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Noise pollution in the high-traffic areas and proposed solutions: A case study in Ilam, Iran

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ABSTRACT

Introduction: Noise pollution caused by vehicles is one of the major environmental problems in cities and has harmful effects on residents. The aim of the study was to examine the noise pollution in high traffic areas of the city of Ilam and finally to propose solutions.

Materials and methods: This descriptive-analytical and cross-sectional study was performed in the spring of 2020 in three shifts in the morning, noon, and evening at the beginning and end of the week in Ilam city. According to the Iranian standard by Department of Environment in residential and commercial-administrative areas, noise measurement was performed with CEL-440 sound level meter in seven high-traffic points. In this study, the factors affecting noise pollution caused by traffic were recorded in the form of a checklist.

Results: In morning shift at the beginning of the week with the noise level of 70.59 dB, in the noon shift at the beginning of the week with 71.74 dB, and in the evening shift at the beginning of the week with 68.37 dB has a higher noise level. A comparison of sound pressure levels in the morning, noon, and evening shifts at the beginning and end of the week showed no significant difference (P=0.26).

Conclusion: Ilam city has high noise pollution in commercial-residential and commercial-office areas, which was evaluated beyond the standards of noise limits in the open air of Iran. Solutions have been proposed to reduce noise pollution from residents at the measurement points.

Introduction

Noise pollution is defined as unwanted noise [1]. Noise pollution caused by vehicles is one of the major environmental problems in cities and has harmful effects on residents such as hearing loss, sleep disorders, high blood pressure, and gastrointestinal disorders [2-5]. In recent years, noise pollution and its consequences on the quality of human life, have become a common

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and important topic in scientific research. Many studies have been conducted to reduce the problem of noise pollution in different cities around the world. In Iran, Environmental pollutants in water, soil and air have been considered for more than two decades [6]. Since vehicles are typically the main producers of traffic noise, it is necessary to closely monitor the level of noise and air pollution in large cities, at different times and places [7]. The increase of various activities in municipal services for a livelihood has made noise pollution appear as a social problem, but unfortunately, the importance and place of noise pollution in our country, like many other pollutions, is not very clear. Various studies in this field report the spread of noise pollution in large cities of Iran [8-13]. The most important and definite effect of noise is to reduce the hearing threshold; non-auditory effects of noise include physiological effects, activity interference, and psychological effects. Noise at all levels causes the body's peripheral arteries to constrict and the heart rate to decrease [14]. In a study in Colombia, a survey of people living near airports found that more than 90% of them suffered from sleep disorders [14]. The increase in population and the number of cars has caused a new problem called noise pollution in urban life [9]. The World Health Organization (WHO) has set the allowable sound pressure levels in high-traffic areas, residential areas, and hospital rooms at 70, 55, and 35 dB, respectively [15]. Research conducted in the cities of Tehran, New Delhi, Tokyo, and Rome showed that the amount of noise pollution in the busiest areas of these cities is more than the allowable limit of 70 dB [5]. A study in the Sivas region of Turkey showed that the equivalent noise level (L_{eq}) was higher than the standard in the region and the average sound pressure level was measured in the morning, noon, and evening shifts of 75.19, 73.72, and 75.92 dB, respectively [16].

The results of a study in the Tunisian city of Monastir showed that the measured noise exceeded the limits of the World Health Organization and the environmental standards of Tunisia [17]. Traffic noise pollution accounts for almost two-thirds of all noise exposure in urban areas. Traffic noise on existing urban roads reduces the quality of life and property value of people living in the vicinity of these urban corridors. Due to limited access to land and property resources, many highways and roads are located in residential and commercial areas. According to studies, the mean noise level in "residential and commercial areas" is higher than in other land uses [18, 19]. Hence, there will be some adverse and environmental effects, including psychological and physiological effects on those who live in the vicinity of these corridors [20]. Undoubtedly, measuring noise pollution is a prelude to identifying, prioritizing, and judging results and control methods. The aim of the study was to examine the noise pollution in high traffic areas of the city of Ilam and finally to propose solutions.

Materials and methods

This descriptive-analytical and cross-sectional study was conducted to evaluate traffic noise pollution and proposed solutions to control and reduce it in spring 2020 in selected high-density areas of Ilam city the capital of Ilam province and located in the west of Iran. After the necessary coordination with the urban traffic area, the necessary information and statistics were received about the number of squares and main streets of the city and the amount of urban traffic. Based on the information, there are eighteen main points for traffic in Ilam city. Among them, seven points (square and

street) with the highest amount of traffic and urban traffic were selected. The selected points included Keshvari Square, Khayyam Square, 22 Bahman Square, Ferdowsi Street, Ayatollah Heidari Street, Saadi Square, and Payame Noor Crossroads, respectively (Fig. 1).

The measurements were taken in three shifts morning (7:00 to 9:00), noon (12:00 to 14:00), and evening (19:00 to 17:00) and at the beginning and end of the week. The selected points were measured for two months. The reason for choosing to spring for this study was the high volume and presence of people in the city compared to other seasons. In this study, a CEL- 440 sound level meter was used to noise measurement.

Before each measurement, the SLM was calibrated by a calibrator, and parameters related to noise, including; Maximum, level, and equivalent noise level (L_{eq}) were measured. Measurements were conducted at slow response speed and the A-weighted network. A sponge windscreen was used on the microphone to decrease the wind effect. At each of the 7 points, measurements were monitored at four points and each point for 30 min at different times.

According to the Iran standard by Department of Environment, the sound level meter was located at a height of 1.5 m above the ground and a distance of 3 m from the sidewalk. Review of studies, parameters and factors that were effective in reducing or increasing the amount of traffic noise, it was found that these parameters can be the amount of heavy vehicle traffic, light vehicle traffic, and tree cover around stations. The mentioned parameters were prepared in the form of a checklist and these parameters were recorded at the same time as measuring the noise level. Then, the measured values were compared with the national allowable limits (the allowable values of noise in the open air of Iran approved by the Supreme Council for Environmental Protection). The results were analyzed with SPSS version 26. In the end, based on the results, solutions to reduce the sound level in the measured points were proposed.

Fig. 1. Location map of the noise measurement points in Ilam city

Results and discussion

The results of sound pressure level measurements at the beginning and the end of the week at selected high-traffic points are summarized in Table 1. The results of this table showed that the highest sound pressure level at the beginning of the week is related to the Payame Noor crossroads and at the end of the week is related to 22 Bahman square, however, there was no significant difference between the results at the beginning and the end of the week.

The comparison of the mean sound pressure levels at the beginning and end of the week (Saturday and Thursday) is summarized in Table 2. The highest sound pressure level (70.17 dB) is related to Saturday (first week). Although there was a difference between the overall sound pressure level at the beginning and end of the week, this difference was not significant.

A comparison of sound pressure levels in the morning, noon, and evening shifts at the beginning and end of the week is presented in Table 3. Accordingly, the sound pressure level in the morning shift at the beginning of the week with a level of 59-70 dB, in the first-noon shift of the week with a level of 74-71 dB, and finally in the evening shift with a level of 37-68 dB above other shifts was evaluated, but no significant difference was found between the different times at the beginning and the end of the week.

Based on the comparison of the equivalent exposure level in the beginning and end of the week with the standard values of Iran in Khayyam square (where according to the findings the number of heavy vehicles passing in the first week is also high), 22 Bahman and Ayatollah Heidari st noise level was higher than standard (Table 4).

Table 1. Mean and standard deviation of sound pressure level at the beginning and end of the week around the selected points in Ilam city

Statistical indicators points	Mean sound pressure level at the beginning of the week (dBA)	Mean sound pressure level at the end of the week (dBA)	Mean overall sound pressure level (dBA) (Standard deviation)	P_{Value}
Keshvari square	68.52	69.12	68.82+_13.27	0.94
Khayam square	68.6	71.27	69.93+_8.3	
22 Bahman square	70.07	71.24	70.65+_8.22	
Ferdowsi street	68.77	69.92	69.35+_11.07	
Heidari street	71.46	69.48	70.47+_5.09	
Saadi square	71.58	65.74	68.67+_14.88	
Payamnoor crossroads	72.22	68.04	69.28+_7.43	

Table 2. Comparison of the overall sound pressure level of the selected points measured in the beginning and end of the week

Statistical index	Mean sound pressure level measured (dBA) (Standard deviation)	P_{Value}
Saturday	70.17+_13.85	0.28
Thursday	69.02+_16.95	

Table 3. Comparison of the total sound pressure level in the morning, noon, and evening shifts in the busy squares of Ilam city at the beginning and end of the week

Statistical index time	Week day	Sound pressure level (dB) (Range)	P_{Value}
Morning (7:00-9:00)	Saturday Thursday	70-59 70-42	0.26
Noon (12:00-14:00)	Saturday Thursday	71-74 68-28	
Evening (17:00-19:00)	Saturday Thursday	68-19 68-37	

Table 4. Comparison of the total equivalent noise exposure level of around the busy squares in Ilam city with the standard values of Iran

Statistical index squares	L_{eq} equivalent day exposure measured level (dB)	Type of area	Allowable sound pressure level (based on Iranian standard) (dBA)
Keshvari square	67.5	Commercial-administrative	65
Khayam square	68.68	Commercial-residential	55
22 Bahman square	69.40	Commercial-residential	55
Ferdowsi street	68.10	Commercial-administrative	65
Heidari street	69.22	Commercial-residential	55
Saadi square	67.42	Commercial-administrative	65
Payamnoor crossroads	68.03	Commercial-administrative	65

The number of light and heavy passing vehicles in the squares and busy points of Ilam city is summarized in Figs. 2 and 3. According to Fig. 2, the maximum number of passing cars per minute is related to the Keshvari square on the end of the week. According to Fig. 3, the highest number of heavy vehicles per minute is related to Khayyam square in the beginning of the week.

The results of this study showed that the mean equivalent noise level in all stations surveyed is proportional to the type of overuse allowed in the country. Therefore, it is necessary to study their control strategies in them. The results of studies in other cities of the country and the world are in line with the results obtained from this study [11, 21-26]. The results of a study in Qazvin city also showed that the noise level in most of the measured points is higher than the standard limit for residential and commercial areas, which is consistent with the results of the present study [9].

In another study in Sari, the equivalent noise level was measured at 77.1 dB which is higher

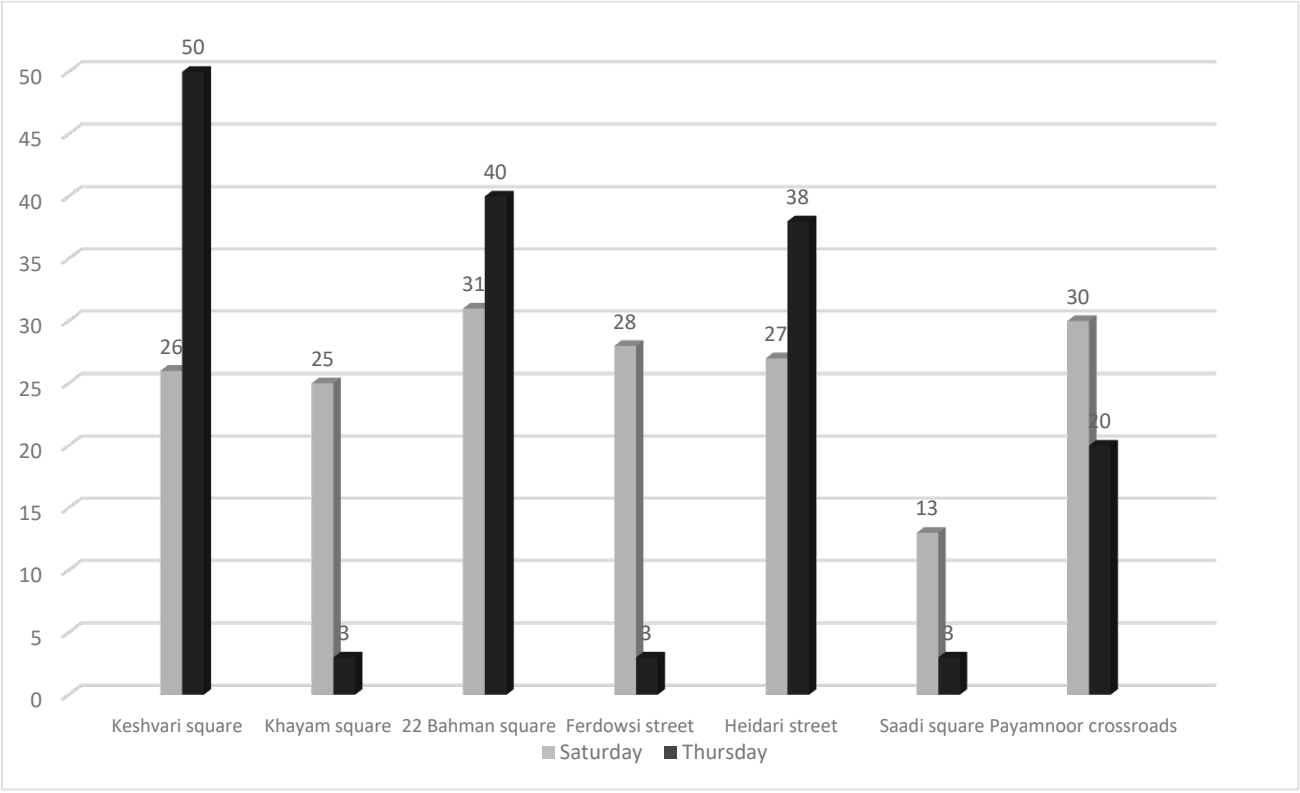

Fig. 2. Number of light passing cars per minute in the busy selected points of Ilam city

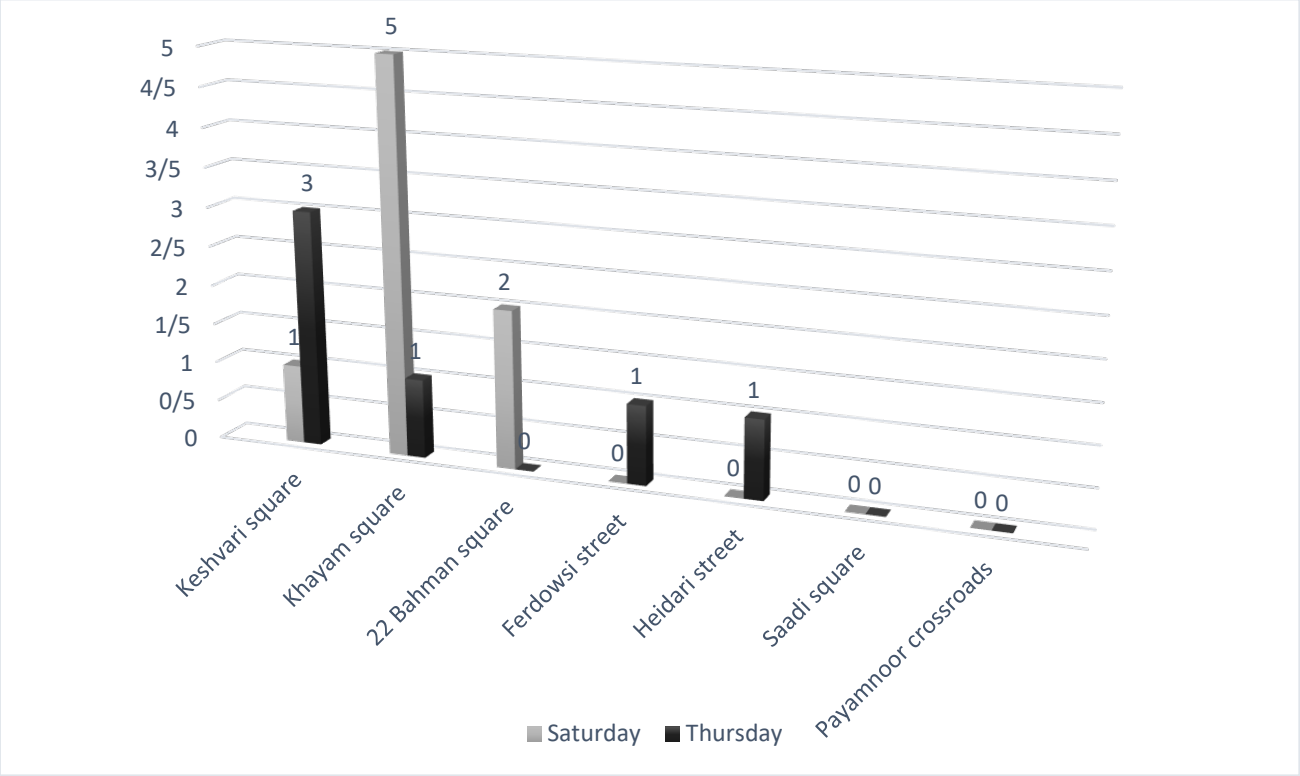

Fig. 3. Number of heavy vehicles per minute in the busy selected points of Ilam city

than the standard limit for residential and commercial areas [10]. Enclosing the busy streets of 22 Bahman, Khayyam, and Ayatollah Heydari squares with high-rise buildings with a stone exterior covering causes frequent reflection, scattering, and sound propagation. Buildings reflect sound like a mirror and in areas with high density, due to many buildings, parked cars, etc., the amount of dispersion is considerable. Traffic noise, which is a linear source of sound propagation in such environments, will cause the production and propagation of secondary noise and increase the level of ambient noise by colliding with reflective surfaces. For this reason, the sound level in these points is higher than in other measured points. Considering that noise pollution can be reduced through absorption in the best possible way, it is necessary to insulate residential buildings exposed to noise during construction using absorbent materials. The use of double-glazed doors and windows and the use of absorbent materials in the walls of buildings under construction, as well as the use of sealants in older buildings, contribute to this sound insulation [27].

On the other hand, the existence of high-rise buildings around squares and streets in the city, on the other hand, can answer many urban problems such as lack of land, housing, etc., and on the other hand, it creates problems and inadequacies such as increasing population

density, reducing urban space, and consequently increasing urban traffic [28]. When designing and constructing residential areas near urban highways, it is necessary to pay attention to the fact that the plans should be presented according to the location of the land and the geographical topography of the building in such a way that they have maximum sound shade. The location of the buildings should be such that they have the least reflection and resonance of sound [27]. Also, the results of a study in Leipzig (Germany) showed that the level of noise depends on the type of urban structure determined by the landscape criteria [29]. The overall noise level in Khayyam square was 68.68 dB. Since there was construction activity in this field and the amount of noise level obtained in construction activities is 74.75 dB [30]. It can be said that construction activities have increased the noise in this field, the noise produced by construction activities is one of the main components of acoustic pollution in urban communities. Traffic temporarily pollutes the environment [31]. On the other hand, the lack of specific standards and laws related to construction activities and machinery has caused the voice produced by construction to be accepted by most citizens as a habit, regardless of citizens' rights [27]. The equivalent noise level measured on Ayatollah Heydari street was 69.22 decibels, a commercial-residential area, due to the existence of Imam Khomeini Hospital and the presence of schools (high traffic of cars and buses related to school services) around, it increases the traffic load. In 22 Bahman square, the noise level was equivalent to 69.40 dB. To increase the amount of urban traffic in this square, as a result of which this square has a higher sound pressure level. In a study conducted in Cordova, it was found a positive correlation between noise pollution and the width of streets and the height of buildings; Narrower roads and complex road networks with high intersection densities lead to higher traffic volumes and consequently higher noise levels [32]. Another study in Mashhad in 1400, showed that pollution in the evening (4:00 to 6:00 p.m) with an average sound pressure level of 78 dB has the highest noise level [28]. In a study in Qom city, the amount of noise pollution in stations was more in the evenings and less in the mornings [33]. The results of these studies are different from the results of the present study. In the present study, the amount of noise pollution in the stations was more in the morning and less in the evening. Increased traffic in the morning shift due to the presence of schools, universities, and hospitals around the measuring stations can be effective in increasing the amount of noise pollution in the morning shift. The study in several main streets of Mashhad during busy summer hours, Showed that the highest sound equivalent level was 75 dB in the morning and 74 and 75 dB in the afternoon and night, respectively, which was higher than the allowable limit in all measurement shifts, which is consistent with the results of the present study, In the present study, the mean sound pressure level in all three shifts was 70.50 dB in the morning, 70.05 dB in the afternoon and 68.10 dB higher than the standard limit at midnight.

Conclusion

The results indicate high noise pollution in selected points of Ilam city. Further investigations and control strategies are needed in these areas. The increase in noise level and

related indicators in these points can be due to their location as the central squares of the city. Due to the high noise pollution in the points, 22 Bahman squares, Khayyam square, and Ayatollah Heidari streets, compared to other stations, traffic management in these areas is mandatory. Implementing the necessary measures to control noise pollution and, if necessary, implementing the traffic plan area and upgrading the urban transportation system will greatly help reduce noise pollution and ensure the health of the residents of these areas.

Among the control solutions, the following points can be mentioned:

1) Widening the streets, especially in the streets around 22 Bahman square, which reduces the traffic load as a result, noise exposure will be reduced. 2) Increasing the quality of asphalt and street surface helps reduce noise pollution caused by car traffic on the streets and highways.

3) Using public vehicles instead of personal vehicles, reducing the speed limit of vehicles, and collecting worn-out vehicles. 4. Increased green space and vegetation along busy streets.

5) Supervise the proper design and layout of new buildings overlooking the streets, if they are not located in a suitable place, it is natural for the city to face many problems, including noise pollution. 6) The use of barriers and transparent sound insulation along the streets, which with the necessary technical specifications cause a shadow and a half-shadow to be created behind it and reduce noise caused by traffic. 7) Using less vulnerable and sensitive uses such as commercial buildings as a barrier between streets and residential areas, concentrating commercial areas outside the residential area. 8) It is also recommended to conduct intervention studies such as increasing public awareness of social behaviors, cultural growth in traffic management, and use of non-motorized vehicles such as bicycles, curfews, and trucks in the city.

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Competing interests

The authors declare that there is not any conflict of interests regarding the publication of this manuscript.

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Ethical considerations

“Ethical issues (Including plagiarism, Informed Consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc) have been completely ob-served by the authors.”

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