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Evaluation of the equivalent level in the case of traffic noise in Isfahan, Iran

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Abstract
Traffic noise is considered as one of the important sources of noise pollution in urban areas. Day-time urban noise quality assessment was studied in Chaharbagh Bala Street in Isfahan that has the combination of critical zones, therapeutic, educational, commercial, residential and touristic. The aim of this study is to determine the equivalent noise level (LAeq30) by metric Castle 450 made in the England. Since the chosen square is a clear hotspot for traffic noise in a large city, the measurements of equivalent level noise in this street performed at 8 stations leading to Azadi Square in order to obtain a 12-h noise level. intersections of Hezarjerieb, Shariati, Pol hotel and Nazar (in 2 lanes of north and south or east and west) at 8-12 of morning and 17-21 of evening with 3 replications on weekdays and compared with standard 60 dB. The volume of traffic was also quantified by reproducing video camera recordings. The highest mean Leq of 83.67 dBA was observed in Hezarjerib educational- residential- commercial zone followed by, 79.47 dBA in Shariati residential- hospital zone at morning, 77.48 dBA in Nazar residential- commercial zone and the minimum was 62.18 dBA in Pol hotel residential- touristic- commercial-zone at evening. All observed Leqs were above the statutory limits that is 60 dB. In addition, measurements in the timeframe of 30 minutes showed that the rate of travel of the vehicle is very high. The noise measurement clearly indicated the alarming condition of noise pollution.

Keywords: Critical zones, Equivalent noise level, Traffic noise, and 12-h noise level

Introduction

Recently, noise pollution has been well recognized as one of the major trepidations that impact the quality of life in urban areas across the globe. Because of the rapid increase in industrialization, urbanization and other communication and transport systems, noise pollution has reached to a disturbing level over the years[1] With the rapid development of urban areas, the traffic noise pollution has become increasingly serious [2] as stated by Trombetta Zannin and de Sant'Ana [3], in economically developing countries, rising levels of noise pollution are associated with the accelerated growth of cities and the increasing circulation of automotive vehicles. In addition, traffic noise is considered as one of the important sources of noise pollution that adversely affects human health [4,5,6], so that the effects of noise pollution on human health have been considered by the WHO [World Health Organization] to be the third most dangerous type of pollution[7]. The World Health Organization [8] considers noise to be an environmental risk factor for poor health and a major environmental issue. The effects of noise on human health and comfort are divided into four categories depending on its duration and volume. They are– [i] physical effects such as hearing defects; [ii] physiological effects, such as increased blood pressure, irregularity of heart rhythms and ulcers; [iii] psychological effects, such as disorders, sleeplessness and going to sleep late, irritability and stress; and [iv] effects on work performance, such as reduction of productivity and misunderstanding what is heard [9].
Berglund et al. [7] has suggested that outdoor environmental noise should not exceed55 dB (A) in the residential areas. In addition, night time noise greater than 40 dB (A) has been suggested to potentially lead to sleep disturbance [10].

One of the primary goals of the present study was to evaluate environmental noise pollution in urban sections of Chaharbagh Bala Street in the Isfahan city. In order to do that, noise measurements were performed by metric Castle 450 made in the English, so that (i) the equivalent noise level (LA eq) measured at 8 stations, Hezarjerieb, intersections of Shariati , Pol hotel and Nazar (in 2 lanes of north and south) at intervals 8-12 of morning and 17-21 of the afternoon with 3 replications on weekdays, all stations lead to Azadi Square. (ii) Measured values are compared with the standard 60 dB, (iii) the volume of traffic was also quantified by reproducing video camera recordings.

2. Methods

2.1. Investigated sites

Eight sites were selected in Chaharbagh Bala Street in the southern part of Isfahan city, this street leads to the Azadi huge square. All of which are typical urban neighborhoods with a condensed mixture of commercial and residential activities and public utilities.

In Hezarjerieb, Sites 1and 2 are among the busiest roads. Among all the sites, Site 1and 2 are of the most densely populated areas. One of the biggest universities (University of Isfahan) is located here. The street of Site 3 and 4 mainly connects the different points of the city's central zone to one of the biggest hospitals in Isfahan (Shariati Hospital) and is therefore busy most of the time. The streets of Sites 5 and 6 which are among commercial areas link the city center with the eastern-western highways, respectively. They therefore endure remarkably heavy traffic, during the day. The street of Site 7 and 8 considered as the commercial-tourism areas and compared with the other sites its volume of traffic is low. The street is located in the vicinity of Zayandeh Rood River and the historic Siosepol Bridge. This feature coupled with the high volume of domestic and foreign tourists, on the basis of the large hotels in the area were built like the Kowsar hotel, Sweet hotel and Park hotel. The Cars, buses and motorcycles are vehicles which pass out Chaharbagh Bala Street.

2.2. Noise measurement

The fourth part of Chaharbagh Bala Street, the beginning of Azadi Square, the crossroads of Shariati, the crossroads of Nazar and Pol hotel in northern and southern and eastern - western runway was considered to measure the level of noise.

Our acoustic surveys were conducted in August [2012] in Isfahan city. The measurement sites are displayed in (Fig1). A 12-h noise measurement was conducted at a reference point 1.2 m above ground, and 0.5–1 m away from the road pedestrian by means of sound level meters (Castle 450 made in England). the equivalent noise level (LAeq) were measured at 30-min intervals, together with noise recordings, were conducted at eight sites in ChaharbaghBala Street in order to obtain data for frequency analysis. During the 12-h noise measurement, traffic volume by vehicle type was also monitored by video camera. The sampling time interval was 30 min in each hour. Traffic quantification was performed later after reproduction of the video recording. Traffic flows were grouped into three vehicle categories: QM = motorbikes, QC = cars/light trucks and QH = heavy vehicles.

2.3. Noise equivalent level standard

Sound can be defined as a physical disturbance in a medium that is capable of being detected by the human ear [11]. Not every sound can be considered noise, however. Schexnayder and Ernzen [12] defined noise as any sound that has the potential to annoy or disturb humans or cause adverse psychological or physiological effects to humans. Noise levels that can be heard by humans are commonly measured using a logarithmic scale named the decibel a scale (dBA). Most sounds that humans are capable of hearing have a range of 10–140 dBA. A whisper is about 30 dBA, conversational speech is about 60 dBA, and and 130 dBA is the threshold of physical pain. Environmental noise fluctuates at high frequencies with time. Thus, for analysis purposes the environmental noise level is often converted into a single number called the "equivalent" sound level (Leq). The Leq (A) indicator is defined as the average acoustic intensity over time, or the equivalent noise energy level of a steady, unvarying tone [13]. World Health Organization [WHO] published the Leq (A) levels for some situations (Table 1).

Table 1: The documents was published for noise by World Health Organization (WHO) (1995) (14)

situation	bedrooms	steady-state	outdoor living	schools and preschools	Playgrounds children	hospitals	wardrooms	Patron to hospitals during a 4-hour period
LAeq dB	30	45	55	35	55	35	30	<100

Noise exposure limits set by Iranian legislation for residential, commercial, and commercial- residential zones day time are 55, 60 and 65 dB(A) respectively. In this study standard noise level was considered 60 dB (A).

3. Results

3.1. Travel rates

Chaharbagh Bala Street is an old street; the street was narrow due to the implementation of development projects at the time of the study. Measuring travel vehicles in the morning [12-8] and the evening [21-17] [Table 2] showed a very high rate of travel, so that the largest travel of vehicles up to 1693 in the morning [8-12] observed on the Hezarjereib1 site, followed by the least the number of 746 in the Pol hotel site. In the evening [17-21] the highest rate of travel, equal to 1472, related to the Shariati 1 site and the least, up to 547, related to vehicles observed in Nazar1 site.

Table2: The rate of travel of the vehicle (at the timeframe of 30 minutes)

Site	Station	Morning								Evening						
		Number of lanes	QM	QC	QH	QM%	QC%	QH%	QM + QC + QH	QM	QC	QH	QM%	QC%	QH%	QM + QC + QH
1	Hezar jereib 1	2	634	1023	30	37.5	60.6	1.7	1687	524	830	24	38	60	1.74	1387
2	Hezar jereib 2	2	478	729	29	38.6	58.9	2.3	1236	652	739	32	45.8	51.9	2.2	1423
3	Shariati 1	2	327	743	28	29.7	67.6	2.5	1098	578	863	31	39.2	58.6	2.1	1472
4	Shariati 2	2	289	695	23	28.6	69	2.2	1007	340	629	22	34.3	63.4	2.2	991
5	Nazar1	2	202	756	28	20.4	76.6	2.8	986	103	420	24	18.8	76.7	4.3	547
6	Nazar2	2	213	742	23	21.7	75.8	2.3	978	209	723	22	21.9	75.7	2.3	954
7	Hotel Pol 1	2	123	580	18	17.0	80.4	2.4	721	308	630	22	32.1	65.6	2.2	960
8	Hotel Pol2	2	118	738	20	13.5	84.2	2.3	876	132	540	19	19.1	78.1	2.7	691

3.2. Noise pollution caused by traffic vehicles

Traffic noise measurements at 8 stations [Figs. 1-8] showed the equivalent level of noise (Leq30) higher than 60 dB at all stations in the morning [8-12] and the evening [17-21] in the days of the week. Equivalent level of noise (Leq30) higher than the standard of 60 dB observed in Azadi Square Station on all days of the week in the morning except Friday morning (Fig 1). The equivalent level of noise (Leq30) was close to the standard of 60 dB on Friday evening at Freedom Square station (Fig 2) .The equivalent level of noise at the crossroads of Shariati (Fig 3 and 4) provided a significant increase equivalent level of noise (Leq30) in the morning and evening on weekdays, but at the intersection of Shariati, there was no noise pollution on Friday morning. Diagrams (Fig 5 and 6) provide equivalent level of noise in the morning and the evening at the intersection of Nazar, so that observed equivalent level of noise above 60 dB in the morning [8-12] and the evening [17-21] on weekdays. Noise pollution was not created by vehicle traffic on Friday morning at the intersection of Nazar. Assessment of noise in the Pol hotel (Fig 7 and 8) also revealed a reduction in noise equivalent level (Leq30) on Friday morning, compared with standard level, 60 decibel, and equivalent level of noise (Leq30) was higher than the standard of 60 dB on the other days of the week. (Table 3) indicated the descriptive statistics from equivalent level of noise on morning and afternoon in the measuring stations.

Table3: ***Descriptive statistics equivalent level of noise***

Station	Morning	Evening
Hezarjereib 1	83.67± 16.53	83.04± 16.10
Hezarjereib 2	80.02±13.19	81.24±13.12
Shariati 1	70.74±11.14	73.74±10.83
Shariati 2	79. 47±12.53	77.27±9.07
Nazar1	71.95±12.87	75.14±7.62
Nazar2	73.87±14.82	77.48±11.17
HotelPol 1	65.97±8.00	62.18±7.65
HotelPol2	71.37±10.21	68.48±8.9

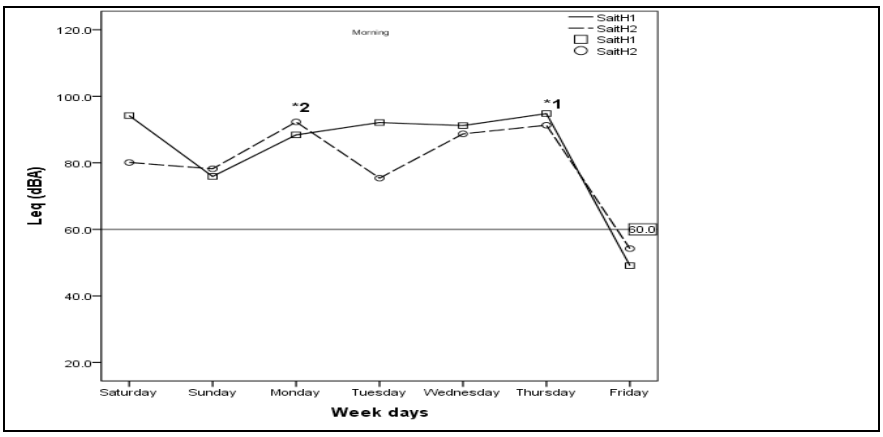

Figure 1: Equivalent level of noise in the morning [8-12] on weekdays (Hezarjerieb-Azadi)

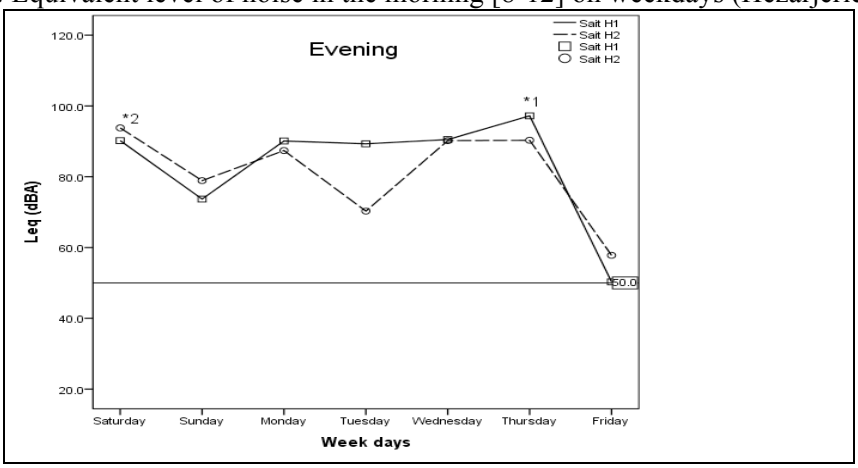

Figure 2: Equivalent level of noise in the evening (17-21) on weekdays (Hezarjerieb-Azadi)

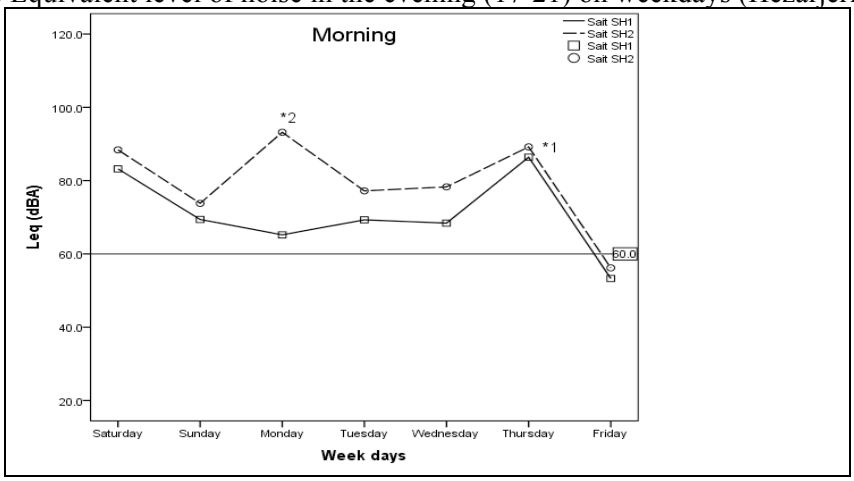

Figure 3: Equivalent level of noise in the morning [8-12] on weekdays (crossroads of Shariati)

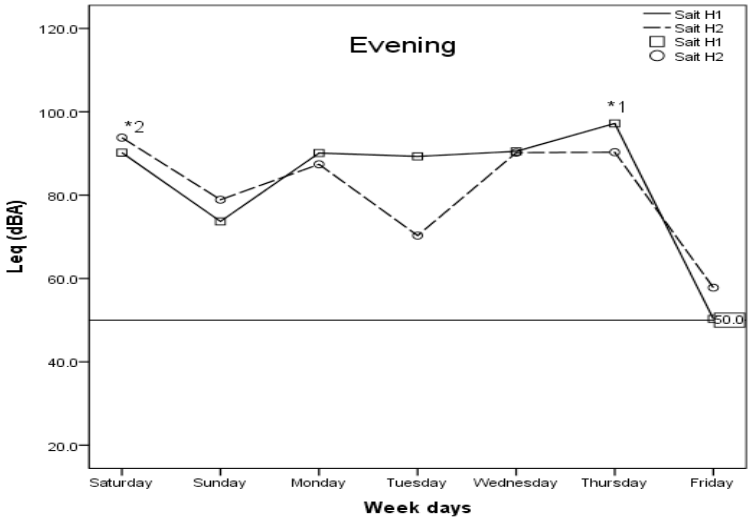

Figure 4: Equivalent level of noise in the evening [17-21] on weekdays (crossroads of Shariati)

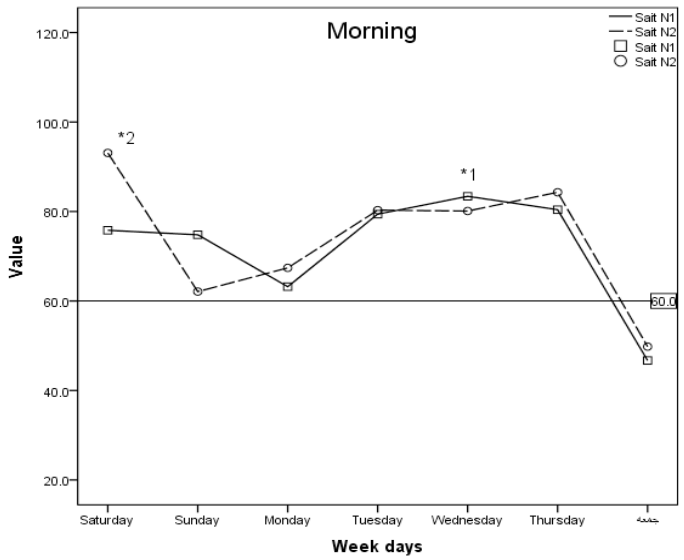

Figure 5: Equivalent level of noise in the morning [8-12] on weekdays (crossroads of Nazar)

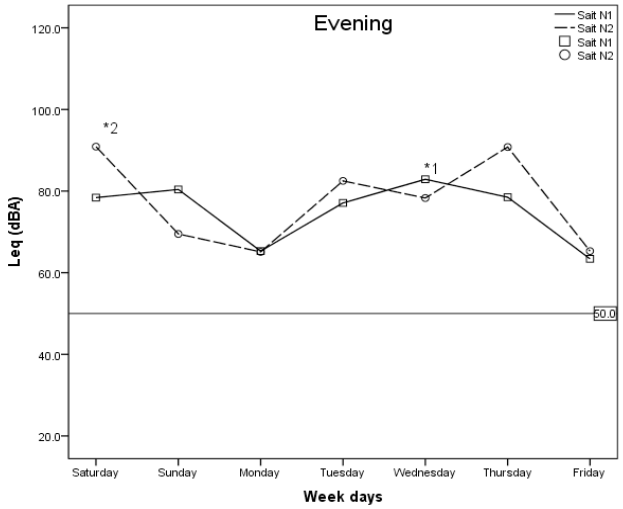

Figure 6: Equivalent level of noise in the evening [17-21] on weekdays (crossroads of Nazar)

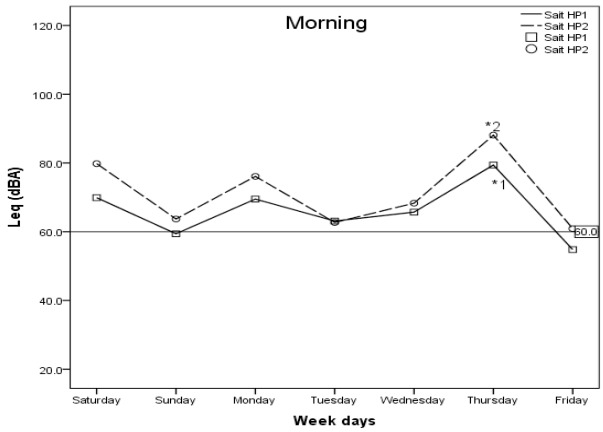

Figure 7: Equivalent level of noise in the morning [8-12] on weekdays (crossroads of Pol hotel)

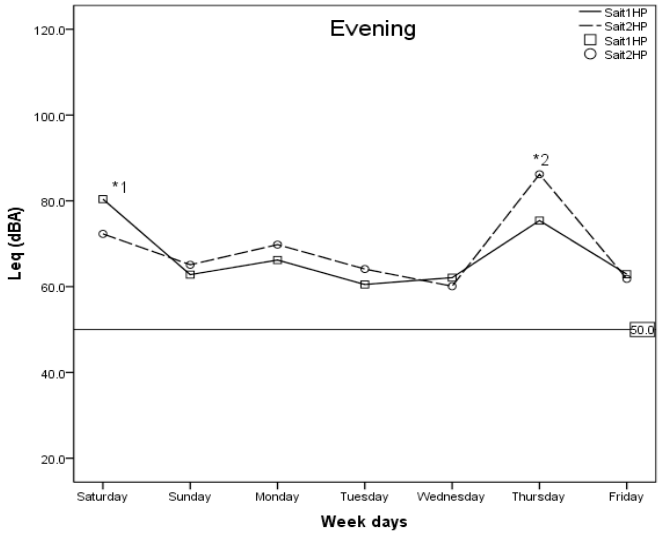

Figure 8. Equivalent level of noise in the evening [17-21] on weekdays (crossroads of Pol hotel)

4. Discussions

The number and kinds of vehicles are considered as the most important effective factor in the level of noise caused by traffic, so that each vehicle makes noise at different levels, noise vehicles is a decisive factor for the level of noise.

The study found that old Chaharbagh Bala Street which is currently too narrow has a very high traffic rate (Table 2).In this situation, reducing the volume of traffic vehicles is possible with the implementation of management plans. many authors have found that the observed sound levels are mainly related to road traffic characteristics, and especially traffic volume, vehicle horns, rolling stock , vehicles which have not been properly maintained, etc. [15, 16, 17]. Noise emitted by vehicles increases with vehicle speed and acceleration [18]. It thus depends on the local traffic situation and not only on the number of vehicles (level of congestion, mean speed, etc). [19].

More than 97% of travel related to the light vehicles such as cars and motorcycles in both the morning and evening period and travel heavy vehicles such as buses and minibuses was less than 3% (Table 2). Porous asphalt of the Chaharbagh Bala street surface is reconstructed every five years. The local road surface, top layer and the tire parameters (width, groove pattern, etc). play an important role too [18]. Traffic composition strongly influences noise levels [20]. The noise generated from the interaction of vehicular tires and the road surface is a major contributor to the overall highway noise. A dense road surface mainly reflects the sound energy, while a porous road surface mainly absorbs it [21, 22, and 23]. Open–graded asphalt generally shows the greatest potential for noise reduction of sideline noise and reductions when compared to dens-graded asphalt. In addition, the noise reduction seem to decline with surface age and in approximately 5 to 7 years, much of the noise benefit has diminished, although the surface is still usually quieter than PCC pavements. Also, porous

asphalt suffers from problems such as plugging and deterioration due to freeze/thaw cycles. Other asphalt surface, such as stone mastic and rubberier asphalt, also hold promise, but do not appear to give the noise reductions of open-graded asphalt although most are equal it or better than dens- graded asphalt [24].
According to the results the equivalent level of noise in the morning [8-12] and evening [17-21] during the weekdays was higher than 60 dB in the old and narrow streets in the Chaharbagh Bala Street of Isfahan, but noise equivalent level was less than 60 dB on Friday morning (Figs1-8). As a result of the noise pollution associated with activities in commercial areas, offices, hospitals, schools and other businesses. Based on Steensberg [25], the noise in the old streets caused by surface texture of street and lack of capacity for the passage of the new high-speed cars .The different decibel values during morning and evening measurements of traffic equivalent noise level [Leq] created in sites (Table 2). The results suggest that an irregular and unplanned urbanization prevailed in the Chaharbagh Bala street of Isfahan. It is vital to prevent non-normative urbanization, to design the sensitive against noise places on the separate area. On the issue the places such as schools, private education center, hospitals, hotels and resorts have priority. Kalipci and Dursun [26] gave more importance to isolation in these buildings to be built later, during the building process, it should be made to use materials providing noise isolation and made attractive. Moreover using double pane for windows in the buildings should be compulsory. Whether material are used or not for noise in the buildings to prevent noise is to be checked seriously by municipality. In addition, negative effect of noise should be induced by planting trees.
Essandoh and Ato Armah [27] showed that there is variation in the noise levels with the period of the day and the nature of the location, and there are high noise pollution levels (LNP) in the daytime, except in the residential areas where the majority of the residents are not always at home during the working days of the week; hence, the noise levels are low at residential areas (especially in low-density residential areas) in afternoon time. They showed the variations of noise pollution levels with location and period of the day. At commercial centers, road junctions, passenger loading parks, and high-density areas, noise pollution levels rise from morning and reach peak values in the afternoon and evening to night time. The high noise pollution levels in the morning and evening at these locations can be justified as a result of morning rushing hours of office workers and business men and women, to resume work at offices and open shop for customers. The noise pollution levels in the afternoon time (11:30 pm-3:30 pm) at low-density residential areas are generally low. This is because the majority of the residents are not always available at home in the afternoon. Some are in their offices, markets, or shops while children are in their schools by this time of the day. Moreover, most of the low-density residential areas are developing areas.
Green belts provide one of the natural ways of cleaning the atmosphere by absorption reflection, diffusion of gaseous and particulates pollutants, and of noise through their leaves which act as efficient pollutant trapping device. Plants have a very large leaves which act as efficient pollutant trapping devices [28].

Conclusion

The evaluation of noise due to traffic as main noise sources represents a big challenge for the Chaharbagh Bala Street of Isfahan city; this study has demonstrated that in Chaharbagh Bala Street of Isfahan city, environment noise levels due to road traffic are notably higher than the noise standard to public health. The highest noise levels—mean Leq above 83.67 dB (A). quivalent level of noise (Leq) was higher of standard in work days .The obtained results indicate it is possible to determine the 12-h equivalent level by means of metric.
Obviously, the identification of the worst affected area requires to employment in the noise management plane. We expect that this study can help to an effective reduction of noise pollution, and consequently the operational capacity of Chaharbagh Bala Street can be maximized. It is expected that the LAeq becomes an alternative for municipal authorities to manage urban land use and traffic in the large cities. We suggest the analysis of traffic noise through LAeq noise metrics as a way to reduce traffic noise in the high-traffic urban centers. The main advantage of using LAeq metrics is to describe the impacts caused by vehicles movement during the day.

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