

## Evaluation of noise pollution in Shiraz in 2018

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### ABSTRACT:

**Introduction:** Noise pollution has become one of the most serious environmental issues in the large cities of Iran. Although several studies have been conducted on noise pollution in different Iranian cities, to date no such study has been done in Shiraz, a city of roughly 1,250,000. Therefore, the aim of this study was to provide a map of noise pollution in Shiraz and compare the levels of noise pollution in different parts of the city.

**Materials and methods:** For this study, 33 areas were selected in Shiraz. The level of noise pollution was measured at the hours of 008:00, 13:00, 18:00 and 22:00. Then, with the aid of ANOVA, the level of noise pollution in each area was compared to those of other areas of the city. Finally, with the help of ArcView GIS, noise pollution maps of Shiraz were prepared.

**Results:** The results of this study showed that the average noise pollution of Shiraz at the hours of 08:00, 13:00, 18:00 and 22:00 was 58.55, 59.56, 61.1 and 61.07 dB, respectively. On Mondays and Wednesdays, averaging 61.4 and 62 dB, respectively, the highest noise pollution was found in the city of Shiraz. This city's lowest noise pollution occurred on Friday, Iran's weekend and day of religious observance, with an average of 56 dB.

**Conclusion:** Some parts of Shiraz at 13:00, 18:00, and 22:00 had higher noise pollution (70 dB). This study was carried out in late summer 2018, so it is recommended that such studies be conducted in other seasons. The results of this study can be used to create a comprehensive noise pollution management plan in Shiraz.

### Introduction

Nowadays, due to technological development, there are many environmental issues that can damage human health. Although different studies have been conducted on water, soil and air pollution, noise pollution in many cities has not yet been taken into consideration. It is proven that noise pollution can seriously threaten human

health [1]. In the past three decades, by recognizing the destructive effects of noise pollution on humans, the attention of researchers has concentrated on this issue. Due to the operation of thousands of motor vehicles and the heavy industries and construction activities in large cities, the level of noise pollution has increased significantly [1]. Various studies have shown that long-term

exposure to noise pollution can result in health issues including hearing impairment, hypertension, cardiovascular illness and anxiety [2-4]. Increasing noise pollution can increase the incidence of human disease and drug abuse [5]. A study from Germany shows that there is a significant relationship between the level of noise pollution and the rate of heart disease [6]. There is also a report on the relationship between noise pollution and stress in humans [7]. Noise pollution maps have been prepared for many cities around the world, such as Tehran, New Delhi, Tokyo, Rome, Ilam, Zanzan, Kashan, Hamedan, Khorramabad, Tabriz and Qazvin [1, 2, 8-14]. This study of noise pollution in the above-mentioned cities showed that noise pollution was higher than 70 dB. Management of noise pollution in each city is necessary. To manage noise pollution, its level must first be determined in each part of the city [15, 16]. Then, it can be decided which method to control noise pollution for each part of the city should be used. Therefore, it is necessary to prepare sound pollution maps in all cities. Although many studies have been carried out on the noise pollution in various Iranian cities, no studies have yet been conducted on noise pollution in Shiraz. The purpose of this study was to provide a map of noise pollution in Shiraz, a city of roughly 1,250,000, and to compare the level of noise pollution in different parts of the city. For this purpose, the sound level was measured at selected hours and days of the week. Then, using ArcView GIS, the maps were prepared. In addition, with the aid of statistical analyses, the noise pollution levels of different areas of Shiraz were compared.

### Materials and methods

In this study, 33 areas of Shiraz, including Aboalkalam square, Eram square, Atlasi square, Artesh Blvd., Azadi Blvd., Jomhori Blvd., Chamran

Blvd., Daneshjoo Blvd., Rahmat Blvd., Sartarkhan Blvd., Siboye Blvd., Ghodosi Blvd., Velayat Blvd., Motahari Shomali Blvd., Shahid Mofateh Blvd., Molasadra street, Hazrati street, Tohid street, Forsat Shirazi street, Tawos square, Sinema Sadi junction, Golestan town, Shishegari street, Adelabad Blvd., Fergas street, Lotfallikhan Zand street, Emam Hossein square, Parseh square, Shohada square, Shahid Shirodi square, Nasr square, Namazi square and Vali Asr square were selected. These particular areas were representative of all commercial and residential areas of Shiraz. Selected areas were distributed homogeneously throughout Shiraz.

A General Tool noise meter model DSM8930 (General Tool Co., Cincinnati, OH, USA) was used to measure noise level. Based on sound measurement standards, the noise meter's microphone distance from reflective surfaces such as walls and cars was at least 1 meter, and a minimum of 1.5 m from the ground. The distance of the noise meter was also at least as much as an arm's length from the operator's body. The noise meter's microphone was at a 90° angle during the experiments [17]. In this study, the  $LA_{eq}$  parameter was measured. The definition of  $LA_{eq}$  is the noise level in decibels equivalent to the total A-weighted noise energy measured over a stated period of time [17]. The time period of each measurement was 15 min, and then  $LA_{eq}$  was reported in dB. In this study, other parameters used to describe the noise pollution are introduced and defined below.  $LA_{10}$  is the noise level exceeded for 10 % of the measurement period, A-weighted and calculated by statistical analysis. When noise pollution is investigated, it is ordinarily useful to establish what is the general or background noise level in the area; this is best represented by  $LA_{90}$ , which is the level exceeded for 90 % of the time under consideration. Terrific noise index (TNI) is

an indicator calculated by combining  $LA_{10}$  and  $LA_{90}$ . It can be calculated using Eq. (1).

$$TNI = 4 \times (LA_{10} - LA_{90}) + LA_{90} - 30 \quad (1)$$

Another indicator used in this study is Noise Pollution Index (NPI). This index of environmental noise was developed by the United States Department of Housing and Urban Development. "NPI is an index of the annoyance of noise which has recently been drawing increasing interest. It is based on two quantities, one relating to the equivalent continuous energy level and the other relating to the variations in level" [18].

$$NPI = LA_{eq} + (LA_{10} - LA_{90}) \quad (2)$$

In this study, all statistical analyses were performed using SPSS.

## Results and discussion

The results showed that the highest noise pollution in Shiraz was found at Emam Hossein square, Lotfali Khan Zand street, Adelabad Blvd., Hazrati street, Molasadra street, Golestan town, Tawos square, North Motahari Shomali Blvd.,

Satarkhan Blvd., Chamran Blvd., Azadi Blvd., Atlasi square and Aboalkalam square (Figs. 1-4). The minimum noise pollution in Shiraz at 08:00, 13:00, 18:00 and 22:00 was 45.18, 43.12, 41.23 and 48.98 dB, respectively. Additionally, the maximum noise pollution in Shiraz at 08:00, 13:00, 18:00 and 22:00 was 69.97, 71.15, 72.54 and 78.42 dB, respectively. Average noise pollution in Shiraz at 08:00, 13:00, 18:00 and 22:00 was 58.55, 59.56, 61.1 and 61.07 dB, respectively. Table 1 shows Iran's outdoor maximum permissible noise level, which depends on land use. For example, in residential areas, the outdoor maximum permissible noise level is mandated to be less than 55 dB during the day and 45 dB at night. The maximum measured sound level in some parts of Shiraz was more than 55 dB during the day and 45 dB at night. Therefore, some residents of Shiraz are exposed to levels of noise pollution in excess of the governmental standard. Researchers have stated that the main source of noise pollution in cities is vehicles [11]. Therefore, using comprehensive noise pollution management in Shiraz, the level of noise pollution caused by vehicles should be reduced to improve the living conditions of city residents.

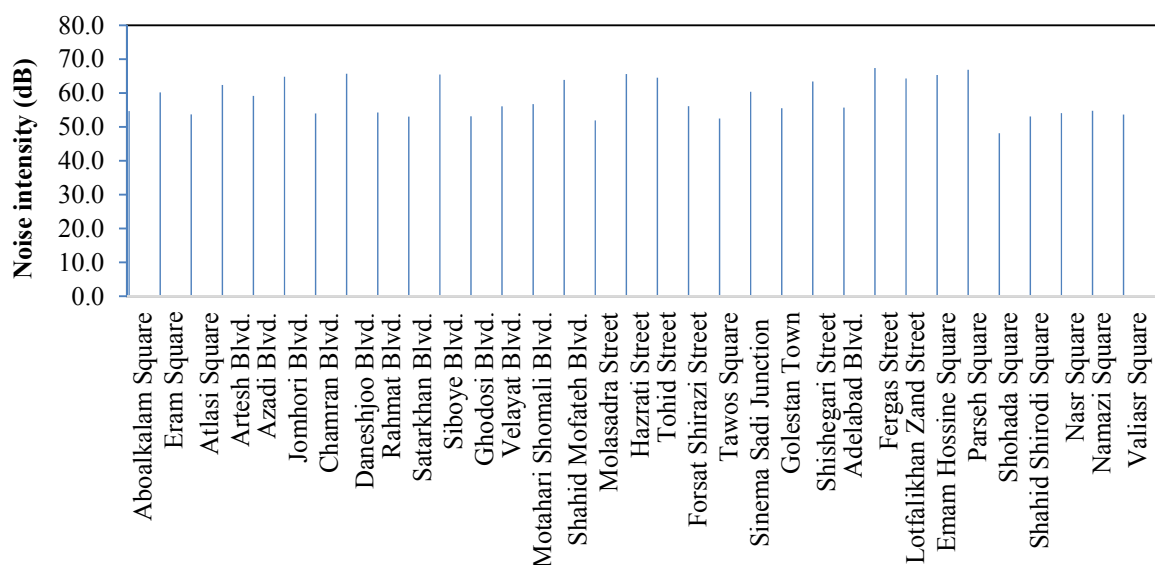


Fig. 1. Average noise pollution for a week ( $LA_{50}$ ) in Shiraz at 08:00

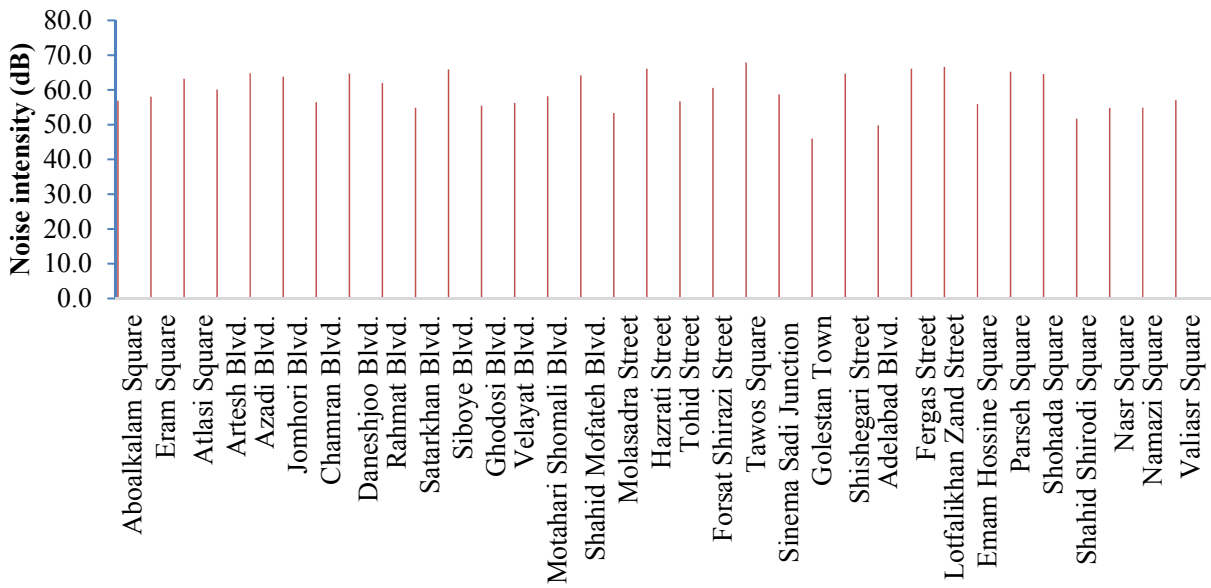


Fig. 2. The average of noise pollution for a week (LA<sub>50</sub>) in Shiraz at 13:00

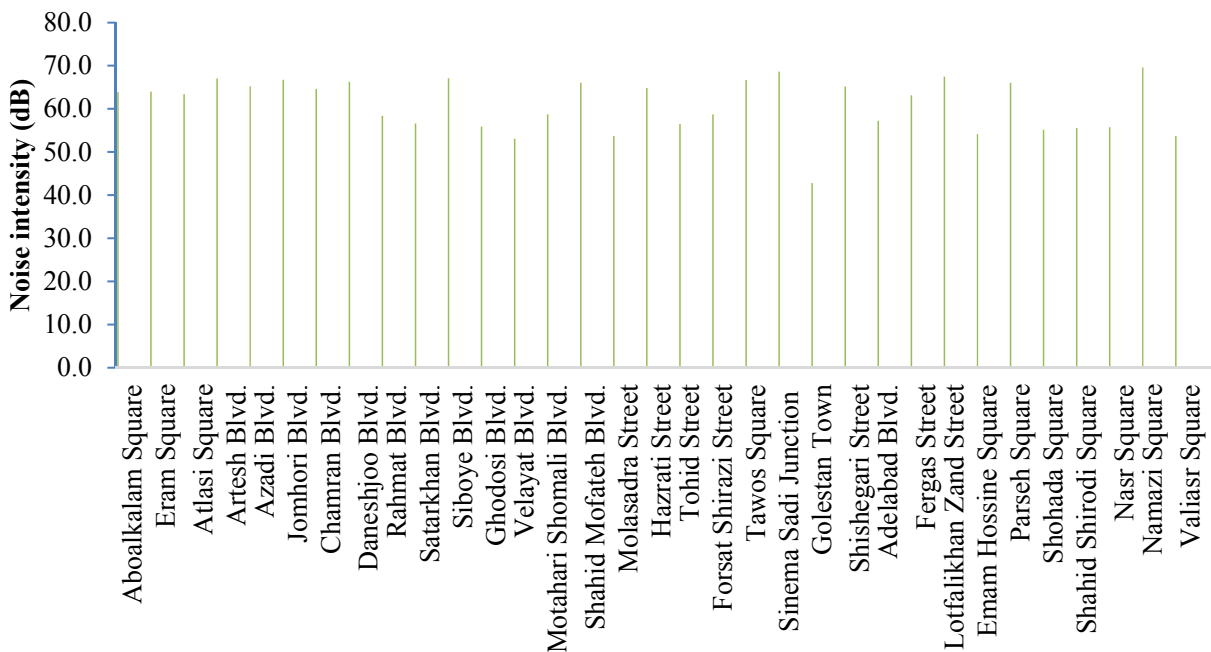


Fig. 3. The average of noise pollution for a week (LA<sub>50</sub>) in Shiraz at 18:00

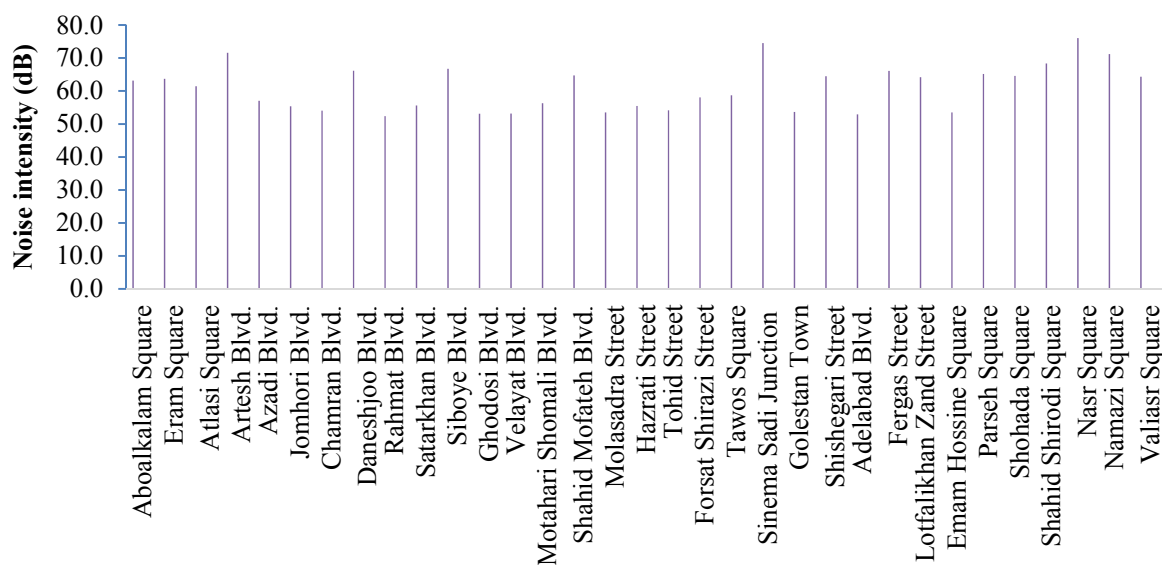


Fig. 4. The average of noise pollution for a week ( $LA_{50}$ ) in Shiraz at 22:00

Table 1. The outdoor maximum permissible noise level in Iran [19]

Type of area	Daytime (07:00 to 22:00)	Nighttime (22:00 to 07:00)
	$LA_{eq}$ (30 min) dB	$LA_{eq}$ (30 min) dB
Residential areas	55	45
Residential and commercial areas	60	50
Commercial areas	65	55
Residential and industrial areas	70	60
Industrial areas	75	65

In this study, the level of noise pollution on different days of the week was examined. The results showed that the average noise level on Monday and Wednesday was 61.4 and 62 dB, respectively. Monday and Wednesday were recognized as days with the highest level of noise pollution in Shiraz. This city also had the lowest noise pollution on Friday at 56 dB. This could be due to lower traffic in Shiraz on Fridays.

The average, minimum and maximum levels of noise in the selected parts of Shiraz are shown in Table 1. In addition, in this table the amount of probability value (P) is shown to find whether there is a significant statistical difference; this

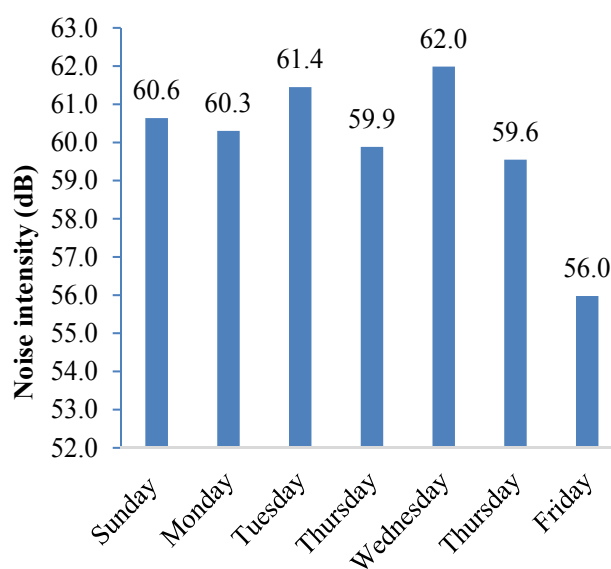


Fig. 5. The average of noise level ( $LA_{50}$ ) by weekday

issue was checked by One-way ANOVA test. In every comparison in which the P was under 0.05 (the significance level), the difference was statistically significant at all hours tested. The results of the ANOVA test were deemed reliable, because the normality assumption was checked independently for each group. It should be noted that in every ANOVA test in which the statistical

probability was under 0.05, the statistical difference was reported as significant, while in the rest of the comparisons in which the statistical probability was higher than 0.05, the difference was reported as insignificant. However, despite insignificant differences, there are some visible sources of differences that undoubtedly are not deniable; however, their intensity was not high enough to

Table 2. Minimum, maximum and average level of noise pollution in different areas of Shiraz at tested hours

Area	Average (dB)				Minimum (dB)				Maximum (dB)				P
	22 PM	18 PM	13 PM	8 AM	22 PM	18 PM	13 PM	8 AM	22 PM	18 PM	13 PM	8 AM	
Aboalkalam square	54.7	56.9	63.9	63.2	49.8	51.2	62.1	62	57.3	59.2	65.6	64.5	0.000
Eram square	60.2	58	64	63.7	57.1	55.1	60.1	61.2	62.2	60	65.8	66	0.000
Atlasi square	53.7	63.2	63.4	61.4	48.2	55.3	54.1	55	56.2	66.1	66	64.1	0.000
Artesh Blvd.	62.4	60.1	67.1	71.6	57.3	56	64.8	69.1	65	62.3	69.3	73.6	0.000
Azadi Blvd.	59.1	64.8	65.2	57	56.1	58.4	63.1	55.3	61.4	67.5	66.9	58.6	0.265
Jomhori Blvd.	64.8	63.8	66.7	55.4	59.2	60.5	64.6	52.2	67.2	65.3	68.6	57.4	0.000
Chamran Blvd.	54	56.5	64.6	54	51.1	52.8	54	49	56	58.3	68.2	56.3	0.000
Daneshjoo Blvd.	65.7	64.7	66.3	66.2	59.4	61	62.4	64.3	68.4	67.4	68.5	68.3	0.646
Rahmat Blvd.	54.2	62	58.4	52.4	49.6	57.7	52.3	51	57	64.3	61.9	55	0.000
Satarkhan Blvd.	53	54.9	56.6	55.6	49	49.6	54.3	53.2	55.3	57.4	58.2	57.5	0.017
Siboye Blvd.	65.5	65.9	67.1	66.7	61.2	62.4	65.2	65	69.6	68.5	69	68.3	0.616
Ghodosi Blvd.	53.1	55.5	55.9	53.1	49.2	51.9	54.1	51.4	56.1	58.2	57.4	54.2	0.011
Velayat Blvd.	56.1	56.3	53.1	53.2	51.3	52.5	51.6	50.2	58	58.9	54.3	56.3	0.005
Motahari Shomali Blvd.	56.7	58.2	58.7	56.3	51	54	56.3	52.2	59.1	60.5	60.6	59.2	0.000
Shahid Mofateh Blvd.	63.9	64.2	66	64.7	59.9	61.1	62.4	62	66.2	66.3	68	66.3	0.000
Molasadra street	51.9	53.4	53.7	53.5	48.5	49	50.2	51	54.3	56.8	55.7	55.7	0.435
Hazrati street	65.6	66.1	64.8	55.5	61	61.2	62.2	54.2	67.5	68	66.2	57.2	0.000
Tohid street	64.5	56.7	56.5	54.2	60.1	55.3	54.3	49.7	66	58.6	58.6	58	0.000
Forsat Shirazi street	56.1	60.6	58.7	58.1	50.1	55.2	54.3	55	58	62.3	61	61.3	0.000
Tawos square	52.5	67.9	66.7	58.7	48.3	60.1	57.2	50.1	55	71.2	72.3	67.8	0.000
Sinema Sadi junction	60.3	58.7	68.6	74.5	54	55.3	57.3	68.7	63.1	60.3	72.5	77.2	0.000
Golestan town	55.5	46	42.8	53.7	50.1	43.1	41.2	50	59	47.9	44.3	56	0.000
Shishegari street	63.4	64.7	65.2	64.5	59.1	61	63.1	61.1	65.3	66.3	66.3	65.9	0.646
Adelabad Blvd.	55.7	49.8	57.2	52.9	50.1	47.3	48.8	50.9	57.4	51.2	60.3	54.2	0.000
Fergas street	67.4	66.1	63.1	66.1	61.3	60.6	59.9	60	70	69	64.9	68.7	0.028
Lotfali Khan Zand street	64.3	66.6	67.5	64.2	58.3	60	62.2	61.1	66	68.2	69.9	66.8	0.063
Emam Hossein square	65.3	55.9	54.1	53.5	58.1	49	50.2	50.2	67.3	59	56	55.4	0.000
Parseh square	66.9	65.2	66	65.2	60.2	61.1	60	58.4	69.8	69.2	69.2	68.4	0.515
Shohada square	48.1	64.6	55.2	64.6	45.2	60.2	52.9	60.2	50.2	66.8	56.8	66.4	0.000
Shahid Shirodi square	53.1	51.7	55.6	68.3	50.2	50.1	54.2	60.6	54.7	52.4	57.9	71	0.000
Nasr square	54	54.8	55.7	76.1	51	52.2	53.2	69.2	56.6	57.9	57.5	78.4	0.000
Namazi square	54.8	54.9	69.6	71.2	47.4	50.2	62.1	69	57.2	57.5	72.2	73.2	0.000
Vali Asr square	53.7	57	53.7	64.4	48.4	52.1	49.7	56.9	56.2	60.2	55.8	67	0.000



make the entire test significant. In this study, the ANOVA test was shown to be statistically significant in some areas of Shiraz, such as Azadi Blvd., Daneshjoo Blvd., Molasadra street, Parseh square and Shishegari street. The maximum permissible levels of noise in ambient air for the selected areas are illustrated in Table 2. Based on this table, the

amount of noise in most areas of Shiraz was higher than the permissible level.

The calculated NPI and TNI values for different areas of Shiraz are shown in Table 3. According to this table, Artesh Blvd had the highest TNI at 18:00. In a study, the highest TNI was observed in Ilam in 18:00 [1].

Table 3. The NPI and TNI indicators in different areas of Shiraz

Area	TNI				NPI			
	08:30	13:00	18:00	22:00	08:30	13:00	18:00	22:00
Aboalkalam square	49.6	53.32	46.25	41.96	62.15	64.93	67.44	65.69
Eram square	47.62	44.58	52.77	50.4	65.33	62.86	69.66	68.5
Atlasi square	50.23	68.46	71.7	61.4	61.7	73.99	75.3	70.5
Artesh Blvd.	58.06	51.11	160.88	56.98	70.09	66.37	98.62	76.06
Azadi Blvd.	47.05	65.08	48.3	38.42	64.33	73.98	68.99	60.27
Jomhori Blvd.	61.08	49.87	50.56	42.92	72.76	68.65	70.7	60.59
Chamran Blvd.	40.61	44.84	80.84	48.1	58.87	62	78.81	61.28
Daneshjoo Blvd.	65.43	56.62	57.11	50.14	74.72	71.11	72.49	70.15
Rahmat Blvd.	49.03	54.17	60.59	38.84	61.55	68.63	67.97	57.02
Satarkhan Blvd.	44.37	50.56	39.97	40.62	59.35	62.63	60.53	59.96
Siboye Blvd.	64.51	58.3	50.37	47.03	73.82	72.38	70.89	69.71
Ghodosi Blvd.	46.87	46.94	37.36	32.87	60.01	61.75	59.21	55.98
Velayat Blvd.	48.04	48.02	32.32	44.73	62.78	62.67	55.77	59.34
Motahari Shomali Blvd.	53.5	51.53	43.21	50.38	64.82	65.08	62.92	63.35
Shahid Mofateh Blvd.	55.05	51.58	54.86	49.07	70.18	69.31	71.62	68.97
Molasadra street	41.94	50.09	42.39	39.8	57.77	61.17	59.25	58.2
Hazrati street	57.19	58.27	48.32	36.11	72.15	72.86	68.83	58.47
Tohid street	53.63	38.37	41.25	52.99	70.38	59.97	60.73	62.53
Forsat Shirazi street	51.85	53.59	50.97	50.26	64.04	67.69	65.36	64.42
Tawos square	44.81	74.21	87.72	90.61	59.12	78.92	81.83	76.32
Sinema Sadi junction	60.46	45.25	88.17	72.65	69.41	63.7	83.81	83
Golestan town	55.57	32.16	23.59	43.98	64.36	50.76	45.89	59.7
Shishegari street	56.51	52.28	45.91	50.28	70.25	70.02	68.4	69.3
Adelabad Blvd.	60.34	54.17	51.38	32.93	65.05	34.04	63.51	53.7
Fergas street	66.04	64.31	49.91	64.99	76.09	74.54	68.11	74.85
Lotfalikhan Zand street	59.33	62.95	62.91	53.82	72.07	74.84	75.18	69.88
Emam Hossein square	64.64	58.99	43.42	40.87	74.43	65.9	59.91	58.67
Parseh square	68.74	63.35	66.75	68.68	76.54	73.26	75.19	75.28
Shohada square	35.38	56.77	38.4	55.02	53.15	71.25	59.07	70.81
Shahid Shirodi square	38.21	29.37	38.99	72.25	57.61	54.01	59.3	78.72
Nasr square	43.23	45.11	40.35	76.14	59.56	60.53	59.99	85.34
Namazi square	56.78	49.38	72.39	55.63	64.65	62.2	79.67	75.36
Vali Asr square	49.55	54.39	44.29	67.31	61.49	65.07	59.86	74.51

The noise pollution maps of Shiraz were generated by ArcView GIS for measurements at 08:00, 13:00, 18:00 and 22:00. In Fig. 6, the noise pollution in different parts of the city of Shiraz is displayed at 08:00. The lowest noise pollution is observed in the northern and southwestern parts of

Shiraz. The central parts of Shiraz have the highest levels of noise pollution. In Fig. 7, it is clear that at 13:00, 18:00 and 22:00, the noise pollution of the city is increased, so that only the northern parts of Shiraz have a low noise level.

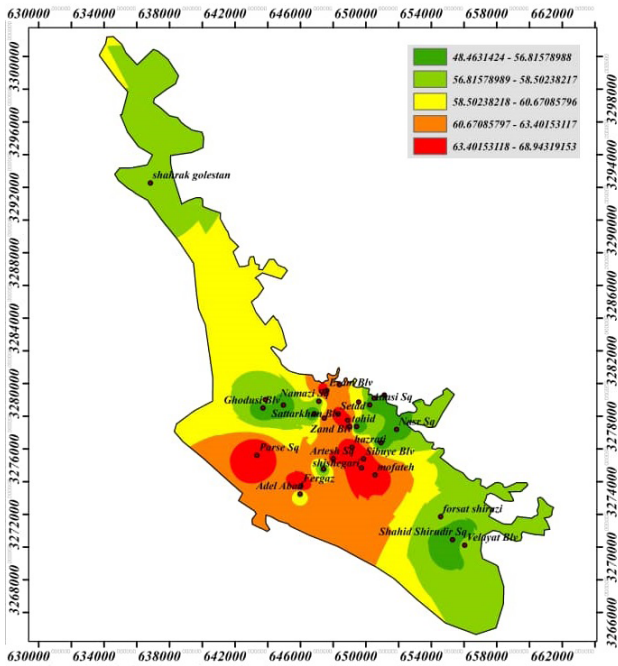


Fig. 6. Noise pollution map of Shiraz at 08:00

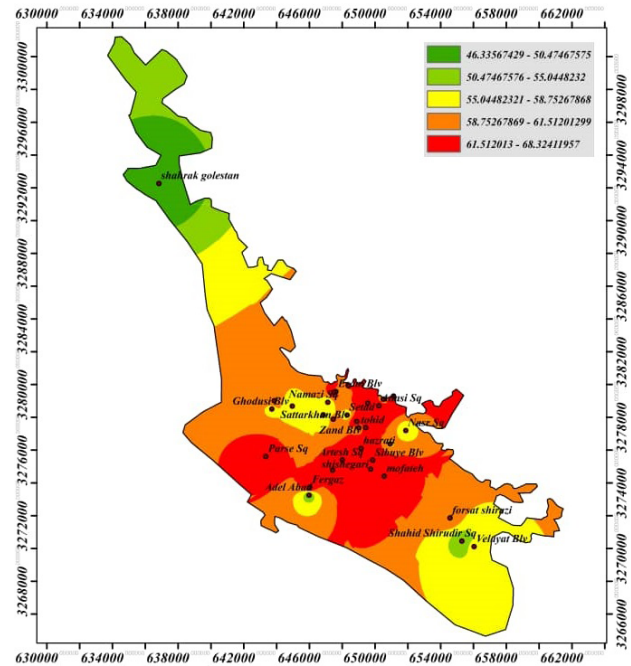


Fig. 7. Noise pollution map of Shiraz at 13:00

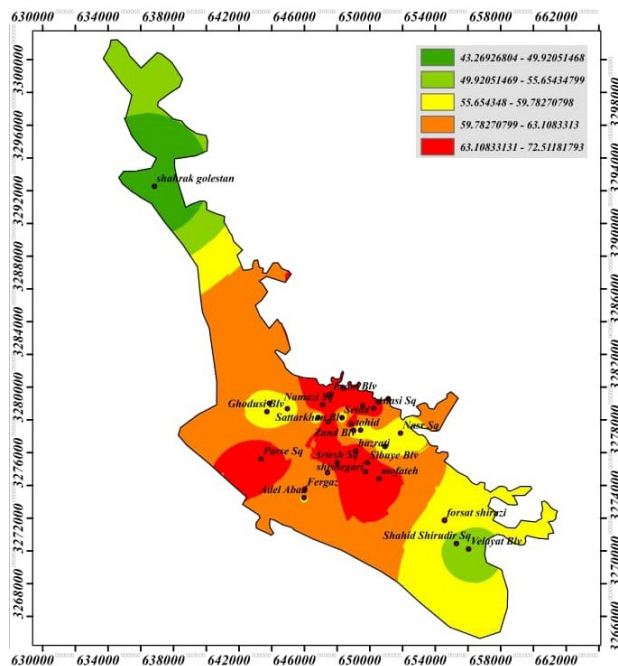


Fig. 8. Noise pollution map of Shiraz at 18:00

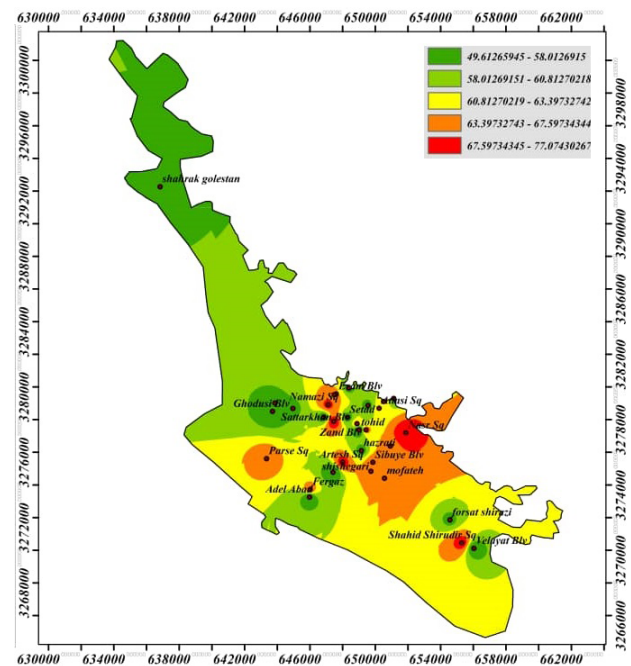


Fig. 9. Noise pollution map of Shiraz at 22:00



## Conclusion

In this study, the noise pollution level of Shiraz was studied in 2018 after selecting particular areas in the city. Some areas of Shiraz at 13:00, 18:00 and 22:00 had noise pollution higher than the government's permissible level. This study was carried out in late summer 2018, so its results may not be applicable to other seasons. Therefore, it is recommended that such studies be conducted at other times of the year. The results of this study can be used in planning comprehensive noise pollution management for the city of Shiraz.

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## Competing interests

The authors declare that there is no conflict of interest that would prejudice the impartiality of this scientific work.

## Author's contributions

It is certified that all of the authors have made the same contribution in the experiments and manuscript writing.

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## Ethical considerations

Authors are aware of, and have complied with, best practices in ethics, specifically with regard to authorship (avoidance of guest authorship), dual submission, manipulation of figures, competing interests and compliance with policies on research ethics. Authors adhere to the publication requirements that the submitted work is original

and has not been submitted or published elsewhere in any language.

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