

Noise assessment in urban recreational areas - Case study: Bistrița city

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Abstract. The study analyses the extent of noise pollution in urban recreation areas, focusing on the city of Bistrița. It aims to conclude the implications of noise pollution on the health, well-being, and sustainability of urban lifestyles. The study object is the playgrounds and parks, and at such sites, a high level of noise may disrupt recreational operations and lower the overall quality of life. A sound level meter was calibrated to measure field noise at different locations and at various times by employing systematic sampling, allowing for the coverage of noise variation over the weekend. Findings indicate that noise levels exceeded the recommended limits in several areas, particularly during periods of high occupancy. These statistics underscore the need for effective noise control measures. The criticality of urban planning and policy measures is to be emphasised as the means to limit acoustic disturbances and enhance the usability of recreational surroundings. Eventually, the study proposes regular observation and intervention to create healthier and livable towns, whereby the urban areas embrace leisure and enjoyment, societal bonding, and their future feasibility.

1. Introduction

Urban structures are in an indirect relationship with residential spaces through commercial areas, industrial platforms, health care facilities, educational institutions, sports facilities and recreation and leisure facilities (Ioja et al., 2012). These functional components contribute to the diversification of urban activities and thus to an increase in environmental noise. Noise intensity varies according to the type of activity, the density of users and the proximity to residential areas, making these structures key factors in the assessment of urban noise pollution.

The primary aims of this research are (1) to assess the noise level in urban recreational places in Bistrița, Romania, (2) to analyse the values based on the type of space and proximity to sources of noise and (3) to provide suggestions for reducing noise pollution. Research into disturbance caused by noise is important because noise pollution, or unwanted as well as disturbing sound, is a commonplace characteristic of contemporary living (Zipf et al., 2020). Noise pollution is a situation of unwanted loud, unpleasant, unreasonable and disruptive sound present in the environment.

This needs to be addressed to safeguard healthy urban ecosystems and ensure the well-being of humans and wildlife (Majumdar, 2024). It is becoming a growing environmental issue and is a new public health concern (Sarker et al., 2023).

Urban noise is widely regarded to be one of the main types of pollution (de Paiva et al., 2015).

The contemporary environmental challenge of urban noise pollution affects human wellness while affecting health (González, Morillas et al., 2023). Environmental pollution

from urban noise in recreational areas produces health risks that negatively affect human well-being. The investigation focuses on Bistrița as the research area, while the main goal is to analyse noise levels at parks and playgrounds where people need rest.

This research maintains importance because it supports urban development sustainability through the creation of social areas (Shahid Ali Khana et al., 2023).

Multiple recent studies show that noise pollution creates three major health problems through stress and sleep disturbances, and cardiovascular diseases (Shahid Ali Khana et al., 2023).

The existing literature demonstrates how green infrastructure functions to reduce urban noise pollution while creating better sound environments in cities (Guillermo Rey-Gozalo et al., 2023; Deepshikha Yadav et al., 2024). Different noise reduction methods generate conflicting opinions regarding their effectiveness for noise reduction through vegetation and urban planning approaches (Firdaus, G., & Ahmad, A., 2010) (GL Waters et al., 2023).

Parks and playgrounds serve as recreational spaces, yet they endure excessive noise levels due to urban activities such as traffic and construction in these areas (Guillermo Rey-Gozalo et al., 2023). The integration of green spaces within urban areas effectively reduces noise pollution, which results in a better soundscape and positive effects on urban residents' well-being (Margaritis, E., & Kang, J., 2018).

Scientific research proves that trees and shrubs placed strategically help block and redirect sound waves to produce more peaceful environments (Shahid Ali Khana et al., 2023). The implementation of noise reduction measures through sound barriers and green buffers in urban planning enhances the acoustic quality of recreational areas (Rifat Olgun et al., 2024). These areas lose their relaxation value when noise pollution exists since it increases visitor stress and diminishes their recreational experience (Nevil Wickramathilaka et al., 2022).

Urban recreational areas need noise pollution solutions for sustainable development because these spaces require their function to promote health alongside relaxation and social interaction (Shengzhi Chua et al., 2025).

Order No 2.328 of 10 December 2021 - Noise limit values for equivalent continuous sound level and waiting time of environmental noise indicators: L_{day} (noise level over the day), L_{evening} (noise level over the evening), L_{night} (noise level over the night) and L_{zsn} (composite index for 24-hour period). These values are adopted for use in assessing exposure of the populace to noise and for use in monitoring of environmental noise. The Order was published in the Official Gazette of Romania, Part I, no. 1235 of 28 December 2021 and shall enter into force in accordance with the provisions of the law. The normative act is issued in accordance with Law No. Law no. 121/2019 on the evaluation and management of environmental noise (<https://legislatie.just.ro>). Ordinance No. 57/2019 concerning the Administrative Code GD 43/2020 regarding the organisation and functioning of the Ministry of Environment, Water and Forests. The Order was ratified after the submission of the report of the Directorate for Impact Evaluation and Pollution Control (DEICP/129.573 of 31 August 2021). The Order aims to harmonise national legislation with European requirements, such as Directive 2002/49/EC relating to the evaluation and management of environmental noise. These mandatory threshold values are used in the establishment of strategic noise maps and action plans to mitigate noise impacts on public health.

This order has provided limit values:

- Parks, recreation and rest areas, spa and health resorts: 45 dB;
- Children's playground: 75 dB.

Results show that noise levels have been found to surpass the suggested noise levels, especially when usage is at its peak and hence the need to employ noise management strategies.

The principal conclusion is that continuous monitoring and implementation of noise reduction measures are essential for promoting healthier urban environments and contributing to the sustainable development of cities (I-INCE, 2022).

2. Materials and Methods

A class 2 sound level meter measured the noise levels at different times and locations in the recreational facilities in Bistrița, as part of this field research. For a cohesive research protocol, I organised my study as follows: study area, Urban recreation elements considered, Equipment and materials, Selection of measurement sites, Measurement protocol, Data collection, Data analysis and Noise map. For a rigorous assessment of noise pollution, the methodology integrated multiple acoustic indicators, such as Leq, Lmax, frequency, amplitude and peak, and took into account the biophysical (topography, vegetation, terrain morphology) and socioeconomic (type of users, frequency of activities) variables of the study area, as well as a careful sampling design to reflect the acoustic and functional diversity of the spaces analyzed.

2.1 Study Area

The research was done in recreational spaces around town, designated areas for recreation by city authorities, such as parks, playgrounds, sports areas, and areas where people gather for leisure time. The study involved 23 public playgrounds, 1 park, and 2 recreational spaces in the municipality of Bistrița (Figure 1).



Figure 1. Location of research areas.

Due to the concentration of the playgrounds in an area, a delimitation of the area of concentration of the playgrounds studied is made.

2.2.1 Biophysical and socio-economic variables

Within the “noise” investigation within the limits of Bistrița city, two outdoor locations were considered “representative” in terms of acoustic contrast and spatial arrangement: the Schullerwald Forest and the Municipal Park. From the biophysical relief configuration, the Municipal Park exhibits a flat and open topography with scattered ornamental plants, which facilitates sound diffusion with no barriers of an acoustic nature. It is close to the busy DN17 road and commercial centres, so this is the direct source of road and city noise for it (Figure2).

The open-air layout and absence of thick greenery belts mean that there is a scatter noise pattern, with high and unsteady noise levels that depend on the time of the day as well as the day of the week.

From a socio-economic perspective, the park is visited by multiple users (children, youth, families) and therefore its noise potential is elevated due to leisure activities, events and significant pedestrian flow.

On the other hand, the Schullerwald was chosen as a reference area, which turned out to have a low noise influence, with its rolling topography and meagre tree cover serving as a natural noise barrier. Activity is lower and sporadic, and background noise is naturally dominated, making this a suitable site for control of background noise.

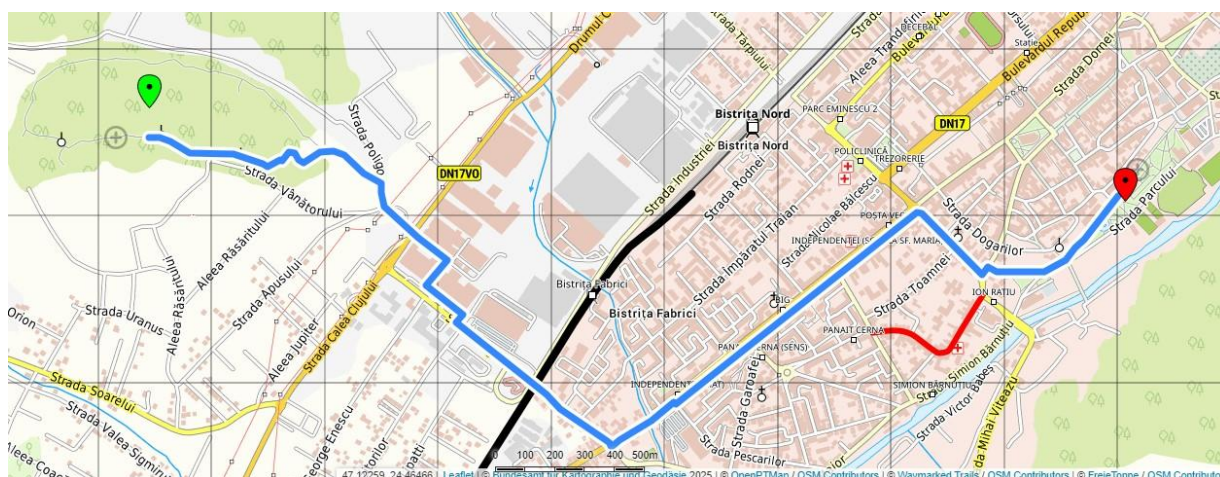


Figure 2. Urban route between Schullerwald Forest (green point) and King Michael I Park (red point)

The noise of the environment is greatly affected by the terrain. In the Schullerwald Forest, the combination of dense vegetation and fragmented terrain pattern effectively weakens sound waves, leading to a stable and low sound environment. On the other hand, the City Park, situated in a valley-like, open area, is a natural amplifier, with no natural barriers to the sound, which results in an amplification of the noise when it gets busy. The contrast between the two sites allows a comparison of the noise effect in a natural and an urban setting. (Figure 3).

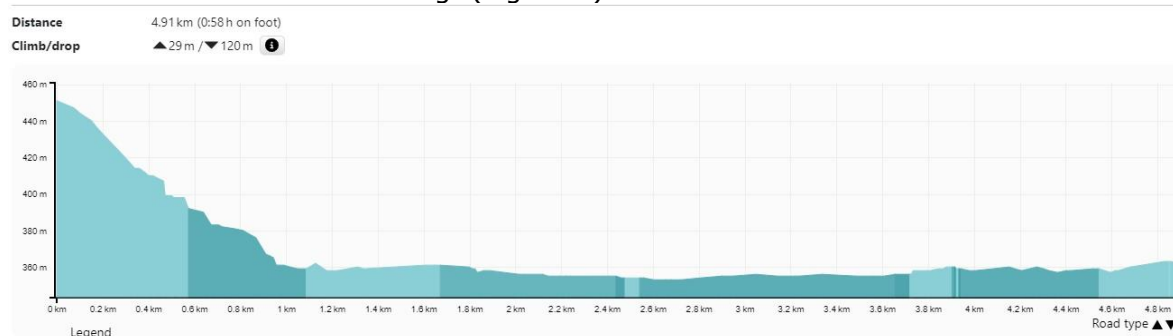


Figure 3. Altimetric profile Schullerwald Forest-King Michael I Park

The 23 playgrounds and the recreation area at the Lamă, Andrei Mureșanu street are spatially distributed in a way that reflects the biophysical and socio-economic diversity of the city. From the biophysical point of view, the sites are located in areas with moderate relief, with altitudes between 341 m and 391 m, according to the altimetric profile of the 14.6 km route. The maximum slopes of $\pm 8\%$ indicate the presence of gentle slopes, which may influence sound propagation, especially in low areas where noise may accumulate. Vegetation ranges from isolated trees in urbanised areas to extensive green areas, such as the park at the Ilama, which provides greater sound absorption capacity (Figure 4).

From a socio-cultural standpoint, between medium and high- and high-density residential areas, playgrounds are for children, adolescents and families. Recreation is

lively at peak times, and the noise levels are high up and down. The recreational space at the llama, which is identified in the photo, is semi-natural in nature and serves several purposes: rest, interaction with animals, and social gatherings. A diverse audience, including tourists, visits it and creates a challenging acoustic environment, which we will analyse in further detail. The closeness of the national roads (DN151, DN173, DN173C) and towns, i.e., Sigmir and Unirea, leads to a magnification of the noise in some areas, mostly those near the road infrastructure.

This division of space and functions provides the opportunity to compare high and low noise potential areas, and as such, it is a rather unique setting within which to study noise exposure in the city and suburban environment.

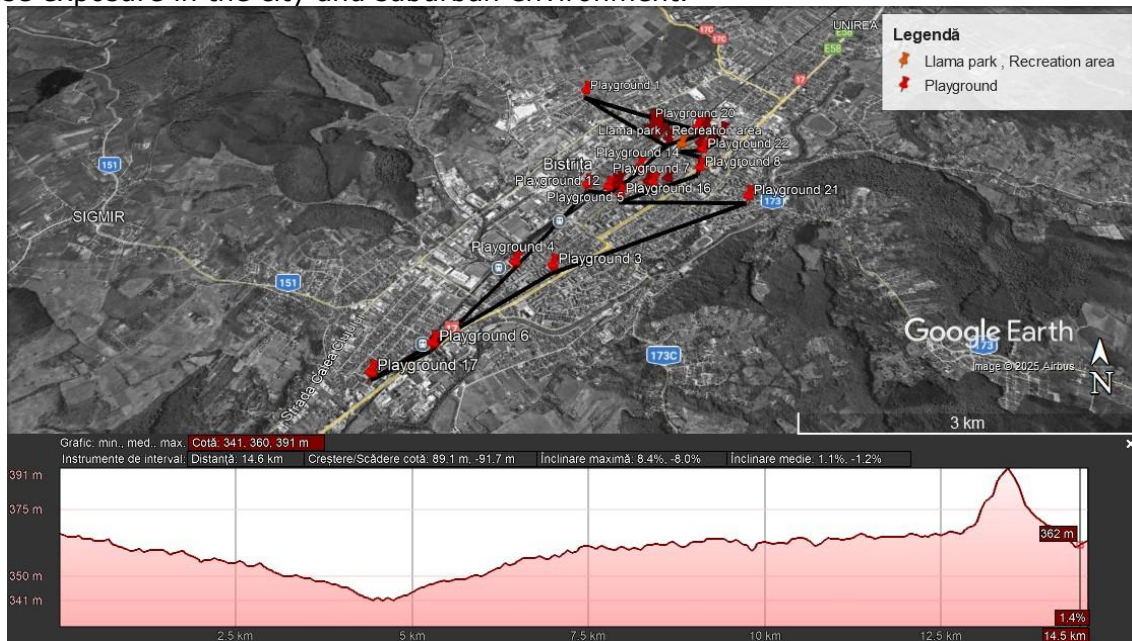


Figure 4. Altimetric profile - 23 playgrounds and Lamă area

2.2.2 Elements of Urban Recreation Considered

Urban green spaces are a major attraction for residential areas, playing an essential role in maintaining the health of the population and improving environmental quality (Iojă et al.,2012).

They help to reduce air pollution, decrease noise levels and mitigate the effects of urban heat islands, while improving the aesthetics of the landscape by stimulating biophilia and preserving urban biodiversity (Iojă et al.,2021). In addition, green spaces help strengthen social relations through community building and good neighbourly ties, and their presence influences the real estate market by increasing the value of nearby housing (Iojă et al.,2012).

Recreational facilities in cities encompass many different elements designed to facilitate leisure, physical exertion, and social activities. The following lists detail the most common resource types and the typical resource characteristics for these resource types. Parks are landscaped green spaces within urban settings that provide opportunities for relaxation, recreation, and contact with nature. According to Sadeghian (2015), the essential components of a park include vegetation such as trees, shrubs, flowers, and lawns; pedestrian walkways; benches for resting; decorative and calming water features like lakes or fountains; designated picnic areas; and facilities for recreational activities, which may include sports fields, running tracks, and cultural event zones.

Children's play areas are purpose-built zones intended to support safe and engaging recreational activities for children. As noted by Levitz (2014), these spaces typically feature play structures such as swings, slides, and climbing equipment. Safety

surfaces made of rubber or sand are used to minimise injury risks. Fencing is commonly installed to ensure child safety, while benches provide resting places for parents and caregivers.

Accessibility features are also integrated to accommodate children with disabilities. Leisure or amenity spaces are multifunctional urban areas designed to facilitate a wide range of recreational and social activities. According to PLOS ONE (2016), these spaces may include sports fields for football, basketball, or tennis; public swimming pools; outdoor fitness equipment; amphitheatres for cultural performances; picnic and barbecue areas; and dedicated bicycle paths.

2.3 Equipment and Materials

The SNDWAY 523 plus Professional Sound Level Meter was used. Established in 2010, SNDWAY is a leader in precision measurement technology. Specialising in hand-type Laser Distance Meters, our commitment to innovation has made us a global force, with products sold in 30 countries. Our annual capacity of 3 million devices reflects our dedication to providing accurate and reliable tools, including laser rangefinders, telescopes, and environmental detectors. At Sndway, we're reshaping the future of measurement technology, focusing on precision, quality, and global impact (<https://sndway.co/>).

- Sound Level Meter: A Class C calibrated sound level meter (SLM) was used to record environmental noise levels that included C-weighted sound levels (dBC);

A practical tool for noise pollution monitoring, health and safety compliance, vehicle noise testing, etc.

The backlight can be switched on or off depending on the situation.

Ergonomic shape ensures a very good grip.

The large-sized sponge ensures protection and optimal results.

The microphone is a condenser type.

It has analogue inputs and analogue outputs.

It is resistant to dust, water and drops from 1.5 meters.

Additional specifications:

- Measurement range: 30 ~ 130dBA; 30dBC to 130dBC.

- Accuracy: ± 1.5 dB

- Resolution: 0.1dB

- Frequency Range: 31.5HZ ~ 8KHZ

- Frequency Weighting: A

- Sampling frequency: 2 times/sec

- Auto Power Off - Low Battery Indication

- Max Hold function

- Operating conditions:

Temperature: 0 ~ 40 °C (32 ~ 104 °F)

Humidity: 10 ~ 80% RH

- Storage conditions:

- Temperature: -10 ~ 60 °C (14 ~ 140 °F)

- Humidity: 10 ~ 70% RH

- Power supply: 3 x AAA LR6 batteries - not included

- Dimensions: 200 x 60 x 27 mm

The microphone is of a condenser type. A condenser microphone (commonly referred to as an electret condenser microphone) is a microphone which features a condenser capsule to detect a sound wave and transduce it into electrical signals.

With an accuracy of ± 1.5 dB, it is designed to be resistant to dust, moisture and drops from 1.5 meters.

To ensure that the device records noise pollution data optimally, a pair of noise-cancelling headphones that have a noise protection function is used, subsequently enabling conclusive readings from the space analysed. (Figure 5)

- Description of measuring device:

The primary measurement tool in this study was a Sound Level Meter (SLM). The SLM was a Class 2 device and calibrated according to the international standard (IEC 61672). The device can record sound pressure levels weighted to C frequency (dBC) and is suited for obtaining low-frequency noise components since they are found in urban-based settings. The SLM featured a digital display, allowed for data logging, and had a microphone with a windscreen to reduce the impact of environmental noise. For quality control, a standard acoustic calibrator was used to calibrate the SLM before and after every measurement period. Class 2, C-weighted instrument calibrated following international standards" - The instrument was calibrated using the standard acoustic calibrator (usually 94 dB at 1 kHz) according to international standards traceable to national standards, establishing traceability of measurements. Weighted to C frequency (dBC)" - C-weighting is used for measuring low-frequency noise such as urban vibration, heavy traffic or industrial noise. Compared to A weighting (dBA), which approximates logarithmic human ear's sensitivity and removes low frequencies, C weighting is much more linear and spans a wider frequency range; therefore, it is better for low-frequency noise analyses.

"Optimal for extraction of low-frequency noise components" - This means that the instrument may be used in the city or industry, where the low-frequency noise is concentrated and affecting the population's acoustic comfort or health.

Calibration is performed to control the stability and the accuracy before and after the measurement. To increase the accuracy of the measurements, the research used auxiliary supports such as tripods to stabilise the sound level meter and noise-cancelling ear muffs to isolate the operator from ambient noise unrelated to the measured source. These measures contributed significantly to reducing external interference and increasing the reliability of the data collected.

- GPS Device: Used to obtain the precise geographic coordinates of each measurement location. For recording the geographical coordinates of the measurement points, a Garmin eTrex handheld portable GPS was used (<https://www.garmin.com/ro-RO/p/835742/>). The GPS data were correlated with the acoustic measurements to facilitate the mapping of ambient noise in the analysed recreational areas.

- Physical and Performance Features

Lens material

chemically strengthened glass

Physical dimensions 6.1 x 10.0 x 3.3 cm (2.4" x 4.0" x 1.3")

Weight 156.5 g with batteries

Water resistance IPX7

Display type 2.2" transfective, monochrome

Display size 1.3" x 1.7" (3.3 cm x 4.4 cm); 2.16" diag (5.5 cm)

Display resolution 240 x 320 pixels

Battery type: 2 AA batteries (not included)

Battery life 168 hours in standard mode; 1,800 hours in expedition mode; Built-in memory 28 MB; USB-C interface;

Maps and Memory

Base map Yes (cities only); Waypoints/favourites/locations 1,000

Sensors: GPS, GLONASS, Galileo, QZSS, BeiDou; Electronic compass, Yes (3-axis, tilt compensated); High sensitivity receiver, GPS compass (while travelling), Daily smart functions, Smart notifications on handheld.

Weather, Safety and monitoring functions: LiveTrack, Tactical functions, Dual grid coordinates, Outdoor functions: Point-to-point navigation, TracBack.

Can be used for Geocaching (Geocache Live), Outdoor applications, Compatible with the Garmin Explore app, and Compatible with the Garmin Explore website.

Connections: Wireless connectivity.

- Weather Station: Utilised to monitor and record the weather: To monitor weather conditions during acoustic measurements, the mobile application Windy was used, which

provides detailed wind, temperature and humidity data essential for the correct interpretation of urban noise levels (<https://www.windy.com/>).

- Data Recording Sheets: Used for manual logging of field observations and measurement values;
- Computer and Software: For data analysis and visual representation. The computer, equipped with software, was used for statistical analysis of the data in both MATLAB R2025a and a visual plot.



Figure 5. Device used in the research

2.3.1 Measuring Instruments

Random Sampling: Points were randomly selected within each recreation area to represent noise levels. Strategic Sampling: Points should be chosen such that they are close to the noise sources (e.g., roads, playgrounds, sporting fields).

2.3.2 Recording Noise Levels

Noise levels will be recorded at various times of the day (afternoon) to record potential differences corresponding to these different time frames.

Duration of Measurement: Each noise measurement will last for 10 minutes and be recorded every 1 second.

Weather Information: Weather information recorded during each measurement was included temperature, humidity and wind speed.

2.3.3 Measurement

Sound Level Meter: The sound level meter (SLM) will be used to record the noise level in dBC. The SLM will be calibrated to ensure accuracy for each session. Weather Station: Weather conditions will be recorded each time an assessment is made at the site. Manual recording: Data recording sheets was used to record readings and manual observations.

2.4 Data Analysis

Descriptive statistics: mean, median, standard deviation and range of noise levels for each recreation area will be calculated.

Temporal analysis: Changes in noise level across the different times of day will be examined. (Table 1) The choice of Saturday as the main day for a noise pollution measurement is scientifically justified. First, the recreational use of the site tends to reach a maximum on the weekends (Saturday in particular) when the outdoor activity

of residents is at its highest. This sets a practical standard for measuring noise at peak usage. Second, the variety of noise sources on Saturday is much more diverse than throughout past weekdays. Although the majority of ambient noise during weekday urban life can be attributed to transportation and commerce, Saturday noise is punctuated by pedestrian traffic, recreational fun, ambient music, and public celebrations. The wider range of sound producers in this study also provides a more complete analysis of sound pollution in recreational settings. Assess the degree of relationship between noise levels and weather conditions.

Table 1. Weekend noise recordings - May 2025 (14:00-15:00)

Day	Date	Afternoon (14:00–15:00)	Explanation
Saturday	03.05.2025	15,600	26 locations × 600 records (1/second for 10 minutes)
Sunday	04.05.2025	15,600	Identical measurements in the same time slot
Saturday	10.05.2025	15,600	Repetition of protocol for consistency and temporal variation
Sunday	11.05.2025	15,600	Recordings under similar conditions for statistical validation
Saturday	17.05.2025	15,600	Capturing noise fluctuations during busy weekends
Sunday	18.05.2025	15,600	Confirmation of trends observed in urban locations
Saturday	24.05.2025	15,600	Measurements in a consistent urban context with traffic and activity
Sunday	25.05.2025	15,600	Completion of the measurement series for May
Total		124,800	8 days × 15,600 recordings = 124,800 total recordings

Additional details:

600 recordings per location: each session lasts 10 minutes, with one recording per second.

23 playgrounds, 1 park, 2 recreational areas for a total of 26 locations.

Pre-established Time Slot: 14:00 - 15:00 Selected due to intense activity in recreation areas.

Purpose: capturing noise levels under real urban usage conditions.

Practical relevance: noise differences (in dB) between minimum and maximum may indicate variations in children's exposure to noise, which is important for risk assessment (e.g., discomfort, impaired hearing or concentration).

Measurements were made under optimal weather conditions:

- Clear sky (sunny, no clouds to interfere with acoustic measurements);
- Lack of precipitation (rain, snow, etc.), which could have affected the quality of the data through additional ambient noise;
- Constant and negligible wind (without gusts or significant increases in wind speed), to avoid distortions caused by turbulence in sound propagation.

h. Noise Map

Map is used to model and analyse noise propagation in recreational areas in Bistrița city. It introduces noise sources (traffic, industrial areas, terraces, etc.) and receptor points (playgrounds, parks). Simulates outdoor sound propagation according to the ISO 9613 standard, used in professional environmental studies

3. Results

Precise delineation of recreational zones is essential for the rigorous assessment of noise pollution. Some of the factors which characterise the areas under investigation. Noise levels in leisure areas are strongly dependent on the type of activity. Sports fields, children's play areas, and picnic sites produce their own particular noises at different levels and types according to the nature of the activity. Thus, for the spatial planning and design interventions that can contribute to the minimisation of noise pollution to be effective, a definition of these zones has to be explicit and adequately detailed.

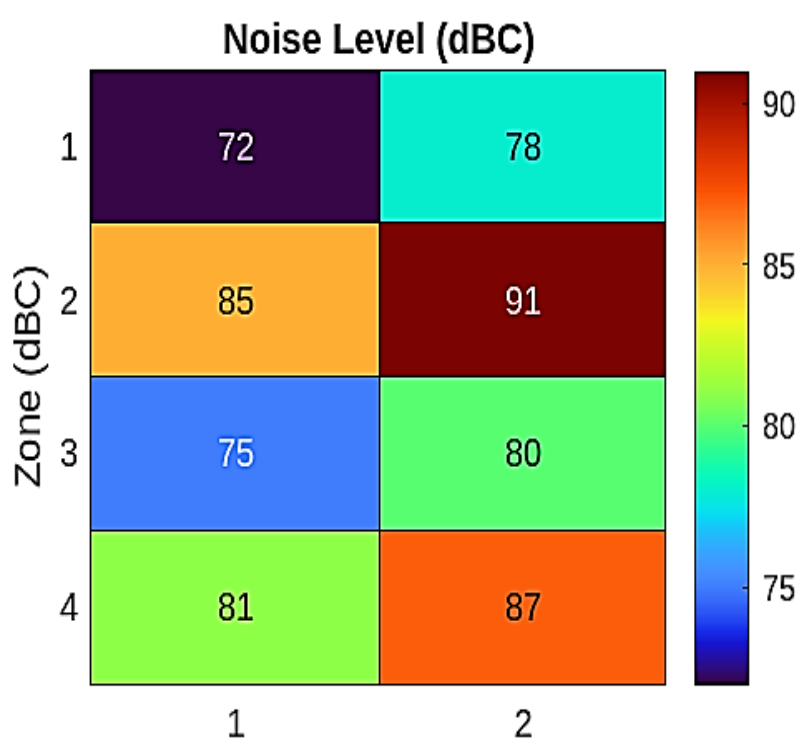


Figure 6. Noise levels in King Michael I Park (<https://matlab.mathworks.com/>)

In King Michael I Park, four distinct noise variation zones were identified based on decibel level measurements (Figure 6). The first zone, located at the park entrance, recorded sound levels ranging from 72 dB to 78 dB over a ten-minute interval. The second zone, which contains recreational equipment, exhibited the highest noise levels, with values fluctuating between 82 dB and 91 dB. Zones three and four are positioned along the park's periphery, where noise levels gradually decrease with increasing distance from the central activity areas. Notably, zone four coincides with a road crossing, which may influence the acoustic environment due to intermittent traffic noise.

The two study sites (Schullerwald forest, Andrei Mureșanu street, known as Lama) recorded different variations in decibel levels due to the site's location and proximity to moving traffic.

At the first site, Schullerwald Forest, the recorded variation data is 77 dB (minimum) and 84 dB (maximum). (Figure 7)

The second recreational area on Andrei Muresanu Street, known as Lama, recorded higher values, conditioned by the proximity and influences of traffic in the neighbourhood; the recorded values were 78 dB (1-minute) and 89 dB (2-maximum).

As the differences between urban areas are relative to areas with vegetated

landscapes, forests and green space, some factors contribute to less noise disturbance:

- Sound absorption through trees and vegetation,
- A physical barrier that breaks apart sound waves,
- Greater distances from sources of noise pollution.

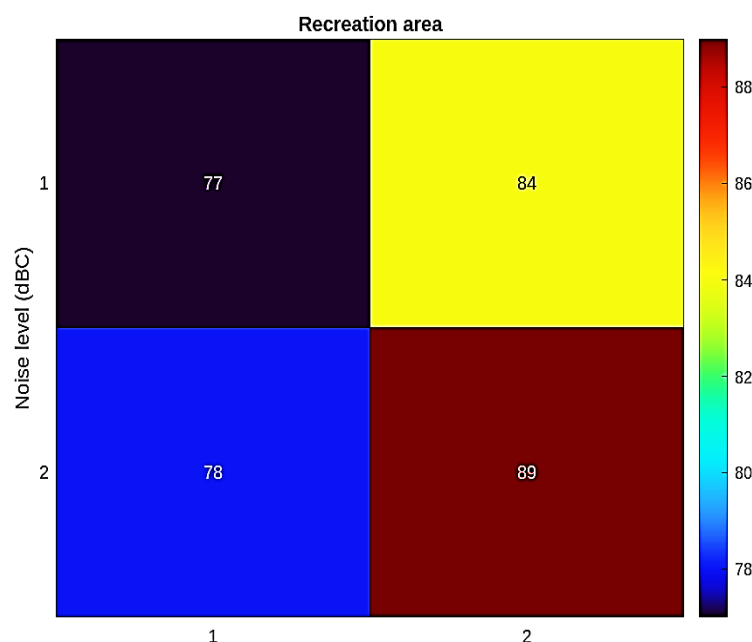


Figure 7. Recreation area Noise level (<https://matlab.mathworks.com/>)

High Noise Levels: Several points burst the upper limit (UCL), representing regions of high noise in the playground. **Unevenly distributed:** The noise is not smooth; there are strong oscillations between different points of measurement, of which some are caused by local noise sources (for example, playground equipment, children's groups, and ambient music).

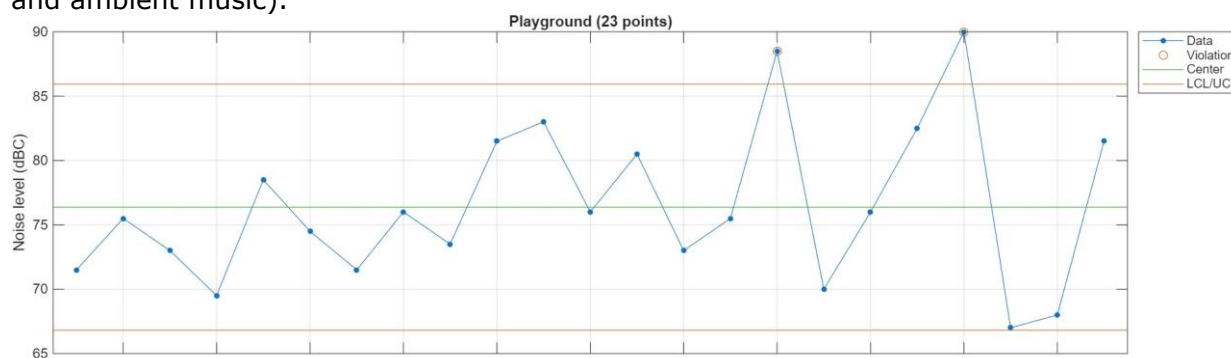


Figure 8. Analysis of the ten-minute difference between the minimum (1) and maximum (2) decibel levels at playground (<https://matlab.mathworks.com/>). X axis: The 23 measurement points (numbered 2 to 23). Y-axis: Noise level in decibels (dB(C)) at a range from 65 to 90 dB(C). Blue curve - The values at which the measurement was conducted at each point - noise evolution in space. Orange circles ("Violation"): the points at which the noise level is above the maximum limit. Brown line ("Centre"): the mean or centre line of the noise level. LCL/UCL Lower and Upper Control Limits - statistical boundaries that delimit the region of normal variation.

Significant Violations - Points flagged as such with a Violation represent critical scenarios that can dramatically influence your acoustic comfort, and potentially even your hearing health (especially for children) (Figure 8). The existence of LCL/UCL control limits assumes a statistical treatment of noise control monitoring - applicable for evaluating compliance with environmental standards.

The main emitting points for the noise maps were the following areas: the Municipal Park, the two recreational areas and the delimited area of playground concentrations. For each of these sources, the spatial area of influence was also analysed, depending on the intensity of the noise emission, the type of activities carried out and the local sound propagation conditions.

The map shows a radial propagation of the noise with a gradual decrease in intensity:

- From 78 dB in the centre (dark red)
- Up to 35 dB at the periphery (green)
- The distance of influence is estimated at 10 meters, according to the scale below.

This zone immediately affects the surroundings, including walkways, playgrounds and rest areas. (Figure 9)

Recommended:

- Regular monitoring of noise levels
- Possible implementation of noise abatement measures (e.g. vegetative barriers, limiting noise activities to certain intervals).

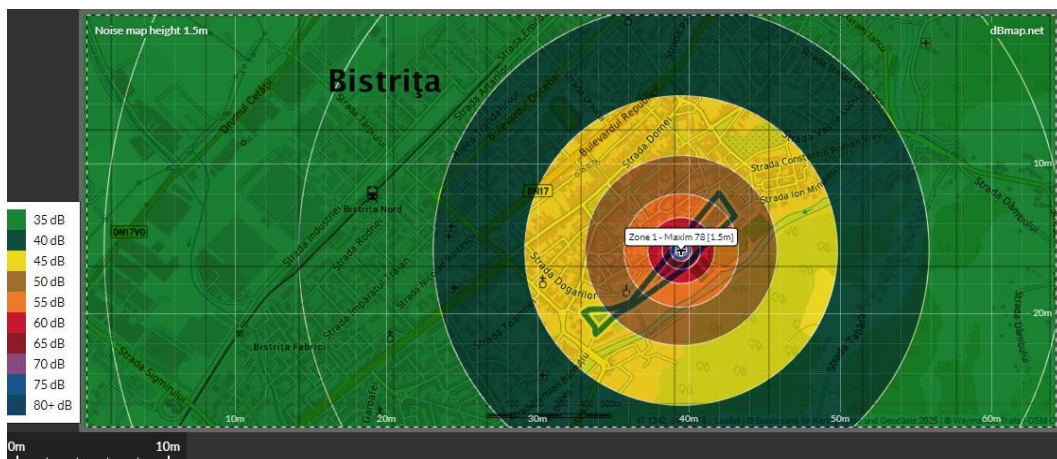


Figure 9. Zone 1 - King Michael I Park (<https://noisetools.net/dbmap>)

The map displays significant noise dissemination, with the colored circles reaching up to 100 m based on the scale. The degradation of the colours is from purple (above 90 dB) through red, orange, yellow, to green (below 40 dB), indicating a very wide noise influence (Figure 10).

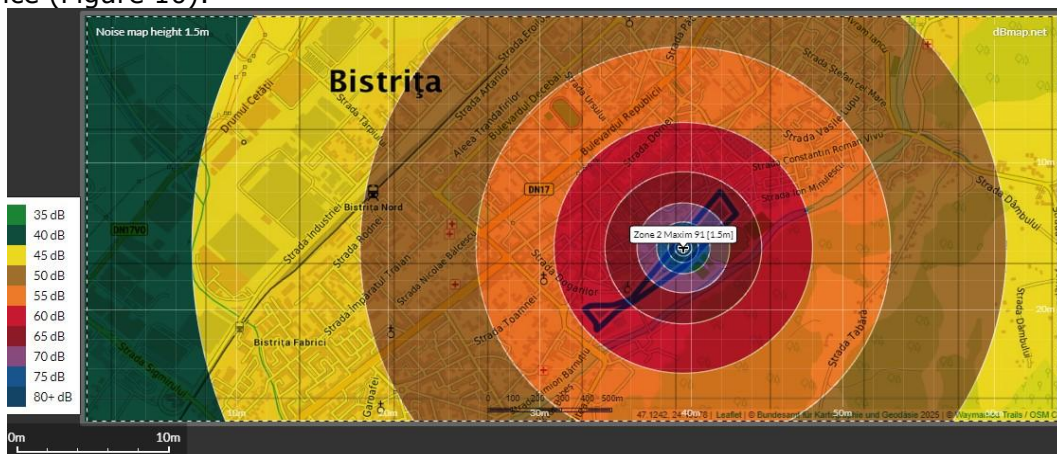


Figure 10. Zone 2 - King Michael I Park (<https://noisetools.net/dbmap>)

Zone 2 is a priority action:

Determine the specific source (recreational activity, equipment, traffic, etc.)

Apply mitigation measures: soundproofing, restricting noise activities, and planting vegetation buffers. It is noted that with increasing decibel noise level, the spatial area that a noise source influences increases, rule of thumb, as the square of the level of emission and propagation condition. 80 dB represents a high level and is similar to the noise generated by traffic on a busy road or by loud outdoor recreational activities. Using the 0–10-meter scale, the range of influence is much smaller than for levels in the higher ranges.

The colours fade from purple/dark red in the centre to yellow and then light green at the outside, and represent an incremental drop in noise intensity. Zone 3 is as noisy as Zone 1, but less noisy than Zone 2 (Figure 11).

The effect area is confined, indicating a point noise source rather than a line source. Recommendations:

- Consistent follow-ups of the noise concentrations, particularly during rush hour.
- Determine the source and type of activity producing the noise.
- Implementation of mitigation measures: Plant or acoustic barriers, Restriction of noisy activities to certain hours.

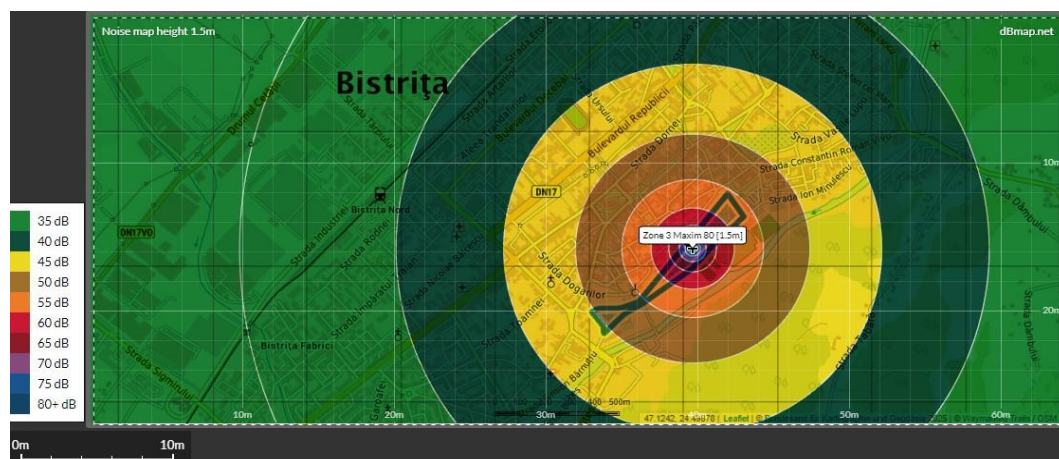


Figure 11. Zone 3 King Michael I Parck (<https://noisetools.net/dbmap>)

An 87 dB sound level is quite intense and may be harmful with prolonged exposure. This level exceeds the threshold of auditory comfort and can be harmful to health with prolonged exposure, especially for children, the elderly or sensitive people. Although the map has a scale of 0–10 meters, the intensity of 87 dB suggests a wide spatial propagation of noise. (Figure 12)

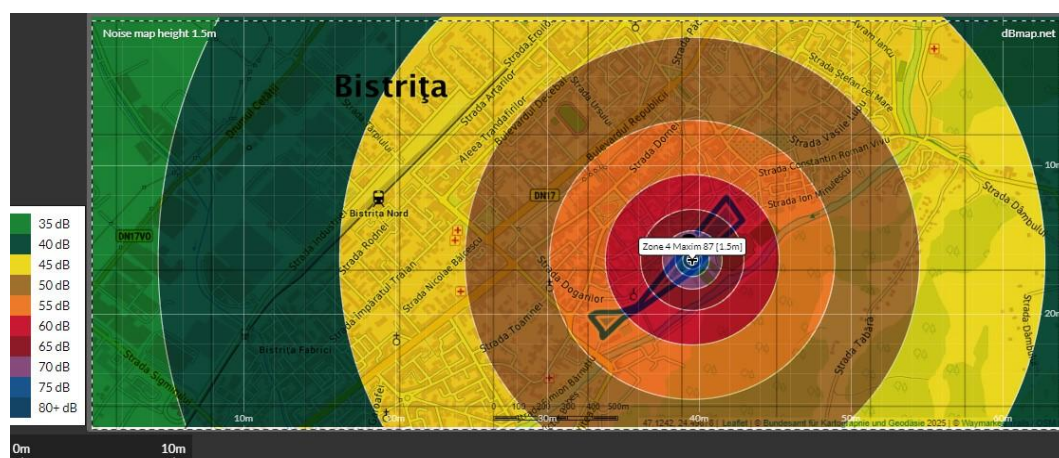


Figure 12. Zone 4 King Michael I Park (<https://noisetools.net/dbmap>)

The dominant colours (dark red and purple) indicate an area of significant noise impact, with influence on neighbouring areas. The area of influence is larger than in Zones 1, 3 and 4, but smaller than in Zone 2, which had 91dB. It is the second most

intense noise zone after Zone 2. The area of influence is extensive, potentially affecting seating areas, pedestrian walkways and play areas.

Recommendations:

- Provide acoustic information points.
- Install interactive panels explaining noise levels and protective measures, turning a problem into an educational and attractive element for tourists.
- Creating themed quiet zones delineating areas with dense vegetation and adapted urban furniture, promoted as "acoustic refuges" for relaxation, reading or meditation, in contrast to more crowded areas.
- Scheduling tourist activities according to optimal acoustic interval. Organise guided tours, workshops or cultural events at times of the day with lower noise levels to maximise the comfort of participants.

The Schullerwald Forest is a natural recreational area in the vicinity of Bistrița city, visited for leisure activities, walking and open-air shows. (Figure 13). The maximum level in a leisure-time place. Due to the age of this standard, the evaluation of the noise exposure was based on a single time measurement. 84 dB was the maximal level recorded at 1.5 m.

It is also a very high level of sound, equivalent to:

Outdoor music with amplification

Amplification, such as music and sports or recreational activities, machinery such as leaf blowers

Heavy traffic nearby

This level surpasses the threshold of auditory comfort, where it could become annoying and perhaps harmful in case of prolonged exposure, especially if it occurs in a natural situation, since a minimum of silence is requested in nature. According to the scale charted in the map (0-100 m), the 84 dB noise is far-reaching and its radius extends for a distance up to 30-50 meters from the source.

The predominant colours (dark red and dark purple) form a large area of acoustic influence, penetrating deeply into the forest and along the driveways.

Such an effect could be detrimental to the tourist experience, particularly for travelers' intent on relaxation, creature viewing or still activities. Corridors of tranquility", Line tourist paths with sound-absorbing vegetation (e.g. tree canopies) to shield travelers from sources of noise.

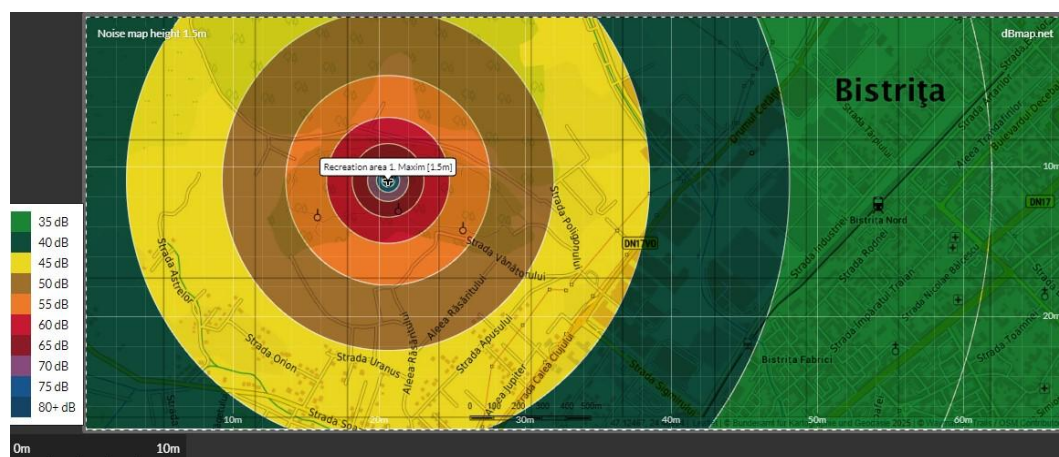


Figure 13. Schullerwald forest values (<https://noisetools.net/dbmap>)

The Lamă field is situated in the busy district of Bistrița, a few minutes from the public reception and traffic arteries. (Figure 14) In the noise map, it is reported with the indication: "Elimination area 2 (Maximum) = 89 dB", which means that the noise level was extremely high, measured at 1.5 m. 89 dB is a very loud level, close to the limit for hearing damage. Also shown on the map are red and orange circles, which are much bigger in size compared to the ones over Schullerwald. because of:

- Open topography: fewer natural barriers (trees, relief) exist in the Lamă, which promotes the unimpeded propagation of sound.

- City layout: impervious surfaces (think buildings and asphalt) bounce sound, increasing where it can travel.
- Source type: unlike point sources in the forest, urban noise is continuous and omnidirectional.

Recommendations:

- Construct acoustic barriers with pergolas, sound absorbent panels or vertical planting in the most exposed areas (side roadside area).

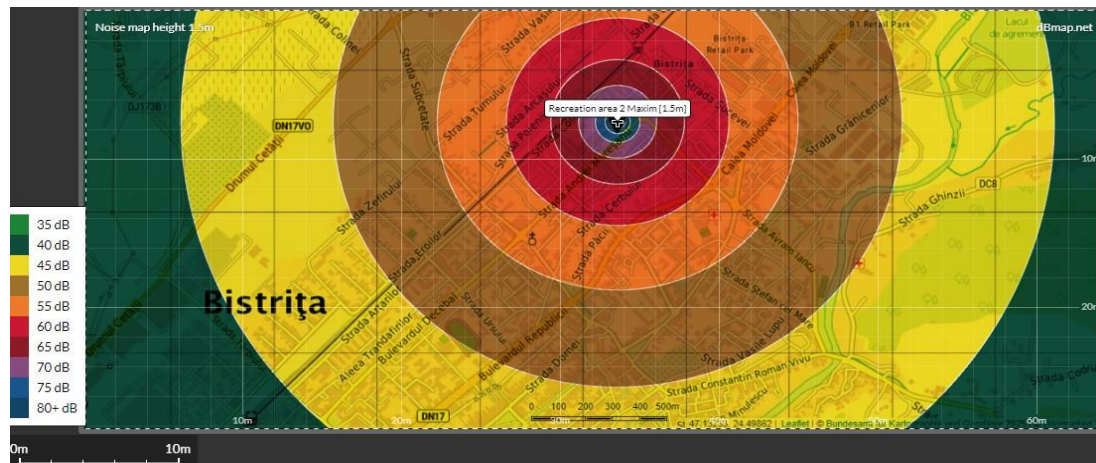


Figure 14. Lama zone values (<https://noisetools.net/dbmap>)

The presented image is the result of noise monitoring for the Bistrița recreational space, considering 23 playgrounds situated in the urban shell (Figure15). These are indicated on the map with colored concentric circles that represent the noise levels registered at a height of 1.5 metres. To each playground corresponds a noise influence area whose radius is assumed to be comprised between 30 and 100 metres, varying according to the intensity of the activities and the surrounding environment. Red, orange and yellow circles are areas of intense noise diffusion, particularly in open or lightly wooded land.

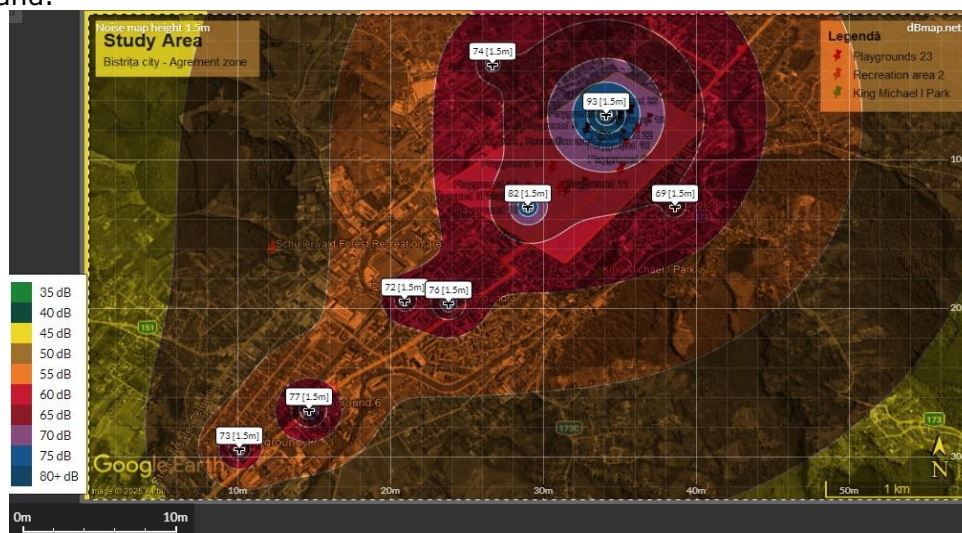


Figure 15. Playgrounds noise influent area (<https://noisetools.net/dbmap>)

Thus, the 23 points create a cumulative noise impact on Bistrița urban noise by the total of them draping over the urban area.

SOURCES of the high levels identified:

- Concentration of leisure activities in small, intensively used areas;
- Absence of natural noise buffers (trees, hedges of plants);
- Near busy roads or shopping centers;

Metal or electronic play equipment that makes loud noises.

Creating playgrounds with smart acoustic design, use of sound-absorbent materials, wood construction and vegetation to minimize reverberation and dissipation of sound.

This analysis highlights the importance of integrating the noise dimension into urban and tourism planning. The 23 playgrounds can become not only places of entertainment, but also benchmarks of good practice in urban noise management.

4. Discussion

Previous studies have shown that prolonged exposure to urban noise can have negative health effects, including stress, sleep disturbances, and cardiovascular problems (Stephanie Dutchen, 2022). These conclusions are supported by the results, which show that recreational zones in Bistrița remain not fully insulated against noise pollution. I found places that had noise levels higher than this limit, implying possible mitigation steps.

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To turn the acoustic challenge into a touristic advantage, I propose the following directions:

- landscaping playgrounds with sound-absorbing materials (wood, rubber, vertical vegetation);
- Delimitation of playgrounds with acoustic planting and urban furniture. Integrated tourism promotion;
- Rebranding playgrounds as "urban experience zones" with a focus on acoustic balance;
- Organising themed events that valorise urban quietness (e.g. "Day without noise").

These results have tremendous implications for environmental policy and city planning. The local governments should ensure that the development or maintenance of local recreation spaces takes cognisance of noise pollution.

5. Conclusions

The results of the field survey conducted on noise pollution in the recreational areas of Tricks have shown that effective measures to reduce noise should be taken as soon as possible. Local governments can formulate mitigation measures, determine noise sources and evaluate their health effects to improve people's and visitors' living standards. The meaning of this research is guaranteed in city planning, educating the masses and alerting them to local policies and regulations.

Once these measures are implemented, this will lead to the development of a healthier and more pleasant environment for all people who use recreational areas in Bistrița. A study reiterates the importance of adopting a comprehensive noise pollution management scheme in urban recreational facilities.

Considering the implications in a broader global context, we can contribute to the development of policies and practices designed to improve the quality of life in urban areas.

Local governments should be in discussion with environmental and community health agencies, so that they can have effective noise reduction rules and safeguard health and good -to -be of the inhabitants.

This research contributes significantly to the knowledge of noise pollution in urban recreational areas and makes recommendations.

Author contributions: Alexandru Marius TĂTAR: Conception, research, and analysis.

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