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REDUCTION OF ENVIRONMENTAL NOISE WITH PANELS

KONYA TECHNICAL UNIVERSITY, FACULTY OF ENGINEERING AND NATURAL SCIENCES

SEDANUR ERTEKİN AKTAŞ

KTUN, Department of Environmental Engineering,

Konya, Turkiye

ADVISOR

PROF. DR. ŞÜKRÜ DURSUN

ABSTRACT

Due to the increasing use of vehicles in city centers, traffic intensity is continuously growing. Within cities, factors such as traffic continuity, road width, location, surface materials, and urban intersection signal systems significantly affect noise levels. Non-compliance with traffic rules—particularly the random stops of minibuses, improper parking, and excessive use of freight vehicles—are major contributors to noise. Neglect of inner city road maintenance also contributes to noise through tire/road friction. Additionally, untrained drivers who frequently brake suddenly and use car horns increase the overall noise level.In this study, a noise barrier panel was designed using end-of-life tires (ELTs) as the core material. A specific area was selected for noise comparison, and data were recorded before and after the panel installation. Potential locations within the city for panel installation were identified. Moreover, noise data from Konya were used to create a noise model map using the SURFER software, helping to visualize both the natural noise distribution and the expected diffraction after panel installation.

Materials and Methods

- A certain amount of sound is reflected from any surface. This reflected sound, while traveling in the air, can cause a phenomenon known as “sound smearing,” which makes understanding and perceiving sound difficult. Therefore, barriers made from acoustic fabric are essential for absorbing noise from any source—especially those over 80–85 dB—before it can reflect. It's also possible to absorb low-frequency and vibration-based noise.The use of such barriers is widespread due to their environmental safety, waterproof nature, light weight, high insulation capability, design variety, applicability to different surfaces, non-toxicity, and inclusion of removable panels for sound insulation between rooms. The primary function of roadside sound barriers is to block the noise emitted by vehicles and prevent disturbance to nearby residents. These barriers are used to reduce road and rail system noise levels to international standard values in residential areas. They are made from materials designed to reduce sound transmission and absorb sound, including sound-absorbing and auxiliary acoustic components. Key design considerations include the distance from the noise source and receiver, barrier height, transmission and absorption values, and shape. In this study, our goal is to reduce noise by 25–45 dBA.

• Study Area

- To evaluate noise originating from highways and its impact on residents living near roads, houses in the affected area were selected for analysis using the following steps. Adana Ring Road was chosen for measurement. Most of the residences in this area are known to be single-family homes. Of the approximately 2200 houses, around 1000 are close enough to the road to be affected by noise. Detailed measurements were taken in specific locations identified through community input regarding areas with the highest perceived noise.

- Key Points for the Barrier

- Durability of the barrier
- Fire resistance
- Maintenance costs
- Ease of installation
- Use of natural materials
- Integration of the barrier with the surrounding environment

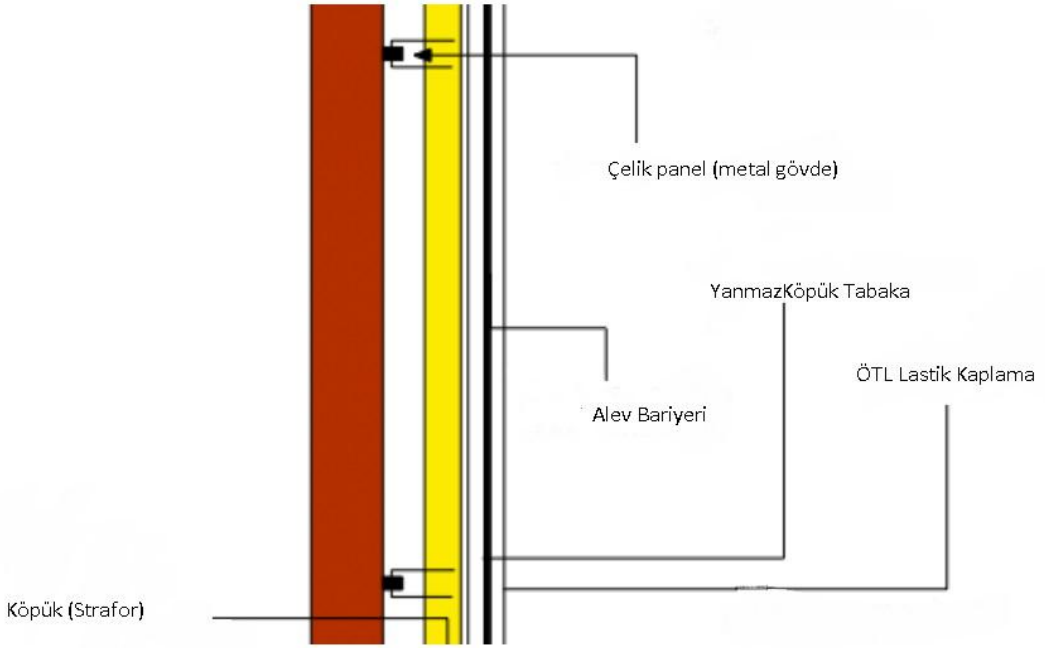
- Structure of the Barrier
- As the porosity increases, the material becomes lighter; as it decreases, it becomes heavier. A high porosity structure helps solve problems related to sound, heat, and acoustics. The goal is to ensure the strength of the barrier by using entirely recycled materials. End-of-life tires will be used as the primary material. The panel will consist of 7 main layers:
- Steel Panel (Structural Frame)
- The panels, due to their material properties, will be high in strength, non-flammable, water- and moisture-resistant, and environmentally friendly. They are not affected by water and are resistant to fire. Steel panels will be used as the load-bearing structure to ensure the panel does not collapse. These steel panels are planned to be sourced from scrap or metal waste materials.
- Styrofoam (Foam)
- EPS (Expanded Polystyrene) Styrofoam is a thermoplastic, closed-cell thermal insulation material produced by expanding and bonding polystyrene beads. It consists of 98% stationary dry air. It provides high thermal insulation with a thermal conductivity group of 040. It is not brittle and is resistant to compression. It has no capillary water permeability, and its thickness does not decrease over time. It is environmentally friendly and does not harm the ozone layer. It continues to provide insulation throughout the life of a building. It is easy to apply and offers an economical system. It is widely used today to prevent sound transmission, making it a suitable material for the panel.

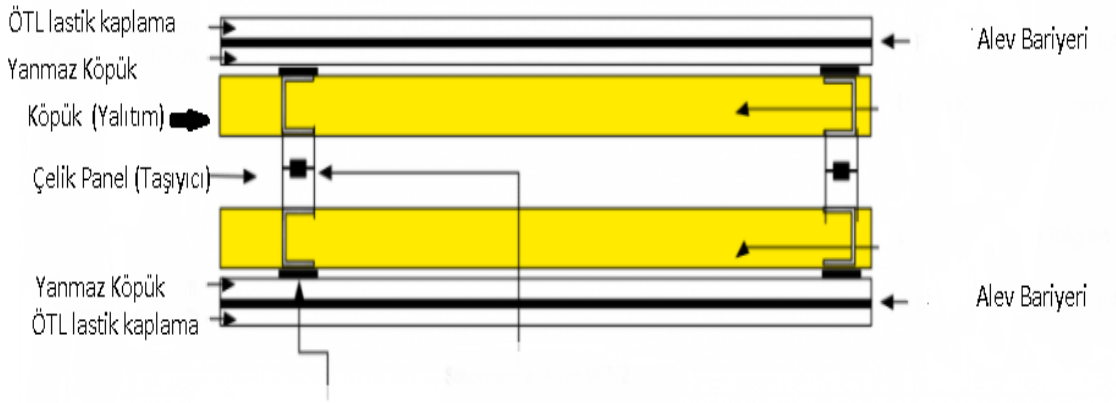
- Improving Fire Resistance
- Oxygen, required for combustion, is present in the air. A lit cigarette, electrical contact, sunlight, stove, or cooker-as well as some chemical reactions and heat generated by friction-can cause combustible materials to reach ignition temperature, resulting in fire. Due to the flammability of materials and fuel in vehicles, and the kinetic energy of fast-moving traffic, the likelihood of fire is not as low as commonly believed. “Fire resistance” refers to structural measures that ensure life and property safety by limiting the harmful effects of fire. Since these panels are placed along roads, they must be both cost-effective and fire-resistant. To achieve this, regular foam is treated with fire-retardant properties using the following chemical mixture: Water Boric Acid Borax Ammonium Sulfate This mixture is sprayed onto the foam. The foam is then left to dry for 7 hours as part of the treatment process.

- End-of-Life Tires (ELT)
- Long-term durability can be achieved by extending the life of ELTs with aromatic amines. It can be ensured that the tires are transformed into a non-flammable form by saturating them with a chemical substance containing borax, thus increasing their durability.
- Rubber floor covering materials have shock absorbing properties and have the feature of providing flexibility, are in the desired color and pattern, have high abrasion resistance, are supported against discoloration, and are flexible enough for outdoor conditions.
- Tile (Square) plate is 40x40 cm wide. These materials are produced by mixing granulated rubbers with polyurethane-based binders and turning them into manufactured materials.
- It prevents fragmentation that may occur as a result of falling and impact thanks to its shock absorbing properties and flexibility. It is long-lasting, easy to clean. It is resistant to weather conditions. It is preferred because it is a recyclable material and has a dry, clean and non-slip surface that does not puddle even after heavy rain.
- Modeling Program (Surfer)
- First of all, in order to draw a data in 3-dimensional form in Surfer, first of all, 3-dimensional data called X, Y, Z is needed (For example, 1st column LATITUDE, 2nd column LONGITUDINALITY, 3rd column ALTITUDE). In addition, in order to prepare contour diagrams and three-dimensional surface maps, first of all, x, y, z coordinates that we get from the field are transferred to A, B, C columns that we will prepare in Microsoft Excel. Then Surfer program is opened.
- Noise map will be created with Surfer program. First, coordinates of points taken from certain locations of the city will be taken on X, Y, Z basis.

Plan View of Panels

- The panels are designed in thin and rectangular forms. It is aimed to easily replace a panel when it is damaged. The purpose of this is to ensure easy maintenance and economy. It is also preferred to provide an aesthetic appearance.





DESIGNED NOISE PANEL

Material Testing

Properties of waste tires used in the study

Speciality	Waste Tyre
Dansity $(Mg/m3)$	1.153 – 1.198
Elastic Modulus (MPa)	1 – 97 – 22.96
Tensile strength (MPa)	28.1
Softening Temperature $(°C)$	175
Components, Carbon block(%)	31
Expander oil (%)	1.9
Zinc oxide (%)	1.9
Stearic acid (%)	1.2
Sulfur (%)	1.1

For each mixture type and curing time determination, 3 (three) samples were prepared and the average of the results was taken (Figure 3). The prepared samples were prepared in the mixture ratios of coarse-grained soil (TZ), TZ+%0.5 AL, TZ+%1 AL and TZ+%2 AL. (Akbulut et al., 2007)

- In a laboratory environment, the panel was tested at different levels of Hz. For the test, the panel was 2 m above the ground and the ambient conditions were 25 C, which is room temperature, and the pressure was 910.8. The panel was given noise (sound) at 125 (Hz), 250 (Hz), 500 (Hz), 1000 (Hz), 2000 (Hz), 4000 (Hz), 8000 (Hz) intensities, respectively. According to this test, the noise level diffraction ratios are shown in Table 1.

Table 4. Results of measurements made in the laboratory.

sampling points	125 (Hz)	250 (Hz)	500 (Hz)	1000 (Hz)	2000 (Hz)	4000 (Hz)	8000 (Hz)
1	76,00	70,50	78,20	77,00	79,70	72,00	78,20
2	70,00	75,00	70,50	75,00	70,00	73,00	70,50
3	80,40	74,00	76,00	75,00	79,30	71,50	76,00
4	77,00	72,00	78,20	5,00	76,00	74,50	72,1
5	75,00	73,00	72,50	75,00	70,00	79,50	77,6
6	78,00	71,50	77,30	76,00	70,5	73,6	76,00
7	77,10	74,50	75,40	71,30	77,00	73	78,20
8	77,00	79,50	77,50	72,50	79	78	72,50
9	75,50	75,00	74,00	72,00	70,1	78,5	77,30
10	76,10	75,00	77,00	77,00	80,1	75	70,5
Mean	76,21	74	75,66	67,58	75,17	74,86	74,89

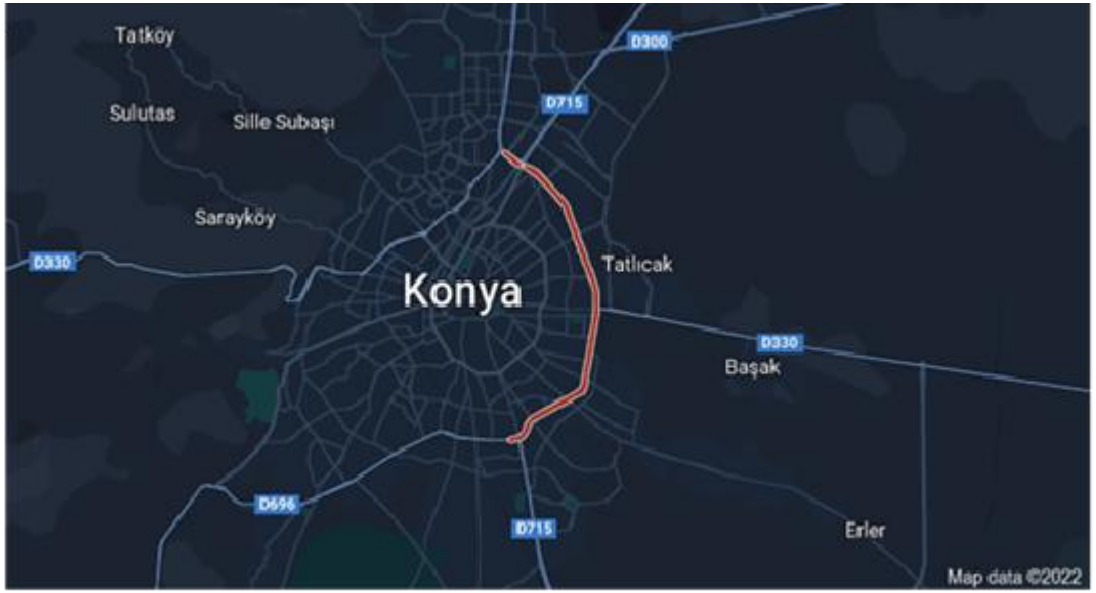


Figure 7. Map view of Adana Ring Road Street 1

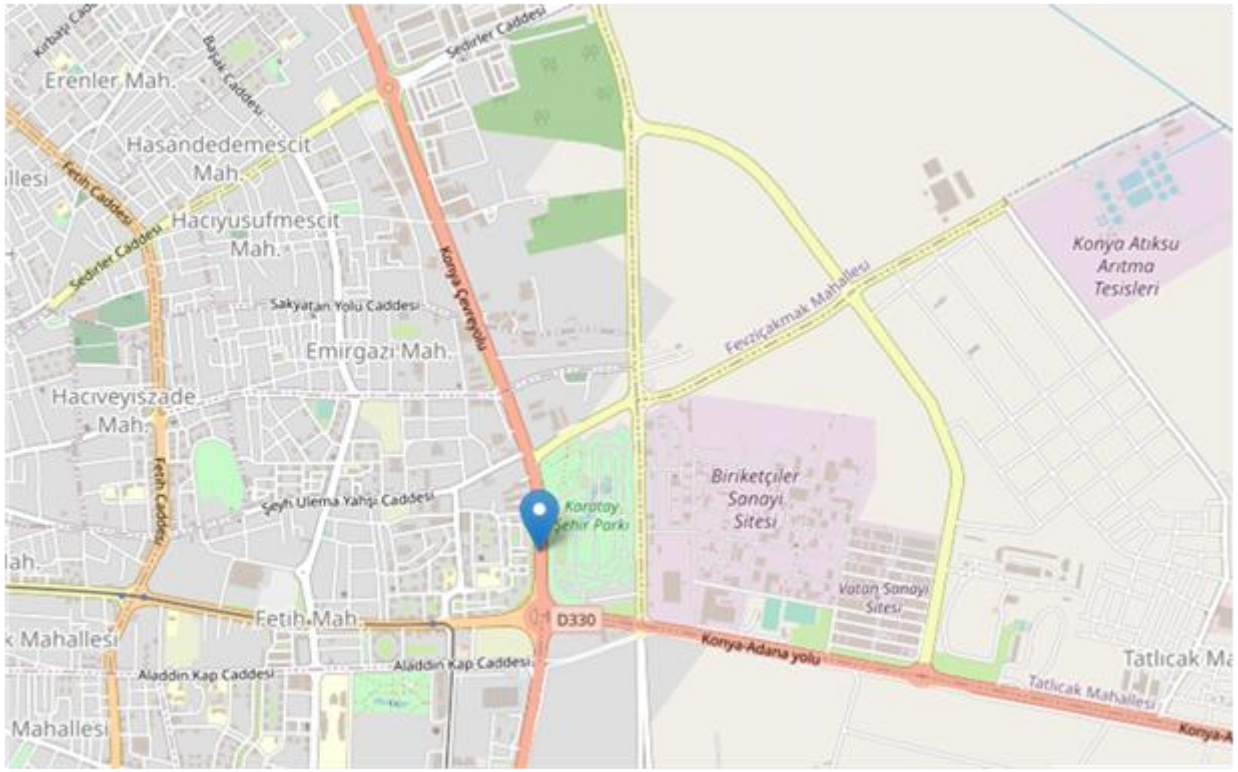


Figure 8. Map view of Adana Ring Road Street 2.

- Determination of the Current Noise Environment
- Due to the continuity and prevalence of noise in residential areas, road noise originating from vehicle traffic on highways is the main source of noise pollution for local people. Mainly due to the increasing population day by day, the increase in the number of vehicles, the widening of highways and the increase in traffic are the main reasons for road noise. According to the noise measurements taken in the area designated as Adana Ring Road street, the noise value varies between 85-90 dB during the passage of loaded vehicles, while the noise varies between 80-86 dB during the passage of cars. In addition, it was observed that the background measurement value when vehicles were not passing was between 70-75 dB. In this area, noise measurements were taken both from the roadside and from the back of the noise panel in 3 periods of 5 minutes, for a total of 15 minutes, and the exposure values and the resulting noise graphs were recorded.

Noise measurement value during the passage of cars

Installation of the Noise Measurement Panel at the roadside

Noise Level Measurements and Evaluations

- The measurement results taken from the points determined in this study are given in the table below. The average of the measured noise levels is also given in the same table.

Table 6. Results of noise measurements made at the roadside (without panels).

Ölçüm Noktaları	1.Periyot	2.Periyot	3.Periyot
1	86,00	80,50	88,20
2	80,00	75,00	80,50
3	104,40	84,00	86,00
4	77,00	82,00	78,20
5	85,00	83,00	82,50
6	88,00	81,50	77,30
7	87,10	74,50	75,40
8	87,00	79,50	87,50
9	85,50	85,00	84,00
10	86,10	85,00	87,00
Ortalama	86,61	81	82,66

Table 7. Roadside (paneled) noise measurement results.

Sampling points	1.Periyot	2.Periyot	3.Periyot
1	66,00	70,50	78,20
2	70,00	75,00	70,50
3	74,40	74,00	76,00
4	77,00	72,00	78,20
5	75,00	63,00	72,50
6	68,00	71,50	77,30
7	77,10	74,50	75,40
8	67,00	79,50	77,50
9	65,50	75,00	74,00
10	66,10	75,00	77,00

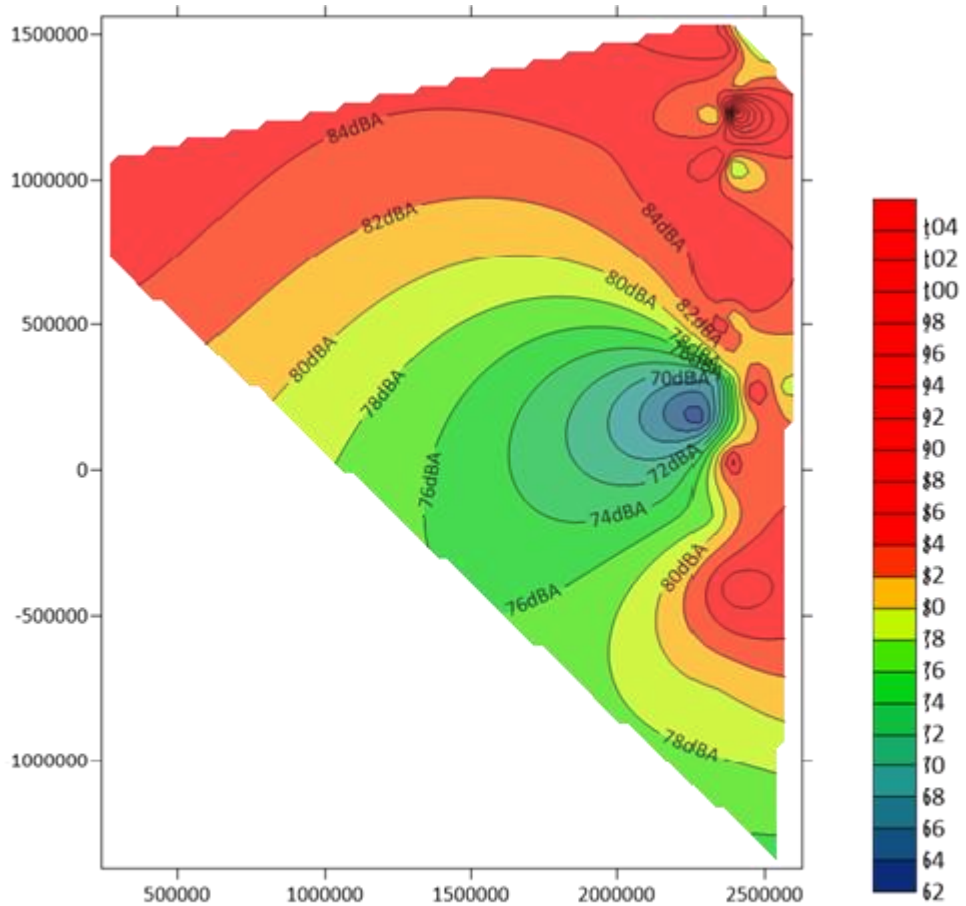


Figure 17. Noise map with measurements taken during daytime (without panel)

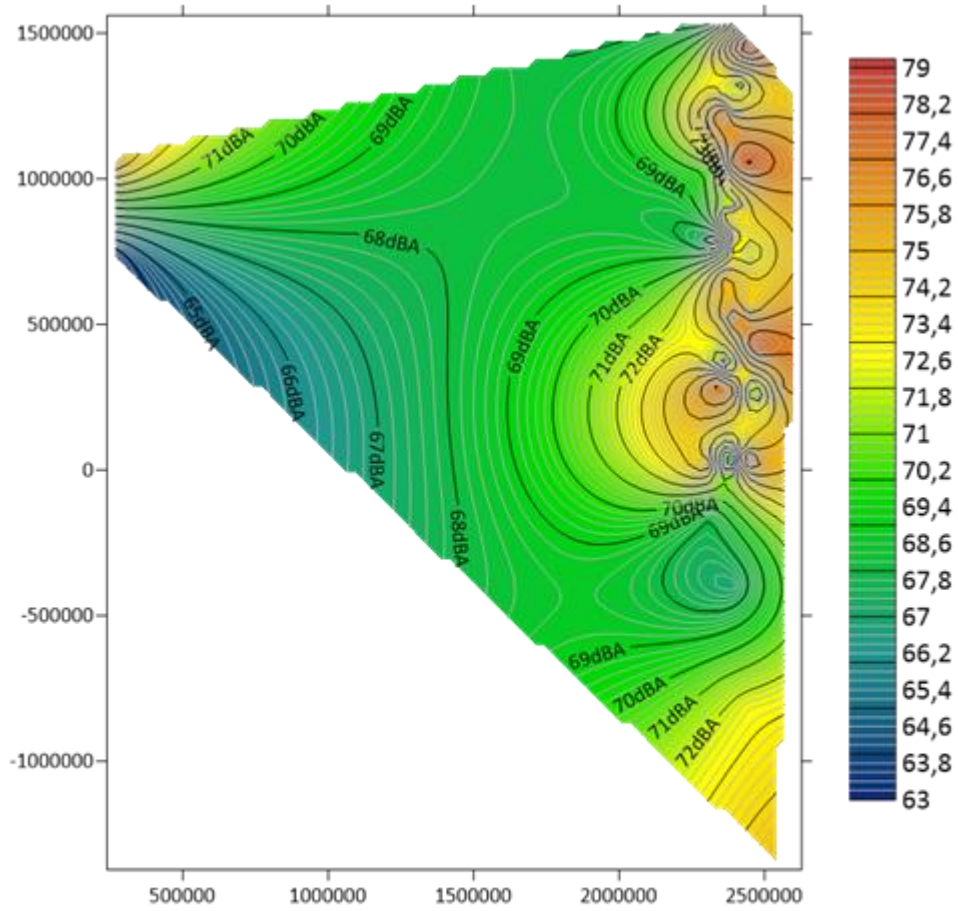


Figure 18. Noise map with measurements taken during daytime (with panel)

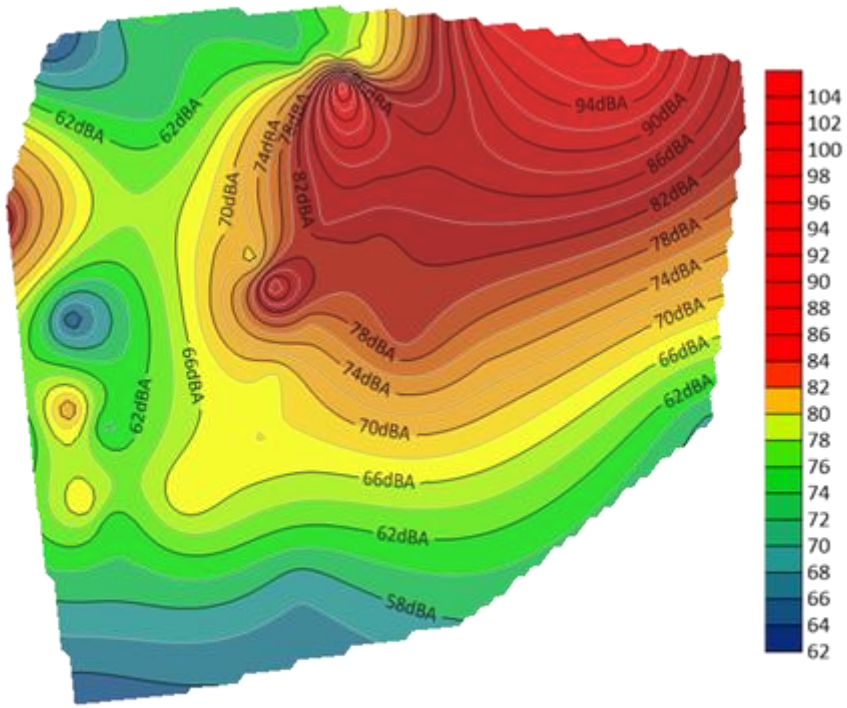


Figure 19. Noise map with measurements taken in the evening (without panel)

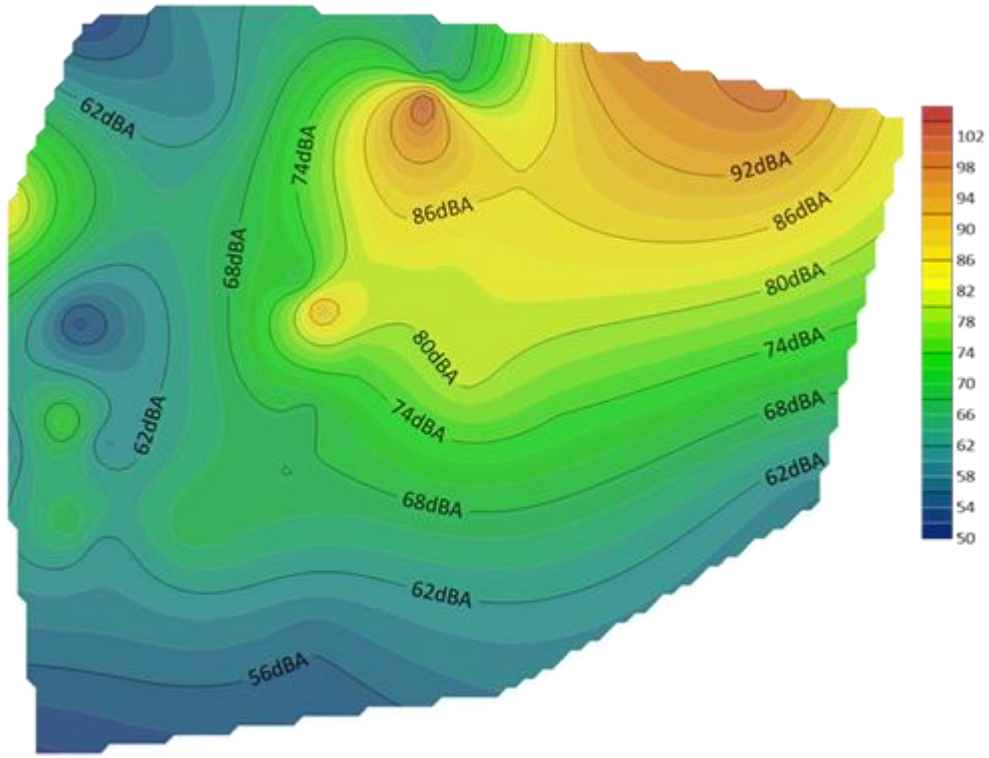


Figure 20. Noise map (with panel) with measurements taken in the evening hours

Conclusion and Discussion

- During the measurements made in the noise area, high noise levels were recorded especially during the passage of loaded vehicles. It was observed that these levels were higher between 08:00 - 09:00 and 17:00-19:00. The reason for this high noise level is due to the use of transportation by the people living in that area for work and school purposes. Again, the high noise level on this road crossing is especially during the passage of vehicles such as trucks and lorries. This road is used for freight transportation to the surrounding cities. When the daytime period was examined, when the impact analysis was made on the noise values of 75 dB(A), it was determined that 2% of the city population in the region was exposed. When the examination was made for the noise value range of 75-83 dB(A), it was determined that 5% of the region's population was affected by noise. It was recorded that the noise was approximately 85 dBA before the panel was installed, while it decreased to around 73 dBA after the noise panel was installed. Again, as can be seen on the map, before the noise panel was placed, the red area was approximately 45% compared to the map, but with the data taken after the panel placement, it was seen that this rate dropped to 12%.

According to the evaluations, it was determined that an area of 8 km2 and approximately 2% of the total city population were affected by noise levels above 75 dB(A) in a 24-hour period. It was calculated that an area of 37 km2 within the study area and approximately 14% of the total city population were affected by noise levels above 80 dB(A). As a result of the calculations, it was determined that 28.6 km2 of land around the highways and approximately 38% of the total city population were exposed to noise levels of 71 dB(A) and above. Noise is harmful to human health. It can cause hearing loss. Studies on the determination, calculation and modeling of noise sources were explained in the previous headings. It was determined in the scientific studies that the most common source of noise pollution was motor vehicles.

Suggestions

- Within the scope of the thesis, it has been determined that noise should not be exposed to noise due to its negative effects such as negatively affecting people's hearing performance and perception in terms of health, disrupting physical and psychological balance, decreasing work performance, disrupting the tranquility and calmness of the environment and therefore changing the quality of the environment. In addition, it has been determined that noise pollution continues to increase with the increasing use of industry and vehicles due to the increasing population. Within the scope of the research, different noise panels have been tested in industrial facilities and successful results have been obtained.
- It has been recorded that while the noise was approximately 85 dBA before the panel was placed, it decreased to around 63 dBA after the noise panel was placed. Again, as can be seen on the map, while the red area was approximately 45% compared to the map before the noise panel was placed, it was seen that this rate decreased to 12% with the data obtained after the panel was placed. Thanks to this decrease rate, it makes a significant difference in terms of the local people being less affected by noise pollution.
- However, although the noise decreased to around 63 dBA after the panel, it was observed that it was close to the daytime limit value. In this area, more comprehensive determinations can be made by taking longer-term data (1 month etc.) with more panels and devices that record more instantaneous noise data. In addition, more pilot areas can be determined in the city and measurements can be taken with panels at more points.

- In order to control and reduce noise in this area; control of silencers installed on some vehicles and attached to exhaust pipes, arrangement of roads to be wider, studies to reduce the use of private vehicles, encouragement of public transportation, mandatory inclusion of sound absorbing materials in zoning regulations, giving more importance to acoustics in architectural areas, preference of insulation materials in buildings, emphasis on afforestation activities in urban areas and especially afforestation of roadsides are the precautions that can be taken to prevent noise that causes environmental pollution. In order for the public to be affected by noise at a minimum level, it is recommended to use noise panels (barriers) for highways inside and outside the city. The base material of the panels can be formed by end-of-life tires (ÖTL). In this way, an environmentally friendly approach can be demonstrated. In addition, materials for panels can be produced from many recyclable materials, sound diffraction can be tested and panels can be placed according to the noise maps determined in the city. We hope that it will be an example for projects aimed at a new environment by providing support within the scope of zero waste.

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