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ORIGINAL RESEARCH ARTICLE



Evaluation of road traffic noise in terms of acoustic comfort on sidewalks at ring road of Konya-Istanbul, Turkey

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ABSTRACT

Walking is an activity that can be easily done by many people in urban spaces even in short periods. The most common areas of walking in urban spaces are the sidewalks. In order for pedestrians to travel comfortably in these areas, acoustic comfort should be fulfilled. This study aims to seek an answer to the question of "Can accurate results be obtained by using an alternative method which is more efficient in terms of time, energy, and cost, in noise measurement studies?". In this study, minimum and maximum noise measurements were made in three different time periods during the day on a part of D300 ring road in Selçuklu district, Konya province, Turkey. The obtained data were subjected to reliability analysis, unreliable data according to Cronbach's Alpha coefficient were not included in the calculations. The reliable data were evaluated in terms of compliance status according to the "Assessment and Management Regulations of Environmental Noise". As a result of this study, it was determined that even the recorded minimum noise values have a very high potential in terms of exceeding the limit values stated in the related regulations. The results of this study showed that more efficient results can be obtained in terms of time, energy, and cost by the way of short-term (momentary) measurements, compared to the long-term (time-weighted) noise measurements.

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INTRODUCTION

In connection with the ever-growing population and developing technology, one of the most important problems encountered in urban areas is that people are stuck in indoor spaces and cannot spend enough time in open areas. This situation makes the need for open spaces (Arı and Güngör, 2019) feel much stronger day by day. On the other hand, various problems such as low population zone (Arısoy, 2020), traffic congestion, air, environmental, and noise pollution are encountered in open spaces. In theory, although people should be at the top of the usage right ranking of open spaces, in many areas people do not feel comfortable due to the reasons mentioned above. Urban open spaces have significant roles in terms of the physical activity of urban residents (Qasim and Güngör, 2019). Besides, the most commonly

used spaces for walking which is one of the most performed physical activity types in urban areas are the sidewalks. For this reason, providing comfort conditions on the sidewalks can be seen as an opportunity to encourage people to walk. In this age where lack of physical activity and obesity stands out as important problems, encouraging pedestrians to walk is important to contribute to the solution of the mentioned problems. Thus, many advantages can be obtained not only by mobilizing people but also by reducing the use of motor vehicles. There are various parameters to ensure pedestrian comfort conditions on the sidewalks. After exposure to exhaust gas or dust and the safety of pedestrians (against traffic accidents), probably the most important comfort parameter is the noise. For this reason, it is very important to fulfill the acoustic comfort conditions after taking precautions regarding the

mentioned parameters, in order for pedestrians to travel comfortably. What is meant by acoustic comfort conditions is the creation of a soundscape that will not disturb people. Noise pollution is seen as one of the most important problems causing disturbance to people in densely populated urban areas. There are many definitions of noise according to various sources are given in Table 1.

Noise has various physical and psychological negative effects on human health at different levels (Table 2). Noise pollution is reported as the third most important environmental pollution in metropolitan areas by the World Health Organization (WHO, 2011). It has been stated in various studies that a significant part of the areas affected by noise are located along with main transport links such as highways and railways (Forman, 2000; Barber *et al.*, 2009; Halfwerk *et al.*, 2011). In a study dealing with environmental noise, environmental problems of Messina city of Italy were analyzed and it was determined that traffic noise constitutes a major problem in this context (Piccolo *et al.*, 2005). Tobias *et al.* (2015) in a study conducted in Madrid, Spain, discussed in depth the relationship between environmental noise and health; investigated the negative effects of traffic noise on human health. They stated that besides air pollution, traffic noise is also an important environmental factor that has a significant impact on human health. Therefore, road traffic can be shown as the most important source of noise in city centers.

The increase in the number of highways and ring roads and the passing of these roads through residential areas cause traffic noise. This traffic-induced noise causes negative effects on people in nearby settlements. The data obtained as a result of the literature review highlights the importance of the subject. According to the Web of Science database, the number of studies conducted between the years 1997-2020 with the term "traffic noise" in their title or keywords is 1892. As a result of the literature review, it is seen that the measurement of the equivalent noise level is an intensely performed application in the studies related to noise pollution issues (Ugnenko *et al.*, 2019; Chebil *et al.*, 2019; Sahu *et al.*, 2020;). This is a measurement method that requires high energy and cost in addition to a long time. Because keeping the measurement process long in this time-weighted calculation method increases the accuracy of the results. The point that distinguishes this study from similar studies stands out here. Because, this study aims to seek an answer to the question of "Can accurate results be obtained by using an alternative method which is more efficient in terms of time, energy, and cost, in noise measurement studies?". Since the long-term data records are needed for currently used measurement methods, the use of this alternative method is very important in terms of obtaining results faster without compromising the accuracy.

Table 1. Noise definitions according to various sources.

Author	Noise definition
Kurra (1982)	Types of unpleasant voices that contradict the person's action and interest.
NCR (1986)	It is an audio spectrum with an arbitrary structure and is defined as unwanted sound.
Çalışkan (1990)	Unwanted voices that don't make sense to the listener.
Hasgür (1998)	It is an important type of environmental pollution that negatively affects people's hearing health and perception, can disrupt their physiological and psychological balances, reduce work performance, destroy the emptiness and calmness of the environment and change its quality.
Devren (1999)	The sound that disrupts the human relations with other people and the environment or causes unnecessary stress on the person with the acoustic energy that arises and causes real physiological destruction.
Aktaş (2002)	It is a kind of technology waste that causes environmental pollution in a wide sense by disrupting the natural feature of the environment and is undesirable for human health and comfort.
Alkan <i>et al.</i> (2003)	Sound irregularity that has no clear structure and can affect the person physically and psychologically with the elements it contains.
Mavruk (2005)	Unwanted and random sound waves that affect our sense organs and nervous system.

Table 2. Negative effects of different noise levels (Adapted from WHO, 1999).

Noise level	Effect
140 dBA	Mechanical damage to the ear can occur in adults
120 dBA	Mechanical damage to the ear may occur in children
80 dBA	Increased risk for noise-induced hearing impairment Increased aggressive behavior
70 dBA	May cause minor hearing impairment with prolonged exposure
65-70 dBA	Cardiovascular effects may occur with prolonged exposure
55 dBA	Likely to bother most people
45 dBA	Possibility of waking up due to noise

In urban areas where long-term planning criteria are not taken into account, the continuous increase in the population and the number of buildings brings serious problems. Therefore, it becomes impossible to make moves to improve the existing conditions in these areas. Since it is more difficult and costly to correct the situation in existing areas, the issue should be addressed in all aspects during the planning phase. Lessons should be learned from the studies carried out in the areas where these difficulties are experienced, and the measures related to the areas to be created in the future should be evaluated, and these researches should be used as a resource in the plan decisions. The sub-aim of this study is to analyze the data obtained from noise measurements on a sample study area and to create a resource for the planning and/or design processes of similar areas that are planned to be created in the future.

MATERIALS AND METHODS

Site selection

A section (length of 1,2 km) of the ring road passes through the Yazır Neighbourhood of Selçuklu District of Konya which is the biggest city of Turkey in terms of the surface area was selected as the study area (Figure 1). The main reasons for choosing this ring road with intense vehicle traffic are that the transportation to Selçuk University, which has approximately 100 thousand students, is provided by this road, and Yazır neighborhood is the most populous neighborhood of Selçuklu District. The main reasons for choosing the mentioned section on the ring road are the residential density on the roadside, the urban parks on both sides, and the tram line located parallel to the road. The study area includes a 3-lane divided road, as well as on the eastern side, it consists of a sidewalk, green belt, tramway, green belt, side road, and residences, respectively (Figure 2).

Methodology

Noise measurements were made on the sidewalk adjacent to the road at 6 different points on the section of the road selected as the study area. The minimum (Lmin) and maximum noise levels (Lmax) values were noted. Considerations in the selection of

the reference points are; -areas densely used by pedestrians (such as areas with pedestrian crossings) should be preferred and -these points should show a homogeneous distribution throughout the area. Dursun *et al.* (2006) made measurements by keeping the sound source and sound measuring device 165 cm above the ground in the study conducted in Konya. In this study, measurements were carried out by complying with the same height. Measurements were made during 14 suitable days (acceptable wind velocity and no precipitation) for noise pollution measurements (Table 3) with a sound level meter.

Noise measurements were made in the morning (07: 30-08: 30), midday (12: 00-13: 00), and afternoon (16: 30-17: 30) for 14 days with Testo 815 model sound level meter by recording the maximum and minimum values. The obtained data were subjected to reliability analysis with IBM SPSS 22.0 Statistics software, unreliable data according to Cronbach's Alpha coefficient were not included in the calculations. Cronbach's alpha coefficient, which is widely used in the literature, is stated as a determining value in reliability analysis. Various studies have used a wide variety of different qualitative descriptors to interpret the calculated alpha values. Nunnally (1978) suggests that this value should be 0.70 or higher for basic research (Panayides, 2013). Taber (2018) discussed these values in more detail in his study (Table 4). Based on these data, the Cronbach's Alpha values determined as a result of the reliability analysis applied to the data sets of the study were evaluated according to the limit value of 0.7 and the measurement values below this number were excluded from the calculations. The current minimum (Lmin) and maximum (Lmax) noise levels in the area were calculated by the arithmetic average of the recorded values of the related category (morning, midday, or afternoon). The suitability of the average minimum level (the lowest level of noise in the area) was evaluated in terms of the limit values specified in the noise regulation (Table 5) and recommendations were developed. The suitability of the average maximum level (the highest level of noise in the area) was evaluated in terms of the negative effects of various noise levels on human health given in Table 2. As a result of the mentioned evaluations, precautions that should be taken were discussed and recommendations were developed.



Figure 1. Location of the study area (Adapted from Google Earth).



Figure 2. Study area and its surroundings.

Table 3. Weather conditions in Selçuklu district on the days of measurements.

Measurement Day	Average Wind Velocity	Mean Temperature (° C)
1	2 m/s	30,6
2	2 m/s	29,4
3	5 m/s	27,0
4	6 m/s	26,8
5	2 m/s	25,4
6	4 m/s	29,5
7	3 m/s	27,3
8	4 m/s	27,6
9	5 m/s	25,5
10	6 m/s	26,1
11	6 m/s	28,7
12	7 m/s	27,4
13	3 m/s	28,5
14	6 m/s	33,7

Table 4. Consideration of various Cronbach's alpha coefficients.

Cronbach's Alpha	Consideration	Cronbach's Alpha	Consideration
(0,93-0,94)	Excellent	(0,67-0,87)	Reasonable
(0,91-0,93)	Strong	(0,64-0,85)	Enough
(0,84-0,90)	Reliable	(0,61-0,65)	Middle
(0,81)	Sturdy	(0,58-0,97)	Satisfying
(0,76-0,95)	Quite High	(0,45-0,98)	Acceptable
(0,73-0,95)	High	(0,45-0,96)	Enough
(0,71-0,91)	Good	(0,4-0,55)	Not Satisfactory
(0,70-0,77)	Relatively High	(0,11)	Low
(0,68)	A Little Low		

Table 5. Highway environmental noise limit values (AMREN, 2010).

Areas	Renovated roads			Existing roads		
	L _{day} (dBA)	L _{evening} (dBA)	L _{night} (dBA)	L _{day} (dBA)	L _{evening} (dBA)	L _{night} (dBA)
Areas that are sensitive to noise such as education, culture and health areas and summer and camping areas	60	55	50	65	60	55
Areas where commercial buildings and noise-sensitive uses are together, areas with more residences	63	58	53	68	63	58
Areas where commercial buildings and noise-sensitive uses are together, areas with workplaces	65	60	55	70	65	60
Industrial areas	67	62	57	72	67	62

Table 6. Minimum noise measurement (L_{min}) values.

Point Day	R1			R2			R3			R4			R5			R6			
	Mor.	Mid.	Aft.	Mor.	Mid.	Aft.	Mor.	Mid.	Aft.	Mor.	Mid.	Aft.	Mor.	Mid.	Aft.	Mor.	Mid.	Aft.	
1	58,0	62,7	53,5	61,3	53,5	56,7	59,5	60,7	63,0	61,2	60,2	57,8	59,3	57,4	57,2	58,2	57,1	54,2	
2	63,3	58,5	60,0	64,1	57,6	55,3	62,3	60,3	56,9	61,2	56,8	59,5	61,2	56,7	55,7	64,2	53,6	50,9	
3	62,4	63,1	59,2	65,2	57,1	59,2	62,7	60,2	57,0	64,0	65,1	64,8	63,0	63,3	60,6	58,1	56,0	59,6	
4	61,2	58,2	57,4	64,2	60,1	62,0	59,8	62,1	62,3	60,1	62,5	64,7	61,5	61,3	56,7	62,6	57,9	54,6	
5	59,2	63,1	58,7	60,0	61,2	59,6	57,5	59,5	60,0	61,1	60,5	59,9	60,2	62,4	61,2	61,3	58,9	60,6	
6	57,6	57,9	65,1	59,0	64,6	62,3	58,7	60,2	66,2	56,8	58,7	59,8	59,1	59,8	58,9	60,2	59,8	61,2	
7	56,9	60,1	61,1	56,5	61,3	64,6	57,9	63,1	59,7	59,2	59,6	63,6	60,1	60,5	60,1	59,6	61,6	58,6	
8	59,1	61,9	56,5	61,7	54,5	59,7	62,5	59,9	63,6	60,6	61,5	60,8	61,3	58,5	57,6	59,2	58,1	55,4	
9	61,5	59,6	61,1	62,2	57,9	55,8	62,9	61,4	58,6	60,1	58,8	59,9	61,7	59,4	57,6	59,2	55,6	54,7	
10	61,5	59,3	60,5	65,6	62,1	58,6	65,1	63,6	61,1	62,1	60,2	59,8	61,6	61,6	57,5	59,9	60,0	61,9	
11	59,2	59,4	61,4	61,5	63,2	57,0	56,8	61,6	61,4	60,8	60,5	59,7	59,5	62,6	63,1	63,5	59,9	59,6	
12	64,1	61,3	60,6	62,1	62,4	58,9	58,9	62,6	61,1	62,2	59,5	59,6	59,6	60,1	62,4	62,9	62,8	57,8	
13	58,5	56,8	61,2	59,2	59,1	58,9	59,7	59,9	64,3	57,6	61,6	61,8	60,3	57,9	62,2	60,3	62,3	63,5	
14	56,5	61,6	63,6	56,9	63,8	61,8	58,1	59,7	63,9	62,3	62,4	59,2	58,8	61,8	61,8	59,9	63,5	59,9	
Avg.	59,9	60,3	60,0	61,4	59,9	59,3	60,2	61,1	61,4	60,7	60,6	60,8	60,5	60,2	59,5	60,7	59,1	58,0	
Point Avg.		60,1			60,2			60,9			60,7			60,1			59,3		
Gen. Avg.																			60,2

RESULTS AND DISCUSSION

Minimum noise level averages

In the current situation, the minimum noise values noted at reference points as a result of the measurements are given in Table 6. Besides, the key codes used in the tables and figures in the following sections of the study are given below:

- R1: 1st reference point
- R2: 2nd reference point
- R3: 3rd reference point
- R4: 4th reference point
- R5: 5th reference point
- R6: 6th reference point
- Mor.: Morning measurement value
- Mid.: Midday measurement value
- Aft.: Afternoon measurement value
- Avg.: Average value
- Point Avg.: Average value at the related reference point
- Gen. Avg.: Average value of all reference points

As a result of the examination of the data obtained from all 14-day morning, midday, and evening measurements; It is seen that the lowest noise levels are 56.5 dBA at R1 and R2 points for morning measurements, 53.5 dBA at R2 point for midday measurements, and 50.9 dBA at R6 point for afternoon measurements. Considering the averages of morning, midday, and evening minimum noise levels at all reference points, it was found

that the lowest average noise level for morning measurements was 59.9 dBA at R1. It was observed that the average minimum noise level for the midday measurements was 59.1 dBA at the R6 point and 58.0 dBA for the afternoon measurements at the R6 point again. Besides, as a result of considering the minimum noise level measurements in the context of general averages; the lowest noise level was determined as 59.3 dBA at the R6 point, and the average of all the minimum noise levels in the area was 60.2 dBA.

Maximum noise level averages

In the current situation, maximum noise values noted at reference points as a result of measurements in the study area are given in Table 7. As a result of examining all morning, midday, and evening measurements of 14 days with the obtained data: the highest noise levels are 93.1 dBA at R3 point for morning measurements, 94.1 dBA at R1, and R2 points for midday measurements, and 96.3 dBA for afternoon measurements at R6. For all reference points, the averages of the morning, midday, and evening maximum noise levels were considered. According to these results, it was determined that the highest average noise level for morning measurements was 88.1 dBA at the R4 point. It was observed that the highest average noise level for midday measurements was 88.6 dBA at R3 point and 88.8 dBA at R6 point for afternoon measurements. As a result of the examination of the maximum noise level measurements in terms of general averages; The highest noise level was determined at R6 point as 88.0 dBA and the average of all maximum noise levels in the area was 87.1 dBA.

Table 7. Maximum noise measurement (L_{max}) values.

Point	R1			R2			R3			R4			R5			R6		
	Mor	Mid	Aft	Mor	Mid	Aft	Mor	Mid	Aft	Mor	Mid	Aft	Mor	Mid	Aft	Mor	Mid	Aft
1	87,2	94,1	86,6	88,4	94,1	84,8	83,6	91,7	84,5	91,3	85,0	85,3	89,3	80,7	86,2	86,5	92,1	85,2
2	87,2	79,8	84,4	85,9	92,3	84,7	83,9	80,9	84,5	86,1	82,3	92,2	86,1	84,2	79,7	86,9	90,9	96,3
3	82,9	87,8	88,0	85,4	93,6	82,2	91,2	85,4	87,6	86,2	91,2	86,5	85,4	89,8	84,3	88,3	82,7	88,6
4	88,4	85,7	83,5	85,2	85,8	84,3	86,7	93,0	86,0	89,2	92,6	85,7	88,4	84,3	80,3	87,2	82,0	87,3
5	89,6	86,8	87,6	85,2	83,1	82,5	88,1	91,4	85,6	91,2	84,6	89,6	88,2	82,1	91,6	83,6	88,6	90,1
6	89,4	89,3	89,3	84,6	85,6	87,1	86,2	86,5	83,7	87,6	82,6	84,0	89,6	84,6	88,8	91,7	84,6	91,3
7	79,8	88,6	85,6	81,2	89,7	88,7	84,1	87,5	89,4	83,6	88,9	87,6	81,6	90,6	82,9	82,3	90,1	90,0
8	88,3	90,1	88,6	89,4	89,2	84,3	84,6	90,7	82,6	90,2	86,1	87,3	88,3	82,2	84,6	87,6	91,9	86,8
9	88,2	81,9	85,6	85,8	90,6	85,9	84,6	88,7	82,5	85,2	86,5	93,3	86,5	84,8	81,7	89,5	91,8	92,4
10	84,6	88,6	90,0	85,4	90,6	84,8	93,1	89,7	85,7	88,2	93,2	89,2	89,6	89,4	82,5	86,4	85,9	86,5
11	90,5	86,8	86,6	88,1	82,9	88,5	82,6	89,9	87,1	88,6	94,0	82,6	90,5	84,7	91,6	84,6	88,0	92,3
12	90,8	89,2	85,6	89,5	88,6	83,7	87,2	90,1	82,9	92,3	90,8	90,8	87,4	85,4	93,1	89,7	91,2	87,8
13	84,4	82,3	90,9	85,6	89,8	86,4	81,2	91,5	91,7	82,8	81,7	88,2	88,8	92,4	90,9	90,1	89,9	85,4
14	83,6	88,9	88,2	80,8	83,4	82,6	82,9	82,8	89,8	90,8	86,9	81,9	84,7	91,7	84,3	81,8	88,3	83,7
Avg.	86,8	87,1	87,2	85,8	88,5	85,0	85,7	88,6	86,0	88,1	87,6	87,4	87,5	86,2	85,9	86,9	88,4	88,8
Point Avg.	87,0			86,4			86,7			87,7			86,5			88,0		
Gen. Avg.	87,1																	

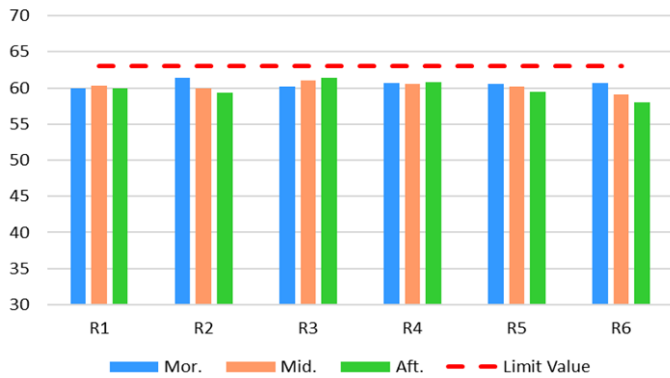


Figure 3. Average minimum noise levels at the reference points.

Reliability analysis and interpretation of the measurement values Based on the data obtained in a study, the reliability of the data sets should be tested in order to obtain high accuracy outputs. In this context, reliability analysis was applied to the measurement values recorded in this study with IBM SPSS 22.0 Statistics software. Another reason for the need for reliability analysis in this study is that measurements were made in which limit values were recorded at a certain time interval. In addition, it was aimed to determine the success level in the results obtained by short-term measurements with the analyzes. Since a sound level meter that can calculate the noise levels on a time-weighted basis is not used in the study, it is important to apply reliability analysis to the data and exclude unreliable values from the calculation in order to reach consistent results. The values recorded in the midday measurements for the minimum values and the midday and afternoon measurements for the maximum values were excluded from the calculations due to the lower Cronbach's alpha coefficient (<0.7) (Table 8). As a result of calculations made with reliable measurement values, average minimum values were determined as 60.2 dBA; The arithmetic average of all the maximum values (given in Table 7) 87.1 dBA, decreased to 86.8 dBA. Paiva *et al.* (2019) stated that the noise levels at all the measured points were found to exceed the critical level for the study area, i.e., 55 dBA and the mean L_{eq} in the area non-exposed to traffic noise was 64 dBA. When this level is accepted as the minimum value, it is possible to say that the minimum noise level of 60.2 dBA determined in this study shows similar results to the study in question. The reason for the 3,8 dBA difference at noise levels can be explained as the different traffic densities of the study areas. According to another study (Gökdağ, 2012) results, data of the 750 measured events showed that approximately 5% of the vehicles exceeded 70 dBA and less than 2% exceeded 80 dBA maximum noise level. The maximum noise level of 86.8 dBA detected in this study is also above the specified value.

Reliability analysis results showed that noise measurement studies in which limit values (minimum and maximum) are recorded have some disadvantages. The reason why the reliability level of the values recorded especially during the periods when the maximum values are measured is not appropriate is that the upper limit value depends on the very short (momentary) increases recorded in the moments such as the passage of heavy vehicles or the braking (lining noise). However,

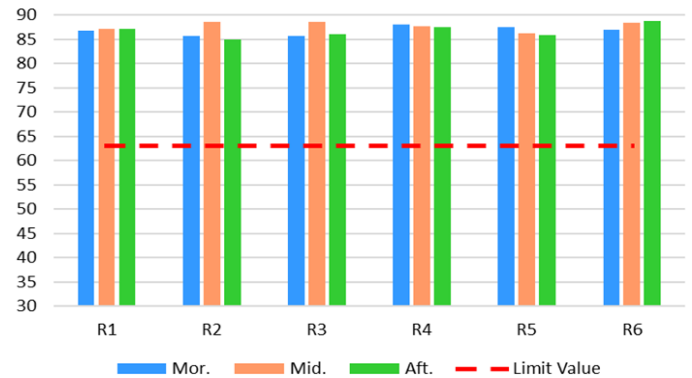


Figure 4. Average maximum noise levels at the reference points.

it is seen that this disadvantage can be overcome by reliability analysis. Although there are disadvantages of measuring the limit values, it is seen that the results can be obtained faster compared to time-weighted and longer-term measurements. The point to be considered in these measurements is that, in cases where the data are not reliable, the measurements should be repeated in order to achieve consistent results. As a result of the examination of the limit values determined according to the area types in the Assessment and Management Regulations of Environmental Noise, it was determined that the study area is within the scope of the areas with more residences. Considering the calculations made with reliable measurement values, it is seen that the minimum noise level of 60.2 dBA in the working area is very close to the 63 dBA limit value stated in the regulation (Figure 3). This indicates that even the short-term values recorded in the quietest moments in the area have a very high potential to exceed the limit value. This lower limit (minimum) noise level recorded at certain moments is not likely to remain at the same level in the area. Besides, although the calculated average minimum noise level is below the limit of 63 dBA, as can be seen from the red cells in Table 6, approximately 14% of the values are above this value and the 34 recorded values in the area were above the limit level. Therefore, it is possible to state that the equivalent noise level to be determined by the time-weighted noise measurement method will be above the limit value. Based on this data, it can be concluded that measures should be taken for noise control in the study area.

Since it is a predictable situation that the calculated maximum level (86.8 dBA) will be much higher than the limit value in the regulation (Figure 4), it would be a more correct approach to evaluate this value in terms of the negative effects of different noise levels on human health. According to the values given in Table 2, it is seen that the noise level above 80 dBA increases the risk of hearing impairment and the possibility of exhibiting aggressive behavior. Also, as can be seen from the red cells in Table 7, approximately only 0,1% of the values are under the value of 80 dBA and the 3 recorded values in the area were under this level. Therefore, this situation, which can affect both the individual health conditions of people and the social harmony level in connection with aggressive behavior, has an importance that should be carefully considered. Although the maximum noise values are recorded instantaneously, precautions should be taken to reduce these values since human health is at stake.

Table 8. Cronbach alpha values of the measurement data sets.

Measurement Type and Time	Cronbach's alpha
Minimum/Mor.	0,795
Minimum/Mid.	0,571
Minimum/Aft.	0,704
Maximum/Mor.	0,715
Maximum/Mid.	Negative*
Maximum/Aft.	Negative*

(*Negative Value: The value is negative due to a negative average covariance among items. This violates reliability model assumptions.)

Conclusion

Although the method of recording limit values in a certain time period seems to be disadvantageous in terms of reliability compared to time-weighted equivalent noise level measurements, the results of this study showed that effective results can be achieved with these measurements by saving time, energy, and cost. In the study, it was possible to predict that the equivalent noise level in the area is above the limit values without long-term and time-weighted measurements. For this reason, especially in terms of saving time, in the studies to be carried out in order to determine the conformity of the noise level in terms of limit value, it will be beneficial to choose the method used in this study (determination of the minimum values by short-term measurements). It is understood from the findings of the study that there is a traffic-based noise problem in the study area. The proximity of the calculated 60.2 dBA minimum average noise level to the 63 dBA value specified in the regulation and the fact that approximately 14% of the recorded minimum values are above the limit level also indicate noise pollution. In addition, the calculated maximum average noise level of 86.8 dBA is a noise level that threatens human health. Therefore, measures should be taken to reduce the noise level in the study area. The findings of the study also showed that the noise level in similar areas can be easily detected without long-term measurements. The point to be considered in calculations is the reliability of the data. As in this study, the data should be analyzed for reliability and unreliable data should be excluded from the calculation according to the Cronbach alpha coefficient. With the method used in the study, the results were obtained without the need for hours of noise measurements during weeks or months. By means of the data obtained, it is possible to take measures to ensure acoustic comfort conditions in areas with noise pollution problems. By providing acoustic comfort conditions on the sidewalks that are generally closer to the highways than residences and other living areas, the negative effects of traffic noise will be reduced not only in sidewalks but also in all other areas. Therefore, fulfilling the acoustic comfort conditions on the sidewalks generally adjacent to the highways (as the source of vehicle noise) is also very important in terms of increasing the quality of life in the near environment. For the roads (similar to the study area) planned to be created in the vicinity of settlements, the most accurate location to pass the road should be defined by preliminary studies to determine the noise level. If there are not

many options regarding location, measures to be taken against noise should be considered during the planning phase. Fixing an issue that will be overlooked in the planning phase will be very difficult and costly after the road construction is completed and the area is used. Sidewalk design adjacent to the road should not be preferred, pedestrian and vehicle traffic should be separated with the buffer zone. Structural and vegetational materials used in noise control should be placed in these zones. Other advantages of these areas can be listed as acting as a barrier against accidents, exhaust gas and dust, and providing shade for pedestrians with trees. The disadvantage is that they also create a barrier for crossings to the other side of the road. Therefore, openings should be leftover at certain distances to allow crossing. As in all types of design studies, ensuring the participation of users in the planning/design process of the highways and sidewalks is very important in terms of achieving successful results. In summary, the opinions of the users, who are the real owners of the sidewalks, about the acoustic comfort features should be taken before the application phase. Then, the obtained data should be synthesized with the experience and technical knowledge of professionals and shape the final product. At this point, it will be possible to reach successful pedestrian spaces as the final product of this process in terms of the sound environment if the planning and design decisions to be taken to ensure acoustic comfort conditions are determined on the basis of the communication of experts and users.

Conflict of interest

The authors declare there are no conflicts of interest.

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