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# Investigating Noise Pollution Levels in Tripoli City

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## Abstract

Noise pollution is known to have significant implications for public health and overall well-being. In this study, noise pollution levels were analyzed in selected areas of Tripoli, Libya. The investigation focused on seven distinct locations: Martyr's square, Algeria square, University hospital, Al-Jalaa hospital, Al-Dehmani park, Al-Tholathaa park, and the Second Ring Road. Noise levels were assessed during working days and weekends across three different time periods: morning, afternoon, and evening. The primary objective was to conduct a thorough evaluation and analysis of environmental noise pollution in Tripoli. This was achieved by employing sound level measurements throughout the seven areas. Additionally, dB mapping has been utilized to visualize the spatial distribution and intensity of noise at the surveyed locations. The initial observations of the study revealed fluctuations in noise levels across the surveyed locations. These variations suggest potential correlations with temporal factors and human activities. This study provides valuable insights into the noise levels in Tripoli, thus creating a comprehensive database for further studies. The identification of elevated noise levels in specific areas and during particular periods underscores the necessity for targeted environmental control measures, such as the implementation of noise barriers. Therefore, a thorough investigation regarding noise barriers should be conducted. In general, the outcome of this study revealed that noise barriers appear to be necessary alongside the Second Ring Road, along with the planting of tall and dense trees, which play an important role in reducing noise in the surrounding areas.

**Keywords:** Noise pollution; environmental noise; noise mapping, Tripoli city.

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# دراسة مستويات التلوث الضوضائي في مدينة طرابلس

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قسم الهندسة الميكانيكية والصناعية

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**الملخص**

من المعروف أن التلوث الضوضائي له آثار بعيدة المدى على الصحة والرفاهية العامة. قامت هذه الدراسة بتحليل مستويات التلوث الضوضائي في مناطق مختارة من مدينة طرابلس، ليبيا. ركزت الدراسة على سبعة مواقع مختلفة (ميدان الشهداء، ميدان الجزائر، الطبي الجامعي، مستشفى الجلاء، سوق الثلاثاء، ميدان الدهماني والطريق الدائري الثاني)، حيث تم تقييم مستويات الضوضاء خلال أيام العمل وعطلات نهاية الأسبوع عبر ثلاث فترات زمنية مختلفة: الصباح، بعد الظهر، والمساء. تهدف الدراسة الى إجراء تقييم وتحليل شامل للتلوث الضوضائي البيئي في مدينة طرابلس. تم تحقيق ذلك من خلال قياسات مستوى الصوت في المناطق السبعة المذكورة آنفا. بالإضافة إلى ذلك، استخدمت خرائط الديسيبل لتصور التوزيع المكاني وشدة الضوضاء في المواقع التي تم مسحها والتي سجلت أعلى مستويات للضوضاء. كشفت الدراسة عن تقلبات في مستويات الضوضاء عبر المواقع التي تم مسحها. هذه التغيرات أشارت إلى احتمالية وجود ارتباطات مع العوامل الزمنية والأنشطة البشرية. تساهم هذه الدراسة في تقديم رؤى قيمة حول مستويات الضوضاء في مدينة طرابلس، وبالتالي إنشاء قاعدة بيانات شاملة لمزيد من الدراسات. يجدر الذكر بأن مستويات الضوضاء المرتفعة، والتي لوحظت في مناطق معينة وخلال فترات زمنية محددة، تحتاج إلى اتخاذ تدابير تحكم مختلفة، مثل انشاء حواجز على الطرق الرئيسية من أجل التقليل من مستويات الضوضاء. من أجل ذلك، وجب إجراء تحقيق شامل بشأن نوع وأطوال هذه الحواجز. بشكل عام، استنتجت الدراسة أن حواجز الضوضاء ضرورة ملحة لاستخدامها في الطريق الدائري الثاني، بالإضافة الى زراعة أشجار طويلة وكثيفة على جوانب الطريق، والتي سوف تلعب دورًا مهمًا في تقليل الضوضاء في المناطق السكنية المحيطة.

**الكلمات المفتاحية:** التلوث الضوضائي، الضوضاء البيئية، خرائط الضوضاء، مدينة طرابلس.

## Introduction

Assessing and mapping acoustic noise in urban environments play a pivotal role in comprehending and alleviating its repercussions. Nikolaeva and Krasnopol'skij [1] underscores the significance of cartographic exploration in this regard, emphasizing the necessity for precise noise assessment and mapping to accurately depict noise levels. Hadzi-Nikolova et al. [2] accentuates the value of noise maps in guiding decision-making and urban planning, especially in smaller metropolitan regions. In a study by Liu et al. [3], the strategic nature of noise mapping is highlighted as a tool to visualize both long-

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term trends and real-time noise pollution across urban centers, industrial zones, and other pertinent areas. The research delves into the technical challenges and design considerations integral to noise mapping, leveraging mobile crowdsensing and acoustic sensor networks. Moreover, it sheds light on potential avenues for further exploration, notably in the domain of noise prediction aided by artificial intelligence and concurrent noise detection.

The creation and analysis of noise maps was discussed by Probst and Huber [4], where the calculation of sound power levels is conducted and noise maps are used to rank noise problems and inform noise abatement strategies. More advanced concept of 3D mapping was introduced by Stoter et al. [5], which provides an enhanced information particularly in urban areas. Herrera and Cabrera-Barona [6] and Kou and Chai [7] both highlighted the negative effects of noise on self-perceived health and satisfaction with life, as well as the potential for annoyance and stress. All these studies sheds light on the importance of addressing noise pollution for better life quality and human well-being. Various strategies and methodologies are employed to evaluate noise levels in urban settings. Nemec et al. [8] emphasized the significance of integrating measurement-driven approaches with modeling methodologies. Diverse noise mapping techniques and tools have been devised to tackle the issue of noise pollution in cities, encompassing GIS-based mapping, statistical modeling, and predictive algorithms. The imperative nature of noise mapping and assessment is underscored as it assumes a pivotal role in urban planning, policy formulation, and decision-making processes.

As of the time of composing this paper, no noise assessment information has been uncovered for Tripoli city. There is a strong recommendation for additional research in the major cities of Libya to establish databases that facilitate comprehension of noise levels, potentially serving as a reference point for urban planners and policymakers. Thus, the objective of this paper is to evaluate and chart noise pollution levels in key zones within Tripoli city. This research is intended to serve as a gauge for noise levels and to provide a framework for urban area planning, aiming at noise reduction.

## Methodology and Equipment

### Study areas

Tripoli is the capital of Libya, located in the northwest of the country. It has a population of about 2.0 Million (2021 est.), and covers an area of approximately 1507 $km^2$, characterized by a mixture of residential, commercial, industrial, and recreational areas. According to the World Bank Development Indicators [9], there are more than 2 million vehicles in Tripoli (2019 est.) including foreigners-owned and government vehicles, due to lack of reliable public transportation system. The study in this paper focused on seven distinct areas, where comprehensive acoustic measurements were collected: Martyr's square, Algeria square, University of Tripoli (UoT) medical hospital, area near Al-Jalaa hospital, Al-Dehmani park, Al-Tholathaa park, and the Second Ring Road (the highway).

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These areas, shown in Figure 1, are selected as they are the most frequented and utilized sites in Tripoli.

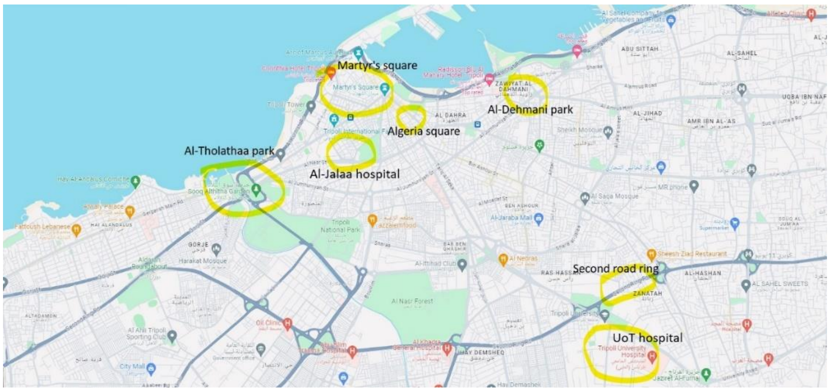


Figure 1. The regions under study in the city of Tripoli.

The two hospitals are the main hospitals in Tripoli and are considered critical sites for investigation, and Martyr’s square and Algeria square are central public areas. The two parks represent the dimension of recreational spaces in urban soundscapes, and the Second Ring Road is a major traffic artery that represents a focal point for assessing the level of vehicular noise impact on vehicles on the roadways and on surrounding nearby buildings.

**Utilized equipment and software**

The fieldwork was conducted using a Bruel & Kjaer 2232 precision Sound Level Meter (SLM), shown in Figure 2. The 2232-SLM is a precision device suitable for various applications, including environmental noise assessments, industrial noise monitoring, and workplace noise measurements. The device is equipped with a microphone and has the ability to accurately capture sound levels. Before conducting the field measurements, it was calibrated, with a calibrating source provided by the manufacturer. For mapping purposes, the web-based noise mapping tool from dBmap.net was used.


Figure 2. Bruel & Kjaer precision Sound Level Meter type 2232.

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Besides noise level measurements, a sound signal of wav-file type was recorded at the Al-Jalaa hospital, as it is a hospital and lies in a more populated area compared to UoT hospital. The recordings were taken for a span of 10 seconds, using a small handheld microphone and a laptop. The recordings were made during the afternoon time, and on a workday and weekend. Acoustic spectra were then calculated, which provide a detailed understanding of the frequency characteristics of the measured signal, enabling precise analysis and evaluation that might be useful in noise control processes, if intended. The spectrum analysis helps identify different noise sources present in the signal, identify dominant frequency bands, conduct compliance assessment: by comparing it with environmental noise regulations and standards, and put up noise control strategies and mitigation measures.

## Results and Discussion

The measurements of noise levels were taken at three different times of the day, averaged over three measurements. The noise levels were measured over the course of two distinct settings: working days and weekends, as shown in Figure 3 and Figure 4. The data collection covered morning hours from 9:00 to 11:00, afternoon hours from 12:00 to 15:00, and evening hours from 17:00 to 19:30. This approach aimed to comprehensively capture variations in noise levels during various daily routines, contributing to a thorough examination of noise patterns within the study areas.

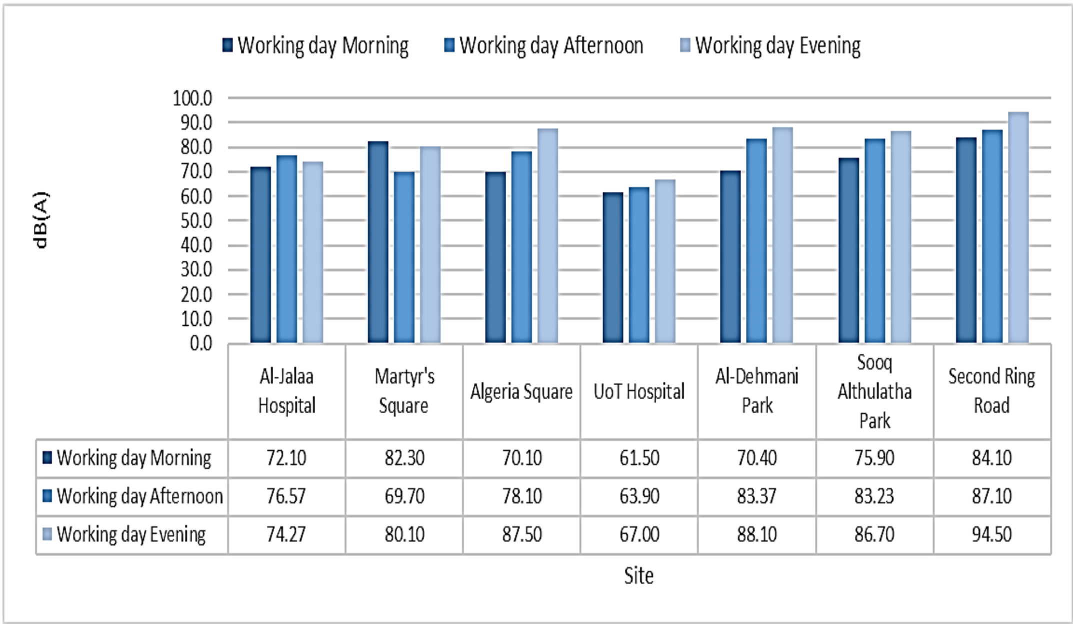


Figure 3. Noise levels measured during a working day.

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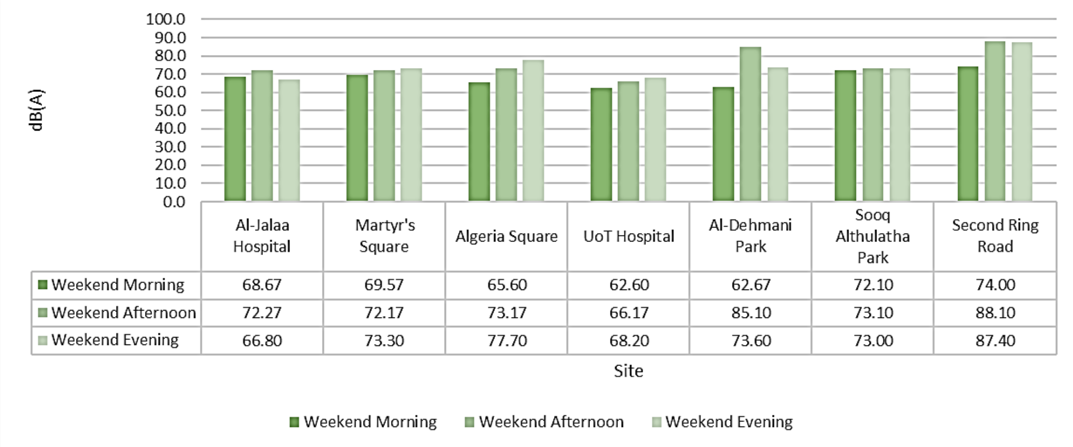


| | Al-Jalaa Hospital | Martyr's Square | Algeria Square | UoT Hospital | Al-Dehmani Park | Sooq Althulatha Park | Second Ring Road |
|---|---|---|---|---|---|---|---|
| Weekend Morning | 68.67 | 69.57 | 65.60 | 62.60 | 62.67 | 72.10 | 74.00 |
| Weekend Afternoon | 72.27 | 72.17 | 73.17 | 66.17 | 85.10 | 73.10 | 88.10 |
| Weekend Evening | 66.80 | 73.30 | 77.70 | 68.20 | 73.60 | 73.00 | 87.40 |

Figure 4. Noise levels measured during a weekend.

Based on our measurements, the Second Ring Road stands out as the noisiest location, registering 94.5 dB(A) during a typical working day. As expected, weekends are generally quieter overall. Al-Dehmani Park and Algeria Square also exhibit slightly higher noise levels compared to other areas we investigated. For a comprehensive overview, we have visually mapped the highest recorded noise levels, as depicted in Figure 5.**خطأ! لم يتم العثور على مصدر المرجع**.

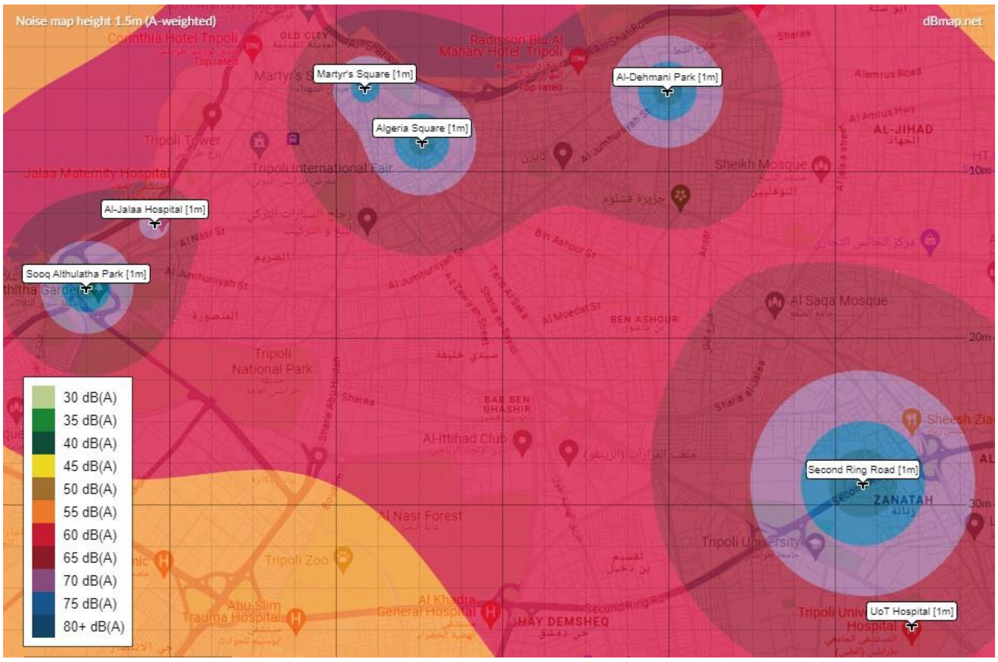


Figure 5. The highest recorded noise levels in the chosen sites in the city of Tripoli.

The sound signals shown in Figure 6 represent the time-amplitude measurements recorded in front of Al-Jalaa hospital, during the afternoons of a workday and a weekend. The amplitude of time-varying signals represents the difference of sound pressure at the microphone diaphragm.

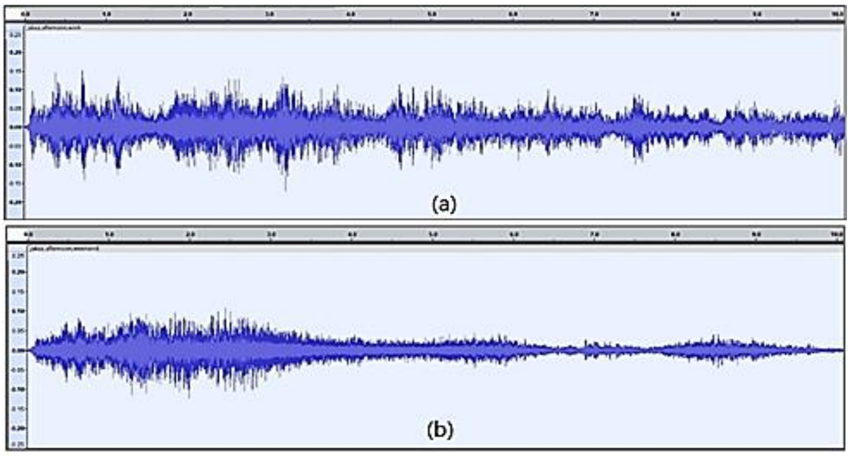


Figure 6. Afternoon audio signal recorded at Al-Jalaa Hospital: (a) workday; (b) weekend.

Spectrograms are then generated from these signals, which represent the intensity of each frequency component, as shown in Figure 7. These contribute to a comprehensive understanding of noise patterns in the specified area, thus help in noise control procedures. High amplitude noise signals could be observed at frequencies of 10kHz to 12kHz. These play a significant role in shaping the acoustic profile of noise during afternoons of workdays.

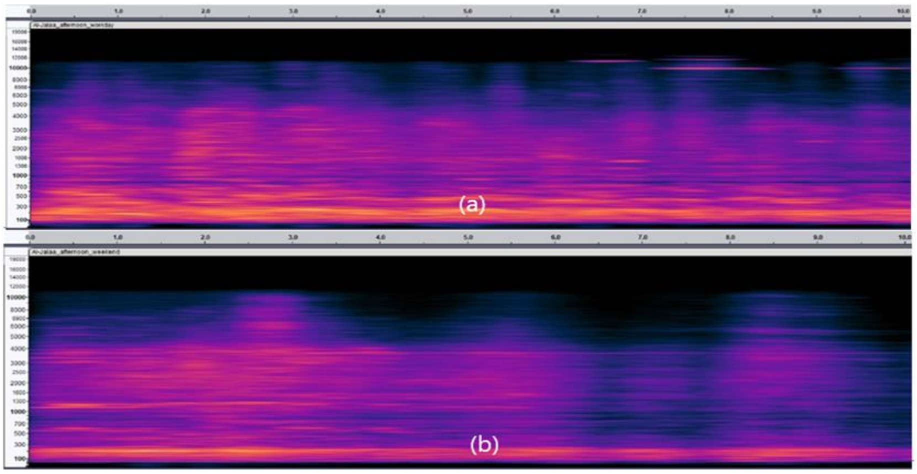


Figure 7. Afternoon audio spectrogram recorded at Al-Jalaa Hospital: (a) workday; (b) weekend.

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During the weekend, a different behavior was observed. The aforementioned high amplitude signals are no more observed, which indicates quieter area compared to working day data. As a recommendation, spectrograms should be analyzed for all potentially noisy regions in the city of Tripoli. By examining spectrograms, undesired noise can be distinguished from desired signals or background noise.

**Remarks and guidelines on noise exposure limits**

Noise is often underestimated as a hazard, yet it presents various health risks—both immediate and long-lasting. These risks encompass sleep disruption, cardiovascular complications, reduced productivity at work and in education, hearing loss, and more. The World Health Organization (WHO) acknowledges noise as a significant environmental concern, as evidenced by the increasing number of public complaints related to excessive noise.

The U.S. Environmental Protection Agency EPA [10] has set an average exposure limit for environmental noise at 70 decibels (dB) over 24 hours (or 75 dB over 8 hours). Additionally, it identified 55 dB as the maximum average noise level for outdoor environments and 45 dB for indoor environments, allowing for activities such as spoken conversation, sleep, work, and recreation [11]. It is essential to recognize that these values represent average levels, not peak levels. The WHO recommends that noise exposure should not exceed 70 dB(A) over a period of 24 hours, and 85 dB(A) over a 1-hour period, to prevent hearing impairment [12] and [13]. Furthermore, the use of hearing protection, and yearly hearing monitoring become necessary when the exposure surpasses 85 dB(A). Comparing our obtained results for the city of Tripoli, some areas could exceed the recommended noise exposure limits of 85 dB(A) if exposed for more than one hour. This could be the clear case for residents close to the Second Ring Road, Al-Dehmani park, and Sooq Al-Thulatha park.

**Recommendations for noise mitigation**

There are mainly three approaches that can be adopted for noise abatement and control: controlling the noise at the source; altering noise path from source to receiver; and protecting the receiver area. In Tripoli, due to lack of industrial constructions in the studied areas, noise is mainly road traffic noise. Therefore, controlling the source is not feasible in this case. The second approach of rerouting noise path between source and receiver seems is apparently the most applicable in the case of the Second Ring Road. Two solutions are applicable: (i) sound barriers strategically placed between the two sides of highway routes; and (ii) sound barriers placed on the sides between the highway and the residential close area. The effectiveness of the barriers is determined by four parameters: source-of-barrier distance; barrier height; barrier-to-receiver distance; and length of barrier [11]. The barriers could be of natural-type such as planting trees at the sides of the Second Ring highway. Noise reduction is achieved when these barriers,

natural or artificial, intercept, redirect, or absorb part of the noise. A schematic diagram representing these barriers and their positioning is demonstrated in Figure 8.
Among other mitigation procedures are the construction of low-noise roads, maintain frequent road maintenance, use of low-noise tires that could contribute to about 10 dB noise level reduction [14], and avoidance of traffic congestion. In the case of residential areas close to main roads, noise could be controlled by using better fitting seals of windows and doors, and adopting better noise-compatible rooms layout in building designs.

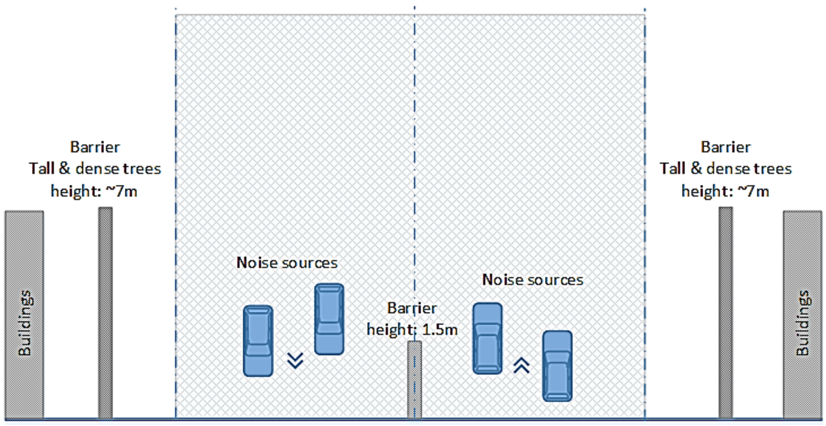


Figure 8. Schematic diagram of recommended barriers scenario for the Second Ring Road.

Planting tall and dense trees alongside the ring road could definitely play a role in reducing noise levels. Previous studies have demonstrated that noise attenuation by trees can be improved if trees are arranged in a periodic lattice configuration, in what is called green acoustic screens [15]. The other affecting factor is to have the foliage dense enough for proper attenuation to occur [16].

## Conclusions

This investigation focused on assessing noise levels in key areas of Tripoli, recognizing noise pollution as a significant factor affecting residents' well-being. The study covered seven regions, with road traffic identified as the primary noise source. As expected, measurements along the Second Ring Road confirmed elevated noise levels. Additionally, Al-Dehmani Park emerged as another noisy area. To mitigate noise along the Second Ring Road, we recommend conducting detailed measurements, including spectrograms of sound signals. Based on these findings, two measures can be implemented:
(i) designing and installing sound barriers between highway lanes that would help reduce noise

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(ii) planting tall dense trees alongside the highway and adjacent to the residential areas, as trees possess sound absorption, deflection, and refraction properties.

As a suggestion for further studies, broader areas within Tripoli should be covered, and extend to other major Libyan cities, using a strategic methodology for selecting target regions and spatially dense measurements to improve noise mapping. State authorities should maintain noise pollution records and GIS data as a comprehensive database for future comparisons and efforts to enhance residents' well-being.

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