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ORIGINAL RESEARCH PAPER

Measuring noise pollution from sports events in urban environments (case study: Azadi stadium

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ABSTRACT

Sound pollution is known as one of the main disturbances in urban environments. The purpose of this study is to measure the sound level during sports competitions in the vicinity of settlements. For this purpose, Azadi stadium was selected as the largest sports space in the IRAN and the measurements were performed cross-sectional and in two different times, which included days without sports competition and after the end of the sports competition. Measurements were used 5 times by KIMO-DB100. All measurements were made to determine the sound pressure level in network A. The mean data (Leq) was the basis for drawing the maps. To do this, the pattern of changes was entered into the Arc map software and based on the Inverse Distance Weighting method. The results showed that the minimum sound level on the day without exercise was 50 dB and the maximum sound level measured at this time was 80 dB. On the day of the race, the minimum and maximum sound levels were 55 dB and 95 dB, respectively. On a non-racing day, large sections of the study range have sound levels of 50-65 dB, indicating relative calm and compliance with outdoor sound standards. However, on the day of the match and after the spectators left the stadium, none of the sound level stations showed less than 75 dB. This situation continues for about 3 hours after the end of the game and until the study area of spectators and their cars is completely emptied. It can be said that in terms of sports competition, 45% of the measuring stations were very different from the standard.

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1. Background

There are several harmful factors in the living and working environment that endanger the health of people (Payandenia, 2016; Tabari et al., 2021; Sekhavati et al., 2021; Hoseini et al., 2022). One of these factors is sound pollution. Sound pollution means any annoying and unwanted sound that disturbs the focus and causes discomfort to people. Sound pollution has destructive effects such as hearing loss, hypertension, hyperlipidemia, hyperglycemia, and decreased liver function in eliminating toxins from the body, insomnia, headache and aggression (Taheri Hosseinabadi et al., 2019). According to medical research, people who have been exposed to sound with an intensity of (A) 80 dB for some time have shown signs of hearing loss (Khayami et al., 2019).

According to the World Health Organization (WHO) reports, exposure to sound pressure level of 80 dB can cause aggressive behaviors. Sound pollution in higher sound pressure levels (more than 85 dB) causes direct effects on hearing organs, including Temporary Threshold Shift (TTS) and long-term contacts cause Permanent Threshold Shift (PTS) (Raap et al., 2017; Chang et al., 2021). Disorders of the digestive system and increase in cholesterol and triglycerides and diabetes are the consequences of exposure to sound (Evans & Hygge, 2007).

The US. Environmental Protection Agency (EPA) standard for sound in open areas (playgrounds) is a minimum of 55 decibels and a maximum of 70 decibels. The UK standard for parks and recreational areas (55) is dB (EPA, 2014). According to some international studies and standards, the sound level in sports venues should not exceed 55 decibels, and sound above 85 decibels can damage the hearing system (Babisch et al., 2013). According to the WHO standard for open and public places, the sound level per hour should not exceed 85 decibels (WHO, 2011).

Exposure to sound occurs not only in the workplace, but also includes non-occupational activities such as leisure, transportation, shopping, etc. (Clark et al., 2013). Sound pollution has a significant role in dissatisfaction with space (Sorensen et al., 2012). In recent years, sound pollution and its consequences have become an important issue in scientific research (Majidi et al., 2019). Sound pollution is monitored in three different areas, which are: 1- Traffic and transportation 2- Industrial activities 3- Sports, trade and recreational places (Bahmanpour & Fahiminejad, 2021). One of the problems that have occurred in urban environments is car traffic and the accumulation of sports fans after the end of sports competitions. So that in order to hold sports competitions, a large crowd goes to the stadiums, and after the end of the competition, this crowd suddenly leaves the sports venue and goes to the surrounding streets. It is natural that the sound level in these passage corridors and neighboring areas, which are mostly residential, will increase, which will cause inconvenience to residents.

Sound mapping is a graphical representation of the sound level distribution in a particular area and is an effective method of assessing sound in urban areas (Oyedepo et al., 2019). In general, sound maps have two main purposes. First, they can be used to provide programs to manage and reduce sound levels. Second, sound maps provide information about sound levels to estimate how many people are affected (Taghizadeh et al., 2013).

Freitas et al. (2012) surveyed annoyance evaluations from activity noise recorded on cobblestones, thick black-top, and open black-top elastic asphalts with respect to vehicle speeds and movement densities. It was discovered that cobblestones asphalts are the most annoying; additionally, while open black-top elastic asphalt forces less disturbance than thick black-top, it is not fundamentally extraordinary. Higher auto speeds dependably prompt more noteworthy annoyance, as does higher movement densities. Ndrepepa and Twardella (2011) showed the association of traffic-related noise annoyance with the danger of blood vessel hypertension and a positive yet unimportant relationship between noise disturbance and the danger of ischemic coronary illness. Sleeping problems caused by annoyance created by night-time traffic noise were examined by Fyhri and Aasvang (2010). Their results indicated a strong association of sleeping disorder with night traffic annoyance. The model additionally indicated strong associations with pseudo neurological complaints. The investigation demonstrated no connection between noise presentation and reaction to noise and cardiovascular issues.

Hosseini Dinani et al. (2020) also measured noise levels in recreational and sports areas. They found that the sound level in some of these areas was higher than standard.

Decrease in sleep efficiency is associated with night-time traffic noise. Frei et al. (2014) indicated that the subjects who were not annoyed with traffic noise showed a more significant association of sleep efficiency with traffic noise. Their study also indicates that perceived noise annoyance due to nocturnal traffic noise has no effects on objective sleep quality.

Accordingly, the purpose of this study is to measure the sound level in the adjacent routes of a large-scale sports complex at 2 different times (before and after the race). In other words, the main question of the research is what is the level of sound pollution caused by the departure of sports spectators in an urban environment?

2. Materials and Methods

This research is a cross-sectional study based on the process of direct measurement of sound levels. For this purpose, the surrounding and residential areas adjacent to the Azadi Stadium (west of Tehran) has been selected as a pilot. In the first step, 24 sampling stations were selected within the study area. The stations were selected to cover the entire area well. The eTrax 20X GPS device made in Switzerland was used to determine the exact location of the sampling stations.

Figure 1 shows the location of the study area and Figure 2 shows the distribution of measuring stations. The sound level was measured in the study area in the following 2 time periods.

Since the quality of the environment is different in different conditions, it was necessary to measure the sound level at different times. For this purpose, 2 different times were selected from different modes:

• 6 to 8 pm (without football match)

• 6 to 8 pm (after the football match and the spectators leave the stadium).

In order to increase the accuracy of the data, measurements were performed in 5 turns. The KIMO-DB100 was used to measure the sound level. A sponge protector was used to eliminate possible errors. The distance of the acoustic microphone from the reflective surfaces (such as cars and walls) was at least 1 meter and from the ground 1.5 (South, 2016). All measurements were made to determine the sound pressure level in network A and the FAST response speed. Leq30 was measured by an average of 15 minutes at each station. After measurement, all data were entered into the EXCEL and the minimum, maximum and average values were calculated. The average data (Leq) was the basis for drawing the maps.

One of the common methods for measuring sound level is using the networking method. In this method, the study area is divided into equal parts and each part is introduced as a measuring station. In this study, due to the size of the site and the proximity to the passage corridors and residential areas, measuring stations were determined.

AHP process is started to recognize and prioritize the elements including different methods and priority estimators. In the first step, each data was weighted and the estimators were located in the matrix and estimated as single and their weight was found. By using normalized method, we estimated all estimators; in the third step, by considering the weight of estimators and alternative points, we obtained the points of alternatives and leveled them. The final step was to determine their compatibility (Mohammadi et al. 2021).

In the modeling step, problem and decision aims were recognized as hierarchy. Decision elements were decision index and decision options. Hierarchical process needed to break a problem with some indicators and high levels showed the main aim of the decision. The second level showed the main and sub-indicators which connected to the sub-indicators and partial ones.

The last level offered decision options (Darko et al. 2019). Hierarchical decision is shown in Figure 2.

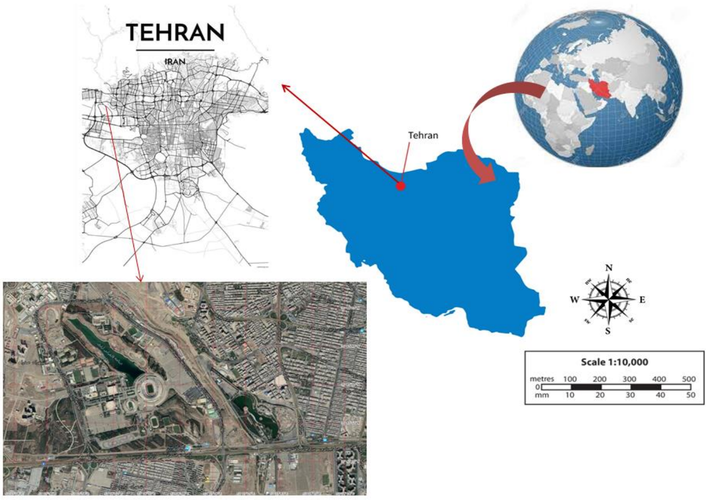

Figure 1. Location of the study area on the map of Iran and the world

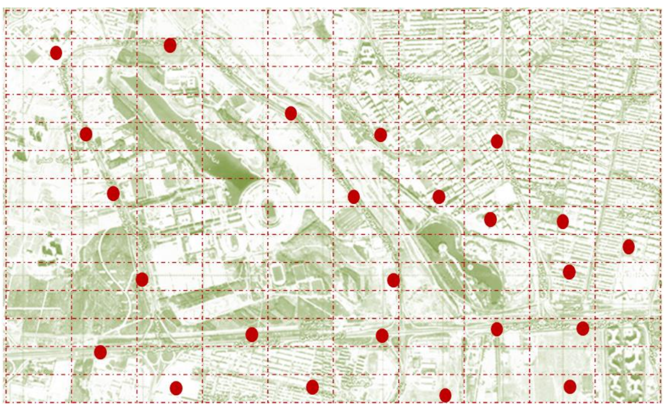

Figure 2. Position of sound leveling stations

3. Results

After performing the measurements in two separate time periods, the values of LAmin, LAmax and Leq were determined and for better understanding and analysis of the obtained levels, the data were entered into GIS software and color maps were drawn. In the maps, areas with lower sound levels were highlighted in green and areas with higher sound levels were highlighted in warm colors such as orange and red (Figures 3 and 4).

As shown in Figure 3, the minimum sound level per day

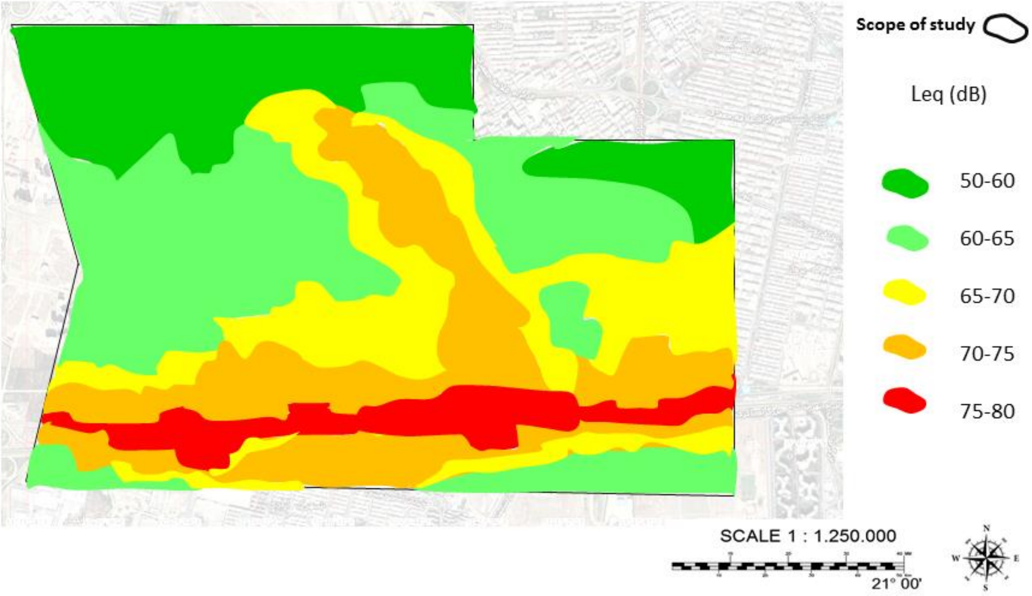

Figure 3. Spatial distribution of the Leq index on a day without competition

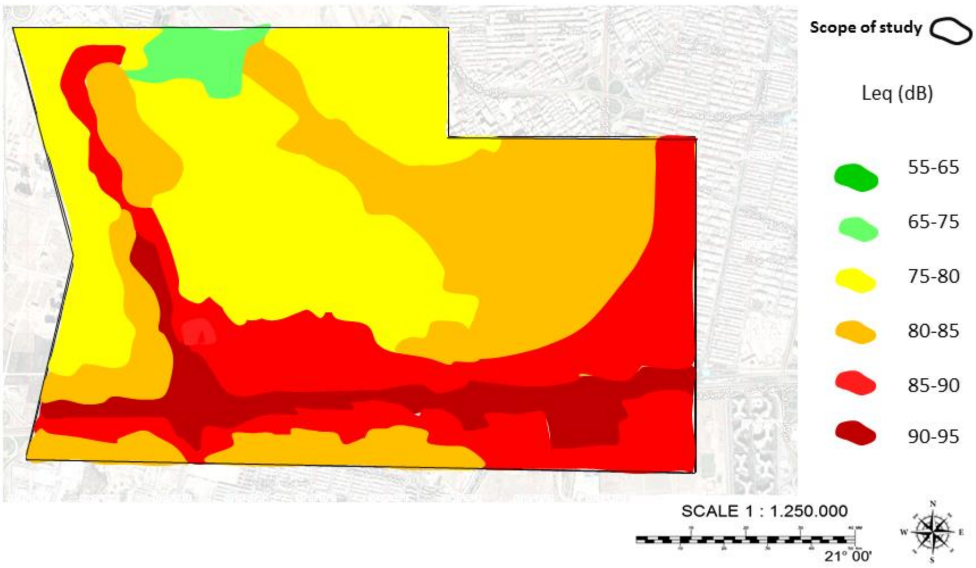

Figure4. Spatial distribution of the Leq index on the day of the match and up to 2 hours after the end of the game

(without football match) was 50 dB and the maximum sound level measured at this time was 80 dB. However, on the day of the sports competition, the minimum and maximum sound levels measured were: 55 dB and 95 dB, respectively, which indicate a significant increase in sound level. Careful maps show that on non-match days, large sections of the study range have a sound level of 50-65 dB, indicating relative calm and compliance with outdoor sound standards. However, on the day of the match and after the spectators left the stadium, with the exception of a small area, none of the sound level stations showed less than 75 dB. Figure 5 shows a comparison chart between the two time periods.

The reason that the sound level of the highways is also considered in the map is that when the spectators leave the stadium, the traffic volume of these routes will increase and as a result, the sound level will increase.

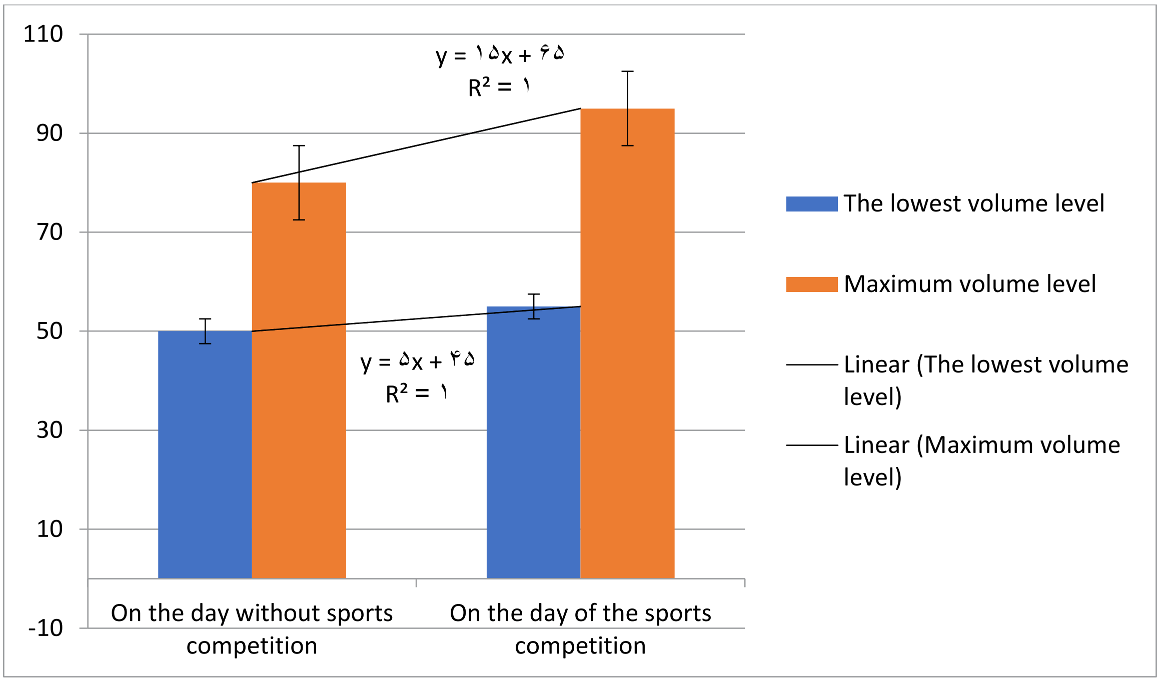

Figure5. Comparative diagram of the lowest and highest sound levels measured at different times

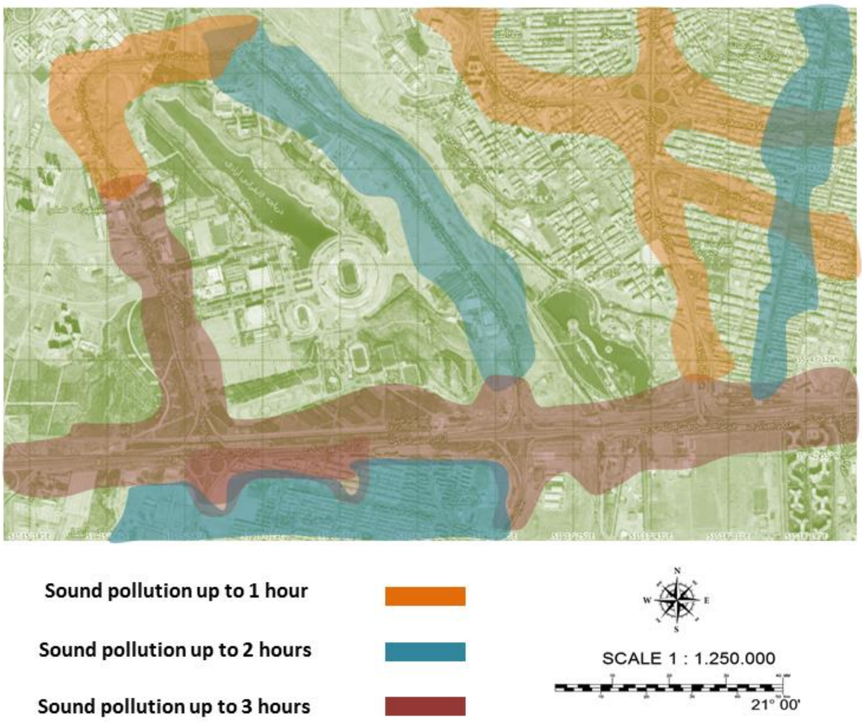

Figure4. Spatial distribution of the Leq index on the day of the match and up to 2 hours after the end of the game

It is important to note that the sound pollution produced is caused by car traffic and spectators leaving the stadium, which leads to continuous beeps, the use of trumpets and the shouting and cheering of sports teams. This situation will continue for about 3 hours after the end of the game and will continue until the study area of spectators and their cars is completely evacuated. Based on experimental data, a map of the duration of sound pollution in the study area can be drawn (Figure 6).

4. Discussion

The purpose of this study was to measure the sound level around Azadi Sport Complex in Tehran, especially the football stadium. For this purpose, two different times were studied. First, the minimum and maximum sound level as well as the equivalent sound level was measured in 24 stations in the study area and on the day without sports competition. Then it was measured in the same stations on the day of the sports match (football) and after the match. Evaluations showed that there is a difference in sound level between the two situations. So that in terms of the lowest equivalent level, 5 dB and in terms of the maximum sound level of 15 dB, the difference of sound level was observed. The color scheme of the maps also illustrates this difference. On the other hand, due to the large volume of cars and the large number of spectators (during the measurement period of about 40,000 people), it was not possible to evacuate quickly, and according to experimental studies, in some cases it took about 3 hours to return to normal. On the other hand, due to the proximity of Tehran Azadi stadium to the Tehran-Karaj highway, as well as several residential areas such as Ekbatan, Apadana, Farhangian, Peykanshahr, etc., it is obvious that the level of social vulnerability will increase and great dissatisfaction with Announced to neighboring areas.

The highest level of sound pollution (NLP) is 95 dB (A) and is related to the stations near the Tehran-Karaj highway and the lowest level of sound pollution is 50 dB (A) and is related to the stations north and northwest of the study area.

According to the standard announced by WHO, which is the maximum acceptable level of sound level for 1 hour in outdoor and public space is 85 dB (A), it can be said that in the second scenario (in the case of a sports competition) 45% of the measuring stations They were very different from the standard. Figure 7 shows the compliance and non-compliance of measuring stations with the WHO audio standard.

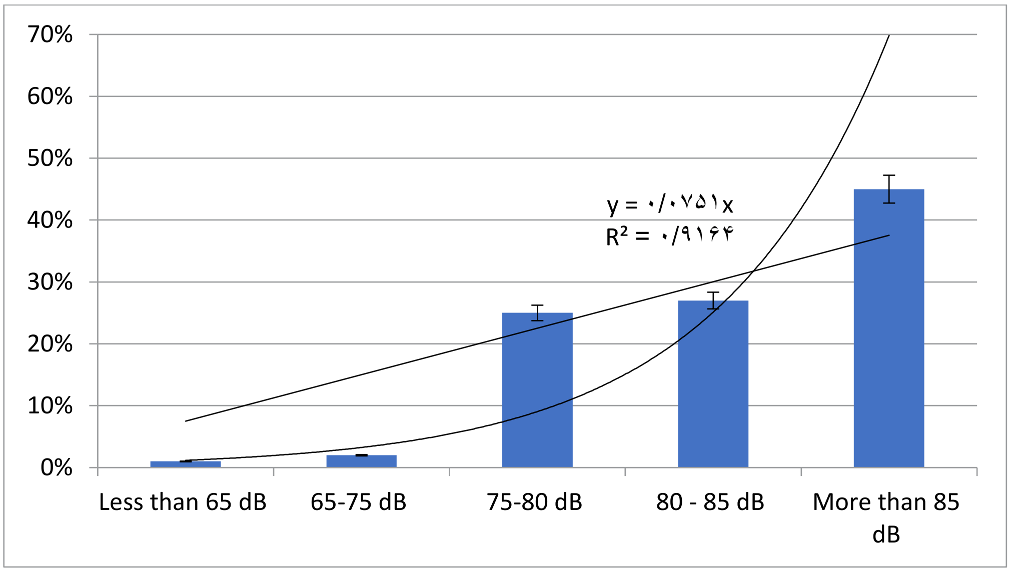

Figure4. Spatial distribution of the Leq index on the day of the match and up to 2 hours after the end of the game

It should be noted that part of the sound level in the area is due to the constant traffic of cars from the highway, which increases during sports competitions and leads to heavy traffic. Residential buildings adjacent to the highway are constantly receiving a lot of sound pollution. Comprehensive criteria and strategies have been defined to prevent the propagation of sound from the streets to the surrounding areas, including the use of acoustic dams, acoustic embankments, vegetation, and porous asphalt, insulation of buildings, and finally sound walls and management solutions. Sound pollution control (Morillas et al., 2018). Having a horizontal wall distance of six meters from residential buildings has the greatest impact on the sound wall (Putland et al., 2017). Since the use of green space in landscaping of residential areas will be effective in reducing sound, in addition to shrubs and shrubs with suitable height and density that currently exist after the sound barrier in open areas between buildings and yards it also used plant insulation (Kondo et al., 2018).

5. Conclusions

According to the measurements made, it can be stated with certainty that during the sports competitions, and especially after the end of the competition and when the spectators leave the sports halls, due to congestion and traffic, it can be expected that the sound level will increase. Of course, in some cases, sound pollution will be beyond the standard. For this reason, the need for planning and management in order to control sound pollution should be considered more than before.

Perhaps one of the most important measures that can be taken to reduce the inconvenience caused to sports by citizens is to be careful when locating and designing sports complexes besides considering multiple entry and exit routes for such spaces to avoid overcrowding. On the other hand, the use of green belts as well as sound walls can also help reduce the sound level.

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