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Evaluation of noise pollution in Parks of Sanandaj City and zoning with Geographic Information System

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Original Article

Abstract

It is accepted that noise pollution has a major impact on health, such as physical, physiological, psychological and performance related effects, all over the world. This study aims to evaluate noise pollution in four urban parks located in Sanandaj City, Iran and to zone it in GIS environment. Sound pressure level (SPL) and maximum sound level (L_{max}) were measured at 45 points (each point was measured in a duration of 1 min) spread throughout the parks. The measurement of SPL alongside L_{max} was performed using a sound-level-meter TES-1351A. Location of measuring points was recorded using GPS. The noise pollution was found to be more than 50 dB (A) during the day and 40 dB (A) at night, which are within the prescribed standard level for commercial-residential-recreational zones by Iran National Environmental Standards. The L_{max} of Amirieh, Koodak, IT, and Maolavi parks were 73.3, 74.31, 74.88, and74.79 dB (A), respectively. Moreover, the SPL of Amirieh, Koodak, IT, and Maolavi parks were 56.99, 60.27, 59.47, and 60.93 dB (A), respectively. Amirieh Park had the lowest L_{max} and SPL due to high cover vegetation and lack of high road traffic, whereas the other three parks showed the maximum amount of L_{max} and SPL due to the surrounding traffic routes. Improving the parks acoustic conditions through noise insulation using green barriers decorated with plant material can be considered as effective method in order to decrease noise to acceptable level in all the parks.

KEYWORDS: Noise; parks; sound pressure level; GIS; Sanandaj.

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Introduction

Over the past three decades, environmental pollution has attracted attention throughout the globe. The issue of noise pollution is pervasive and global and is a problem in many countries.[1] World Health Organization (WHO) has indicated noise pollution in large cities as the third most dangerous type of pollution after air and water pollution.[2] The term noise is given to the unwanted, loud, or disagreeable sound (produced by vibration in air or other medium).[3] In fact, noise has several undesirable effects on human health, it is considered as an environmental pollutant. Many researchers have shown that exposure to environmental noise may increase the risks related to personal health, like nervous frailty, extreme irritability, muscle cramps, stress and anxiety, dizziness, headache and migraine, anger, loss of body balance, vomiting, pain, hypertension, high blood pressure, cardiovascular problems, deterioration of sleep quality, mental stress, etc.[4-8] In addition, WHO estimated that about360 million people suffer

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from mild to severe hearing disorders globally.[9]

Noise was added as one of the air pollutants by the Air Prevention and Control of Pollution Act 1981.[10] Two types of noise emissions are of concern: (1) impulsive noise – that is noise of short duration and high density like explosions, sonic booms, and artillery fires, and (2) continuous noise – that is noise of longer duration and lower intensity like that from construction works or traffic.[11] Furthermore, it has been reported that traffic is one of the major sources of noise.[12] The noise due to traffic along a road is continuously fluctuating and is not easy to be forecasted or quantified.[13] The main sources of noise pollution are man-made activities, mainly transportation and industrialization for the development of urban areas. These sources include construction works and industrial machinery, alongside office and household equipment.[14] Therefore, it is necessary to control noise exposure levels in sensitive areas like hospitals, schools, kindergartens, and recreational centers.[15]

Nowadays, the concept of urban green space without affecting its various forms is not comparable to relieve the obstruction. Cities as focus centers of activity and human life should be able to set their own sustainable place which can affect the choice to accept the structure and functioning of natural systems.[16] Among the urban open spaces, urban parks are typical subjects. Some environmental elements in urban parks are green area, water front, sports facilities, and agreeable landscapes. Rest, sports, relaxation, games, cultural events, and sightseeing are the major reasons for gathering and congregation of people in urban parks.[17] To protect public welfare, standards in terms of noise pollution in the parks and urban areas throughout the day have been published. In this case, the noise limit for green spaces throughout the day on equivalent continuous sound level is L_{eq} = 55 dB.[18] Therefore, the present study aims to evaluate noise pollution in four urban parks located in Sanandaj City, Iran and to zone it in GIS environment.

Materials and Methods

Study Design and Area

This was a descriptive-analytic study carried out in four parks of Sanandaj City located in western Iran. Sanandaj City is located at 14° 35′ N and 46° Efrom the Greenwich meridian and its height is between 1450 and 1538 m a s l varying in different parts of the city and has an area of 2906 km^2.[19] The city has nine major parks; nevertheless, people prefer to spend their leisure time only in a few of them. Hence, considering topography and geographical distribution of the most visited parks in Sanandaj City, four parks, i.e. Maolavi, Amirieh, Koodak, and IT (Figure 1) were selected as the study area. The basic information regarding the parks was collected. Thereafter, the sound pressure levels (SPL) at each park was measured using sound level meter TES 1351 calibrated with CEL-110/2. In addition, the noise map was generated using ArcGIS software.

Procedure of measuring sound level

The station selection and sample size was based on the sub-path and main access routes, resting platform, the gathering place of playing equipment, traffic routes leading to parks, rush hours and days in the parks. Considering total area and length of access routes in each park, number of stations for measuring sound level was determined (Table 1). L_{max}, L_{min}, and sound pressure level (SPL) were measured at each defined station characterized on designed grid map using sound level meter (SLM) TES 1351 calibrated based on ISO 9612 and ISO 11200 methods.[20-21] To eliminate the effect of air currents and wind, a windscreen was equipped on the microphone. The SLM was set at a height of 1.5 meters above ground level (hearing level) at specified stations. Given that the objective of this study was to evaluate noise pollution in the parks, “A” frequency weighting network and the “Fast” response mode were selected as a measure of the noise level. Given that noise pollution has continuous/non-continuous nature and the sound changes are too much with regard to time, each station was measured at least three times and the average of the three readings was used as the noise level at the desired station. The reading was done at 18:00 to 20:00 on Thursdays and Fridays of every week for two months simultaneously ateach park.

Table 1 presents the basis for selecting number of noise measurement stations.

The noise map of different parks was drawn employing ArcGIS software in GIS environment. The buffers and isometric map of noise propagation in the measured domain could be displayed by this software.[22] The data collected were assessed for its normality using Kolmogorov-Smirnov test. Thereafter, the mean values of L_{max} and SPL were compared using analysis of variance (ANOVA).

Results and Discussion

The L_{max}, L_{min}, and SPL were measured at different measuring stations of the most visited parks in Sanandaj City, Kurdistan, Iran for 3 months in 2014. The IT Park had the maximum mean of L_{max} = 74.88 dB and the Maolavi Park had the maximum mean of SPL= 60.93 dB among the four parks.

Table 1. Number of measuring stations allocated for each park

Park name	The total length of the access routes between the park (m)	Area (m^2)	The number of stations per unit length of 100 meters Access
Amirieh	1900	68761	19
Koodak	900	28861	9
Maolavi	550	18530	6
IT	1110	20333	11
Total	4460	136485	45

The results of statistical mean of measured L_{max} and SPL for each Parks are shown in Table 2. The statistical analysis indicated a significant relationship between the parameters measured in the four parks.

Table 2. Statistical mean of the measured L_{max} and SPL in the Parks

Park	L_{max}					SPL				
	N	Mean	Std Deviation	F	P-Value	N	Mean	Std Deviation	F	P-Value
Amirieh	304	73.3	4.501	6.41	<0.0001	304	56.99	6.76	16.647	0.0001
Koodak	144	74.31	4.106			144	60.27	5.552		
IT	176	74.88	3.705			176	59.47	5.478		
Maolavi	96	74.79	4.843			96	60.93	5.25		

Table 3 reveals a significant relationship between mean L_{max} and SPL in terms of months and time of day. The L_{max} (74.88 dB) was recorded in June, while the SPL (60.27 dB) was observed in May. Nevertheless, the minimum value for both L_{max} (73.3 dB) and SPL (56.99 dB) was recorded in April. The highest values of L_{max} and SPL could be attributed to the onset of heat season, in turn, congregation of people in these parks and heavy traffic congestion in adjacent roads passing by the parks. The maximum value of L_{max}=75.11 dB and SPL=60.47 dB at 19:30 to 8 pm are due to cooling the air and visiting very high parks and the minimum value of L_{max} =73.33 dB at 18 to 18:30 pm and SPL=57.31 dB at 18:30 to 19 pm was due to warm weather and no crowd in the parks.Chowdhury et al (2009) carried out an analysis of day time traffic noise level. A case study of Kolkata in India found that each sampling station in peak (09:00 – 10:00 a.m.) and non-peak (02:00 – 03:00 p.m.) traffic hour was above the national day time noise standard determined by Central Pollution Control Board (CPCB) of India (2000).[23] The results of Table 4 reveals that there was a significant relationship between mean L_{max} and SPL with respect to traffic. According to Table 4, the minimum logarithmic average of L_{max} = 73.35 dBA and SPL =57.17 dBA was observed in low traffic volume and maximum average of L_{max}=76.56 dBA and SPL=63.35 dBA was observed in high traffic volume. It can be said that the volume of traffic on the amount of noise in the park is effective. Based on the measurements carried out, the level of traffic is one of the reasons for noise pollution in Sanandaj City parks and these are one of the variables in this study.Ozdemir et al (2014) attributed the noise pollution of Trabzon parks to the heavy traffic on the roads.[24]

Figure 1 illustrates the SPL maps of the studied parks in Sanandaj City. The red color shows that the high SPL is mainly due to their adjacent to highways and secondary roads. Studying noise pollution in urban areas of Nigeria, Oyedepo et al (2012) found that the

Table 3. Statistical analysis of the measured Lmax and SPL at different hours and months

Month	L_{max}					SPL				
	N	Mean	Std Deviation	F	P-Value	N	Mean	Std Deviation	F	P-Value
April	304	73.3	4.501			304	56.99	6.76		
May	144	74.31	4.106	6.41	<0.0001	144	60.27	5.552	16.647	0.0001
June	176	74.88	3.705			176	59.47	5.478		
Time										
18-18:30	138	73.33	4.982			137	58.94	6.88		
18:30-19	148	73.45	4.093			148	57.31	5.358		
19-19:30	149	73.82	4.281	6.547	<0.001	149	57.7	6.579	6.547	0.0001
19:30-20	150	75.11	3.973			150	60.47	6.587		
20-20:30	129	74.68	4.105			129	59.53	5.098		

Table 4. Statistical analysis of L_{max} and SPL based on traffic conditions

Traffic intensity	L_{max}					SPL				
	N	Mean	Std Deviation	F	P-Value	N	Mean	Std Deviation	F	P-Value
Low	444	73.35	4.399			444	57.17	5.877		
Medium	96	75.35	4.102	25.147	<0.0001	96	63.19	4.812	74.97	0.0001
High	90	76.56	4.248			89	63.35	5.598		

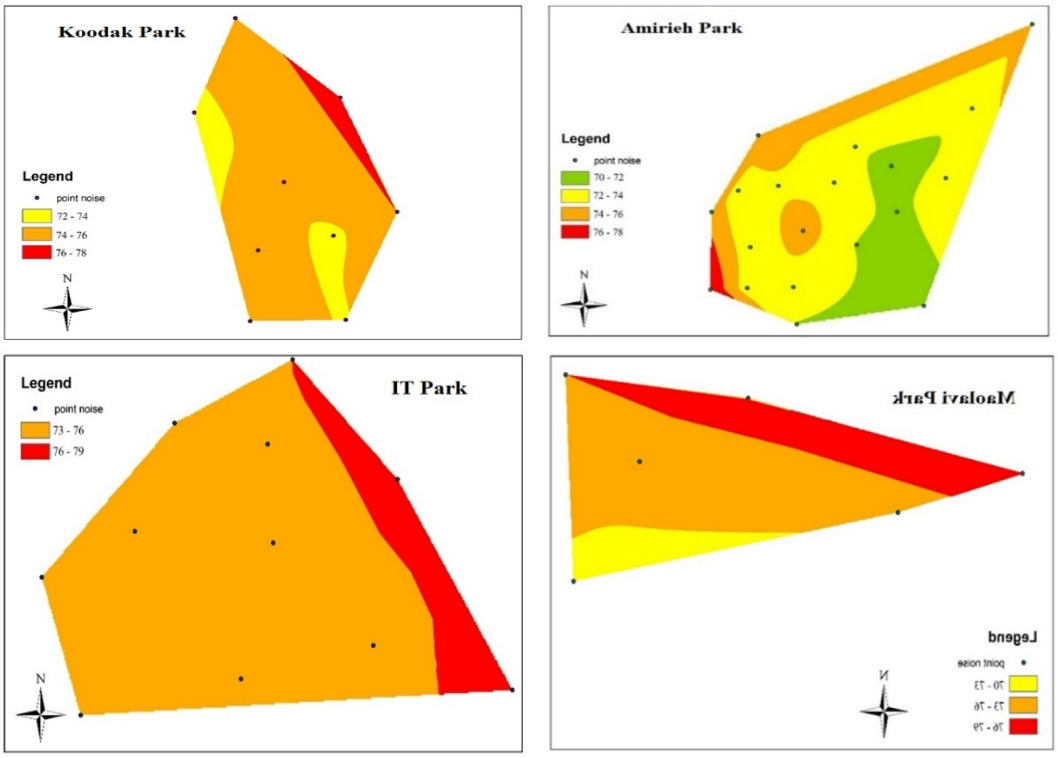

Figure 1. Sound map of the Sanandaj Parks based on Sound Pressure level

main source of noise was in high traffic areas close to the highways and city centers.[25] The high SPL in Maolavi park is due to the movement of heavy and light vehicles with high traffic along with a route ending to the Sanandaj-Hamedan highway. Nevertheless, the areas with high vegetation coverage and trees had the lowest SPL (green color areas on maps).

Figure 2 illustrates the L_{max} based sound map of the parks studied in Sanandaj City. The color coding is the same as presented for SPL maps in Figure 1. The IT and Maolavi parks had the highest level of L_{max}.

In addition, there are some areas in Amirieh and Koodak parks exposed to traffic routes having high points with L_{max}. The areas with high vegetation and trees had lower L_{max} when compared to other parts. These are identified on maps with green and yellow color.

Followed by Maolavi Park, IT park has lighter traffic conditions. However, the topographical conditions have an important role in SPL and L_{max} readings. Therefore, high and intensive vegetation coverage and green space alongside lack of heavy and continuous traffic could be attributed to the low SPL and L_{max} in Amirieh Park. A study on noise pollution of parks in Allahabad City, India attributed the noise pollution to traffic and pedestrians' vehicle.[26] In another study in Curitiba, the highest L_{eq} measured was 67 dB(A) for Botanical Garden Park, where its noise pollution was attributed to the traffic conditions.[17] In this study, it was found that the noise level was higher than the ambient noise standards in all four parks. According to the National Environmental Standard, the allowable limit of SPL in commercial-residential-recreational areas at 5-10 p.m. and at 10 p.m. -7 a.m. is 60 and 50 dB, respectively. Among these parks, IT Park is the much crowded, newest, and smallest park but had the highest L_{max}, while the highest SPL was recorded for Mollavi Park . Parks are places for spending family leisure time and nuisance like noise pollution can create unpleasant hours for those spending their time at acoustically polluted parks.

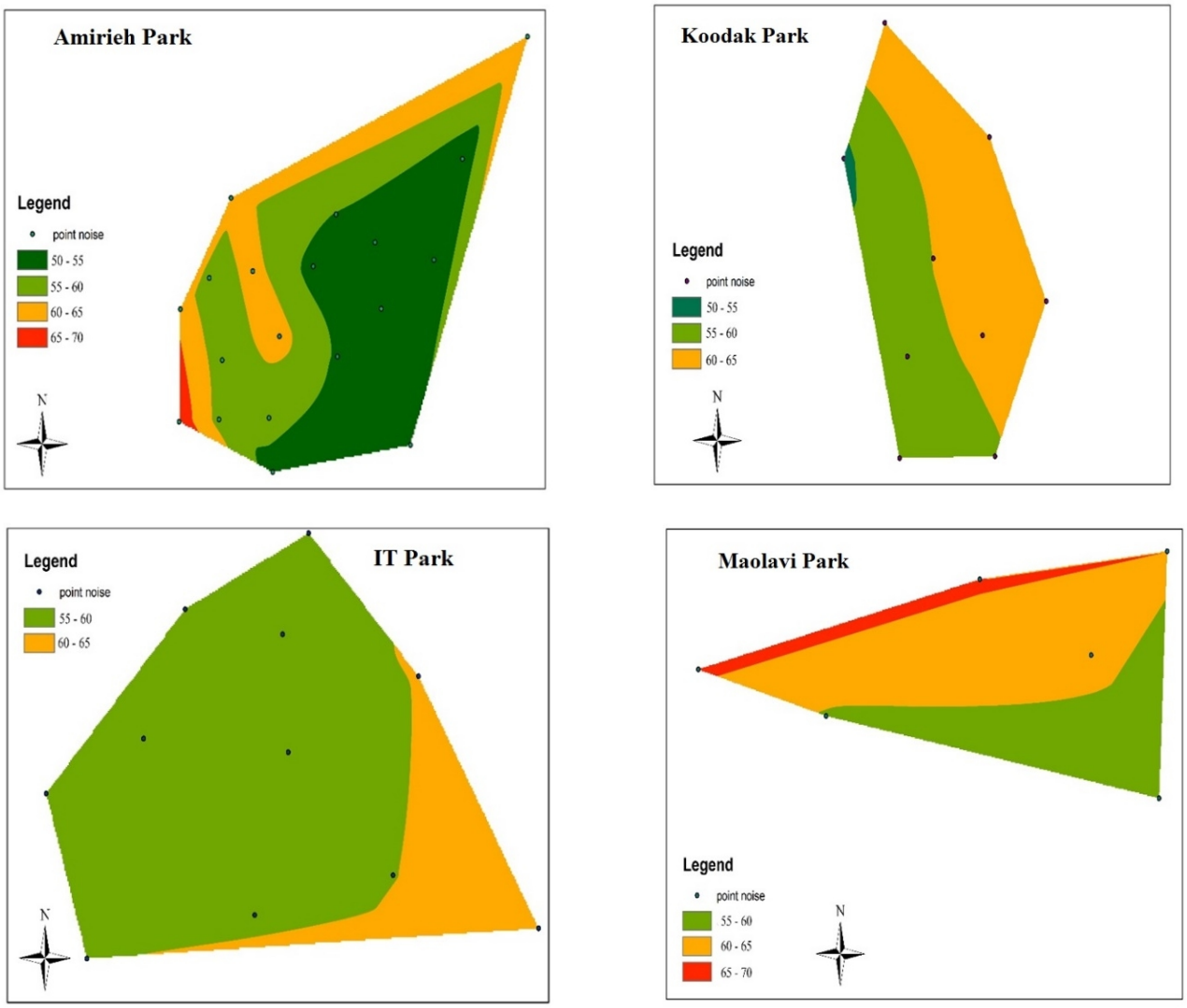

Figure 2. Sound map based on L_{max} in the investigated four parks of Sanandaj City

Conclusion

This study reported the measurements of sound pressure level (SPL) and L_{max} in four most visited parks in Sanandaj City, Iran. Located in urban areas, dominated by commercial activities and services, and surrounded by roads of intense traffic are the major reasons for acoustically polluted parks. Nevertheless, vegetation and trees were the major factors for lower SPL and L_{max} in Amirieh Park. Literature review indicates lack of extensive studies on noise pollution at parks. In fact, there are few studies carried out on this

environmental issue in Iran and it is crucial to have more studies in this regard.

Hints learned from the field observations

Urban parks are one of the typical subjects of open space design, and play an important role in the daily life of the citizens. To reduce noise pollution in such places, the following points are recommended:

-Vegetation cover and trees can act as a sound absorber; therefore, tree planting in open spaces or as barriers can decrease noise pollution.

-Urban parks are suggested to be located and planned in such a way that they are far away from main roads and heavy traffics.

-Placing suitable barriers for reducing noise pollution.

-That street signals indicating the proximity to green areas are recommended to be placed near the parks, with indication of speed limits and forbidding the use of horns.

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