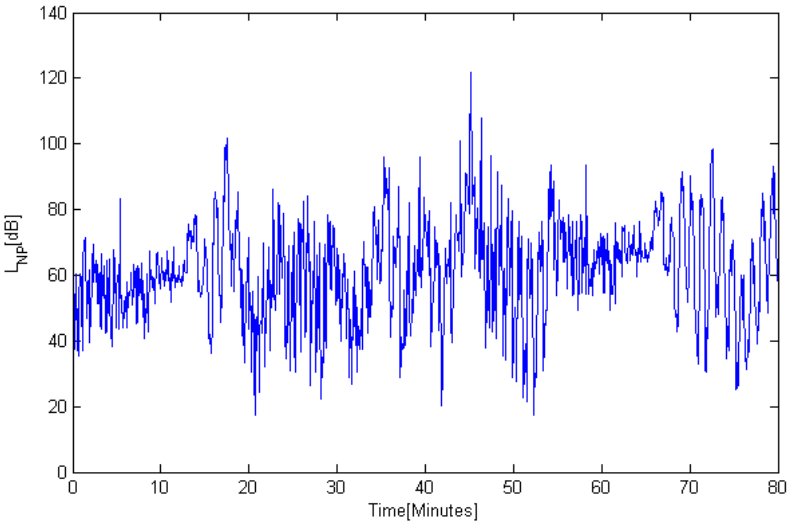

Fig. 7. The average noise pollution level on 04/04/2019 during the morning.

Figure 8 shows the sound levels exceeded with 10%, 50% and 90% of the time over measurement period in the first day of recording. As it is noted in the Figure, at the beginning of the recording, L_{50} is larger than L_{10} and L_{90}. The reason is that, there was an intrusive source of sound that passes on the side of the road which is closer to the market area. In the afternoon time, the sound level exceeded for the large percentage of time L_{90}, since there was continuous, lower-level background noise coming from a distant place which has higher value than L_{10} and L_{50}, as shown in Figure 8. Similarly, on the third day, L_{50} and L_{90} have almost equal values, whereas, L_{10} has low records.

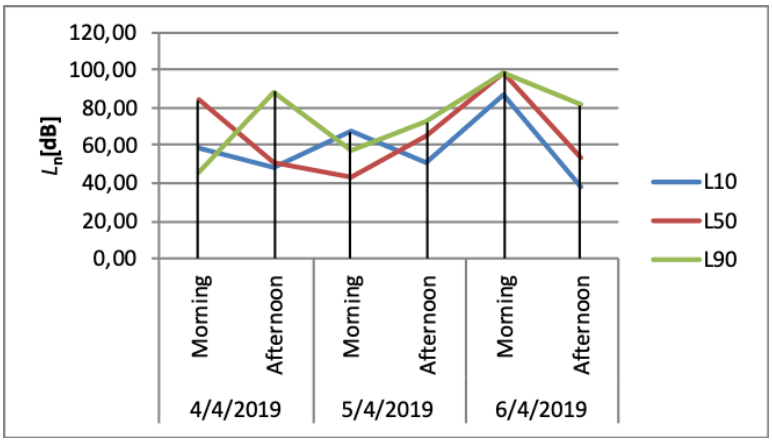

Fig. 8. The noise levels at 10%, 50% and 90% of times.

CONCLUSIONS AND RECOMMENDATIONS

The main purpose of this study was to investigate the noise sources and to identify the pollution levels of the market area. Moreover, it was aimed to see the trends of the noise level shown in [12]. The noise sources in the city and this particular area are the same but the volume of the vehicles and the populations towards this market have increased rapidly. Due to these reasons, the noise levels of the market area are increased. The main sources of the noise are those due to three-wheeled cars rucks, mini-workshops like metal workshops, and people conversation. Moreover, there was a significant amount of noise coming from far distance of worship during the service they were providing to their followers. This has a significant contribution to the environment pollution.

The magnitude of the noise pollution has touched the peak value on 04/04/2019, which was 121.65 dB during 45 minutes of measurements time and its minimum value on the same day was 17.21 dB at 42 minutes. This was due to the transient variation of noise. It has been found that many people are very much irritated due to the traffic noise of their locality. The noise has negative effect on people personal life, and they feel very angry even from very small reason [13]. Overall, the analysis revealed that the noise levels had significant adverse impacts on people in the market and also in the surrounding residence area.

RECOMMENDATIONS

1. Residents in the market area should be watchful of their duties to their neighbor for peaceful coexistence in the community.
2. The awareness of general public that can play an important role to reduce noise pollution must be increased.
3. Urban designers should firmly obey to master plan conceived by the city administration and should monitor and control development of road and market area to follow the already approved land use for the city.
4. The administration municipality and environment agency offices must force the drivers, the workshop owners or worship headers to participate in the mitigation of noise in the city.
5. It is necessary to plan the market place to avoid any factor that would result in any significant change of ambient noise near the market area.
6. Dire Dawa University administration should recognize its role as an environmentally responsible organization being committed to promote the environmental awareness for all residents of the city.

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