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RESEARCH ON NOISE POLLUTION IN THE GEOGRAPHICAL AXIS BISTRIȚA-BECLEAN-NĂSĂUD-SÂNGEORZ-BĂI USING DBMAP.NET NOISE MAPPING TOOL AND SNDWAY 523 PROFESSIONAL SOUND LEVEL METER

Alexandru Marius TĂTAR*
Babeş - Bolyai University Cluj-Napoca, Faculty of Geography, Doctoral School of Geography, Str. Clinicilor Nr. 5-7, Cluj-Napoca 400006, Romania;
e-mail: alexandrumarius232@gmail.com

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Abstract: Noise pollution is a significant problem in many urban areas, including the geographical axis Bistrița-Beclean-Năsăud-Sângeorz-Băi. The use of the dBmap.net noise mapping tool and the SNDWAY 523 professional sound level meter provides accurate and detailed data on noise levels in these localities.dBmap.net is an online tool that allows users to create noise maps based on data collected in the field. It is used to visualise the noise distribution in different areas and to identify the main sources of noise pollution. The SNDWAY 523 sound level meter is a professional device that accurately measures noise levels. It is used to collect real-time data and assess the impact of noise on the health and well-being of residents in the urban axis. Data was collected in the field from February to October 2024, research areas: centre -periphery-communication hubs-industrial centres.

Key words: Noise pollution, urban axis, dBmap.net, SNDWAY Sound Level Meter

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INTRODUCTION

Noise disturbance research is important because noise pollution, or unwanted and disturbing sound, is a pervasive feature of modern life (Zipf, Primack, & Rothendler, 2020). Noise pollution is defined as the presence of excessive, unwanted, unpleasant, loud, or disruptive sound in the environment has become an environmental issue that is increasing globally and has become a significant concern for the public health sector (Sarker, Nur-E-Alam Siddique, & Sultana, 2023). Urban noise can be considered one of the main sources of pollution (de Paiva, Cardoso, & Rodrigues, 2015). Nowadays, acoustical environmental quality in urban areas is threatened. The urban environment comprises several audible sources: traffic (road, rail, and air), industrial facilities, civil construction and social activities (parties, fairs open-air markets, and residential noise).

* Corresponding Author

These all contribute to the conversion of the sound scape into noise pollution. Road traffic noise is considered the main source of noise transportation in urban spaces and the most worrisome when it comes to annoyance (de Paiva, Cardoso, & Rodrigues, 2015). Environmental noise pollution in urban contexts is one of the challenges facing society today, mainly due to its impact on human health and well-being (González, Morillas, & Rey-Gozalo, 2023). Infrastructures for transporting people and goods are considered the main source of noise in this type of environment. Transport noise has become the second most important environmental source of ill health in Europe, after fine particulate matter pollution (González, Morillas, & Rey-Gozalo, 2023). Recent research keeps pointing out a close relationship between traffic noise and different types of diseases and health disorders such as anxiety (González, Morillas, & Rey-Gozalo, 2023).Urban residential noise has been identified in numerous studies as a significant contributor to social unrest and a risk to both physiological and psychological health due to stress. This makes the topic highly relevant to discussions on sustainable urban growth (MacCutcheon, 2021).

The regulatory framework (Romanian Parliament, 2019), sets limit values for the noise indicators L_night (night-time noise level) and L_day (daytime noise level). These values are essential for evaluating and managing environmental noise in various environments.
Limit values set by this order:

1. L_night (night):
- Residential areas: 55 dB ;
- Mixed areas(residential and commercial): 60 dB;
- Industrial areas: 65 dB.
2. L_day (day):
- Residential areas: 70 dB;
- Mixed areas(residential and commercial): 75 dB;
- Industrial areas: 80 dB.

Overcoming these values implies the existence of environmental factors that lead to the object of research: noise pollution in urban areas - urban axis. The geographical axis is defined as a ”line of spatiotemporal shape, a line that allows in a temporo-spaţial way, the diagnosis and geographical forecasting of a territory, a territory that can take different geometric conformations, and dimensions according to the capacity of component polarization” (Pop, 2003). Grafting the territorial planning activity in practice, for example, within the axis, must respond to the elaboration of the main indicators in the development and geographical harmonization of the territory (Pop, 2004): the study of natural, social and economic conditions. The geographical-social axis are concentrated and spread to and from the poles of development, the flows of population, goods, capital and information, playing an important role in their development and dynamics (Pop, 2016).

Noise pollution in cities is closely related to the urban geographic axis, mainly because of the way urban spaces are organized and used. Here are some important aspects: Road Traffic: The main source of noise pollution in cities is road traffic. Main streets and boulevards, which are often the geographic axis of cities, concentrate a high volume of vehicles, generating high noise levels1.

Public Transport: Public transport lines, such as trains and subways, usually follow an urban geographic axis. The noise generated by these means of transport contributes significantly to noise pollution, especially in densely populated areas. Industrial zones are often located along geographical axis to facilitate transportation and access. These areas can generate loud and constant noise, affecting nearby residents.

METHODOLOGY

To achieve coherent research a structure of the working method is used as follows: A. summary of techniques and working principle & B. Description of the apparatus for noise level measurement.

A.The paper uses the decibel meter technique which is used to develop an urban noise pollution database, the dBmap.net mapping tool for modelling external sound propagation, calculating acoustic levels of environmental and industrial noise sources and the geographical axis method, which performs material, energy, information and relational functions (Figure 1). The geographical axis method is used to investigate territorial tasks:

1. Urban structure: cities are organized around major transport axis such as boulevards, highways and railway lines. These axis are major sources of noise due to heavy traffic of vehicles, trains;

2. Urban zoning: in many cities, residential, commercial and industrial areas are demarcated. Industrial and commercial areas, often located along major thoroughfares, generate high noise levels due to manufacturing activities and freight traffic.

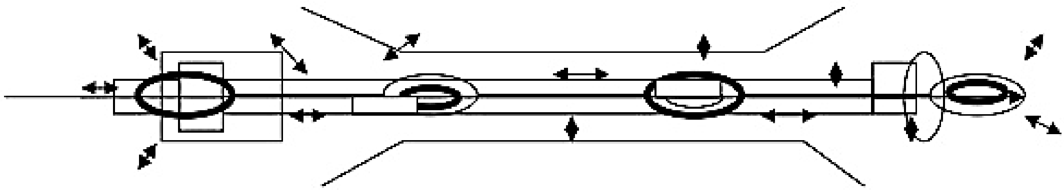

Figure 1. Composite model for spatial structures in the form of a geographic axis used in urban axis noise pollution research
Source: (Pop, 2016)

The geographical element where the geographical axis is built:

- Urban centers: Bistrița, Beclean, Năsăud, Sângeorz-Băi;
- Connecting roads: E 58, DN 17, DN17D, DJ 172B, and DJ 151, the two county roads (DJ), are important for regional connectivity;
- railroad connection: the railroad that crosses the cities of Bistrița, Beclean, Năsăud and Sângeorz-Băi is the Magistral CFR 400. It is one of the main railways in Romania and connects Brasov and Satu Mare, passing through Cluj-Napoca and Dej, Bistrița Nord railway ;
- Social and economic activities between urban centres.

A. SNDWAY 523 professional sound level meter plus decibel meter (Figure 2). The decibel meter has been designed to meet the measurement requirements of safety engineers, health, industrial safety offices and sound quality control in various environments including factory, office, traffic, family and audio systems. This easy-to-use sound level meter is designed for sound quality control. A practical tool for noise pollution monitoring, home theatre setup, health and safety compliance, vehicle noise testing, etc. It measures sound levels from 30dBA up to ~130dBA and loudness in sound over a wide frequency range (31.5Hz ~ 8KHz).

The microphone is a condenser microphone. A condenser microphone, also known as an electret condenser microphone, is a type of microphone that uses a condenser capsule to capture sounds and convert them into electrical signals.

The device has the MAX Hold function. The Max and Hold algorithm monitors one (or more) input signals and routes the maximum value to the output. While the "Hold" pin is held high (1), the output tracks and holds the maximum input value on all algorithm inputs. The maximum value is held and updated until the "Hold" pin is switched low. While the Hold pin is held low (0), the previous maximum value is forgotten. If there are multiple input signals, the maximum input value is transmitted; the same as with the standard "Max" algorithm.

If there is only one input, it is passed to the output unaffected. When the "Hold" pin is brought high again, the algorithm starts to track and hold the new maximum input signal value.

There is no memory between consecutive sequences of "Hold" The accuracy of the device is ± 1.5dB, it is resistant to dust, water and drops from 1.5 meters height.

For the device to optimally record noise pollution data, a pair of noise-cancelling headphones with a noise protection function is used to obtain conclusive data from the analyzed space.

Established in 2010, Sndway is a leader in precision measurement technology, specializing in hand-held laser distance meters, laser rangefinders, laser levels and environmental detector products sold in over 30 countries (https://sndway.co/). SNDWAY 523 plus decibel meter in field data collection, connected to headphones. Handling of the device following Law 121/2019 on the assessment and management of environmental noise.

Figure 2. Field data collection
(Source: Realized by the author according with the law no. 121, Romanian Parliament, 2019)

RESULTS

For a better organization, the results are structured as follows: I. summarised description of the urban space that makes up the geographical axis; II. data noise pollution, III. analysis of decibel level variation in the urban environment as a function of season and IV. comparison of decibel levels in the urban axis at the European Union Level.

I.The city of Bistrița, Bistrița-Năsăud county's residence municipality, is located in the Bistrița depression, on the lower course of the Bistrița Ardeleană River, at a average altitude of 358 m (Bâca & Onofreiu, 2016). Beclean, also known as Beclean on Someș, is a city located in Bistrița-Năsăud county, 252 meters above sea level, crossed by the river Someșul Mare, is an important road and railway junction connecting Bistrița to the other urban centres Năsăud respectively Sângeorz - Băi (Figure 3).

II.In establishing the noise database, frequent measurements of noise pollution, such as once every two days, are beneficial for the following reasons (Table 1):

- Continuous monitoring: These measurements allow constant monitoring of noise levels, helping to quickly identify any significant increases or decreases;
- Accurate and up-to-date data: The high frequency of measurements ensures that the data collected is always up-to-date and accurate, giving a clear picture of the current situation;
- Identification of noise sources: Regular measurements make it easier to identify specific noise sources and take action to control or reduce them;
- Evaluating the effectiveness of measures: If measures are implemented to reduce noise pollution, frequent measurements help evaluate these measures' effectiveness in a short time;
- Protection of public health: Noise pollution can have adverse health effects, and constant monitoring helps protect the public by controlling noise.

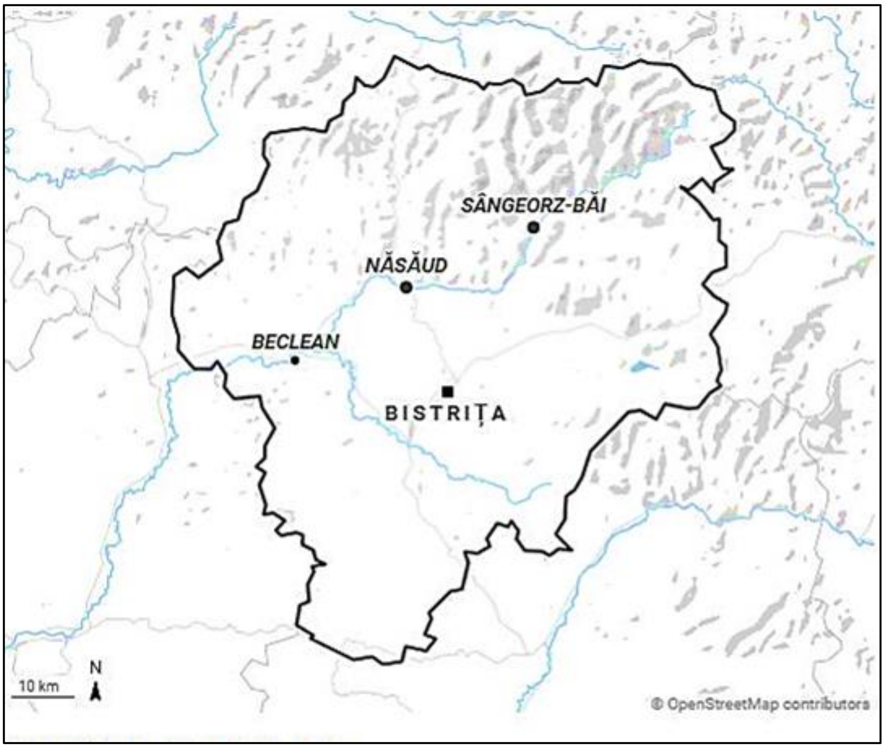

Figure 3. Location of the urban axis within Bistrița-Năsăud County
(Source: Realized by the author)

Table 1. Urban axis noise level database
(Data source : SNDWAY 523 plus decibel meter)

City	Day	Time	Periphery	Center	Road	Railway
Bistrița	Monday	06:00 09:00	58,4 dB	63,4dB	67,4dB	77,6 dB
		10:00 14:00	69,1dB	72,6 dB	74,8 dB	80 dB
		15:00 19:00	75,7 dB	80,8 dB	81,2 dB	90,1dB
		20:00 23:00	62,6 dB	68,4 dB	59,9 dB	62,1 dB
	Wednesday	06:00 09:00	57,7dB	63.9dB	69,8dB	78,4 dB
		10:00 14:00	69,9dB	74,2dB	77,5 dB	83,6 dB
		15:00 19:00	76,1dB	81,1dB	84,7 dB	94,2dB
		20:00 23:00	61,9dB	67.9dB	59,1dB	64,8dB
	Friday	06:00 09:00	59,9 dB	65,3dB	69,9dB	79,1 dB
		10:00 14:00	60,9dB	77,1dB	72,1 dB	88,7 dB
		15:00 19:00	79,8 dB	82,1dB	77,5 dB	97,9dB
		20:00 23:00	60,9dB	61,5dB	70,7dB	56,4 dB
	Sunday	06:00 09:00	48,6 dB	51,2dB	56,2 dB	60,1dB
		10:00 14:00	50,2dB	55,5dB	57,4dB	65,5dB
		15:00 19:00	52,1 dB	59,9 dB	58,3 dB	67,1 dB
		20:00 23:00	47,1 dB	51,8 dB	49,9dB	44,2 dB
Beclean	Monday	06:00 09:00	49,4dB	55,8dB	64,2dB	75,5dB
		10:00 14:00	54,1dB	59,9 dB	70,7dB	78,6dB
		15:00 19:00	57,6dB	60,3 dB	79,3dB	88,5dB
		20:00 23:00	49,1dB	50,2 dB	57,2dB	60dB
		06:00 09:00	46,7dB	50 dB	67,7dB	76,1 dB
		10:00 14:00	49 dB	57,7dB	75,8dB	81,8dB

	Wednesday	15:00 19:00	55,8 dB	62dB	82,3dB	91,2 dB
		20:00 23:00	49,9 dB	53,2 dB	57,5dB	62,4dB
	Friday	06:00 09:00	50,7 dB	58,4 dB	66,6dB	77,9dB
		10:00 14:00	52,2dB	60,1dB	55,4dB	86dB
		15:00 19:00	55dB	63,4 dB	75,2dB	96,3dB
		20:00 23:00	51,1 dB	54,4dB	68,7dB	54,1dB
	Sunday	06:00 09:00	41,9dB	48,7dB	53,8dB	58,6dB
		10:00 14:00	50,8dB	60,1dB	54,9dB	64,2dB
		15:00 19:00	55dB	63,4 dB	56,6dB	65,7dB
		20:00 23:00	52,6 dB	54,4dB	47,7dB	42,8dB
Năsăud	Monday	06:00 09:00	48,8dB	50,1dB	63,2dB	74,2dB
		10:00 14:00	53,3dB	59dB	69,8dB	77,3dB
		15:00 19:00	58,9dB	61dB	78,4dB	87,5dB
		20:00 23:00	53,2dB	55,1dB	56,1dB	59,2dB
	Wednesday	06:00 09:00	50,1dB	53,3dB	66,6dB	75,7dB
		10:00 14:00	52,7dB	59,8dB	74,3dB	80,8dB
		15:00 19:00	57,7dB	63,2dB	81,1dB	90,5 dB
		20:00 23:00	51,9dB	54,6dB	56,8 dB	61dB
	Friday	06:00 09:00	50,4dB	52,3 dB	65,7 dB	76,4 dB
		10:00 14:00	54,4dB	58,8dB	54,2 dB	85,5dB
		15:00 19:00	52dB	54,4dB	74,8dB	95,8dB
		20:00 23:00	49,8dB	50dB	67,9dB	53,6dB
	Sunday	06:00 09:00	46,9dB	49,8dB	52,3dB	57,4dB
		10:00 14:00	49,7dB	50,6 dB	53,1dBB	63,2dB
		15:00 19:00	46,8 dB	54,4dB	55,5 dB	64,7dB
		20:00 23:00	49,8dB	50dB	46,1dB	41,9 dB
Sângeorz -Băi	Monday	06:00 09:00	50,3dB	54,4dB	62,8dB	73,4dB
		10:00 14:00	54,6dB	59,2dB	68,3dB	76,6dB
		15:00 19:00	59,8dB	52,3dB	77,7dB	86,2 dB
		20:00 23:00	50dB	52,3dB	55,6dB	58,8dB
	Wednesday	06:00 09:00	51,1dB	54,4dB	65,2dB	74,2dB
		10:00 14:00	53dB	58,1dB	64,9dB	79,7dB
		15:00 19:00	56,6dB	60dB	80dB	89,5dB
		20:00 23:00	51dB	53,4dB	54,4dB	60dB
	Friday	06:00 09:00	61,6dB	68,8dB	63,9dB	75,5dB
		10:00 14:00	72,6 dB	78,7dB	53,7dB	84,6dB
		15:00 19:00	73dB	74,4dB	73,5dB	94,2dB
		20:00 23:00	73,7dB	71,1dB	66,3dB	52,8dB
	Sunday	06:00 09:00	49,1dB	49,8dB	51,1dB	56,2dB
		10:00 14:00	53,7dB	55,4dB	52,8dB	62,5dB
		15:00 19:00	54,1dB	58,5dB	50,1dB	61,1dB
		20:00 23:00	43,5 dB	49,9dB	45,6dB	40,9dB

Observations from the data provided in Table 1:

- Exceedances of the noise limits established by the regulatory framework are recorded;
- The decibel level is influenced by urban size, traffic volume and time. A larger city has higher noise pollution ;
- The time interval when the decibel level is high in all the studied urban environments is between 15:00-19:00, the downtown area is noisier than the suburbs due to the economic activities under taken and traffic ;
- Sunday is the quietest day of the week when the decibel level is lower.

Analysis of the noise level on the main access roads in the urban axis (Figure 4).

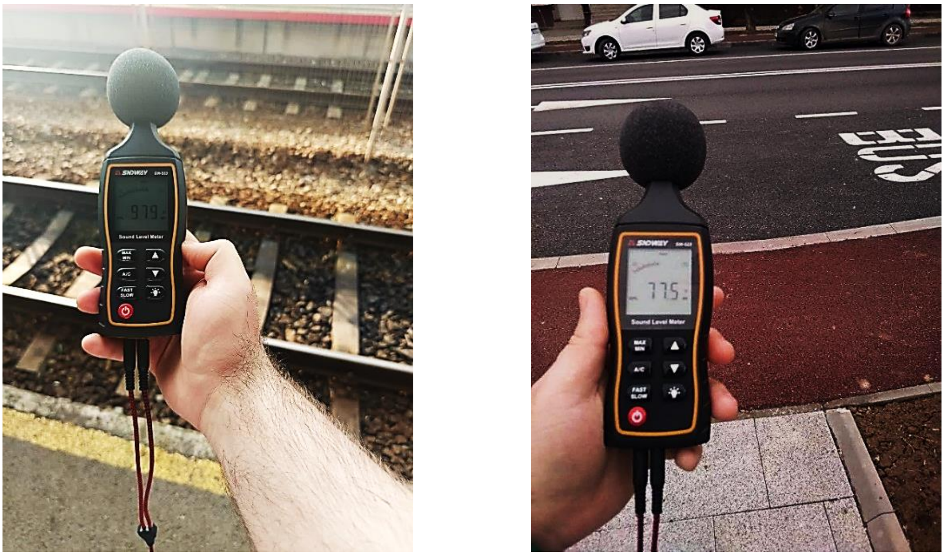

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Figure 4. Noise pollution point measurements
(Source: Realised by the author)

Values recorded:

- 4a. Route 400 CFR (Romanian Railways), adjacent railways section 406: 97.9 dB;
- 4b. National Road 17 (DN 17): 77.5 dB.

These measurements were taken during the daytime between 15:00 and 19:00. This period is characterized by heavy weekday traffic in cities, often coinciding with lunch breaks and the times when many people return to work or complete their morning activities. Sound level measurements were conducted at a major passenger and goods landing point in the urban axis (Figure 5). Noise level measurements were also taken in residential areas (Figure 6).

Figure 5. Value recorded in the main transportation
(Source: Realised by the author)

Figure 6. Daytime noise level measurement in the residential area
(Source: Realised by the author)

Values recorded:

- Station: 54.3 dB (where trains stop to allow passengers to board or alight) in Bistrița-Năsăud county, an important node in the flow of freight transport between urban axis, Bistrița Nord railway station. Friday, 15:00;
- Friday, Bistriţa, 15:00: 82.1 dB.

Investigation of noise levels in residential areas in the geographical axis (Figure 7).

c

d

e

f

Figure 7. Night-time recorded values in residential areas
(Source: Realised by the author)

Values recorded:

- 6c Bistrița: 43.2 dB;
- 6d Beclean: 52.6 dB;
- 6e Năsăud: 46.8 dB;
- 6f Sângeorz - Băi: 43.5 dB.

These measurements were taken on Sunday during the time interval 20:00-23:00. Analysis of urban axis areas that influence noise levels (Figure 8, Figure 9, Figure 10, Figure 11).

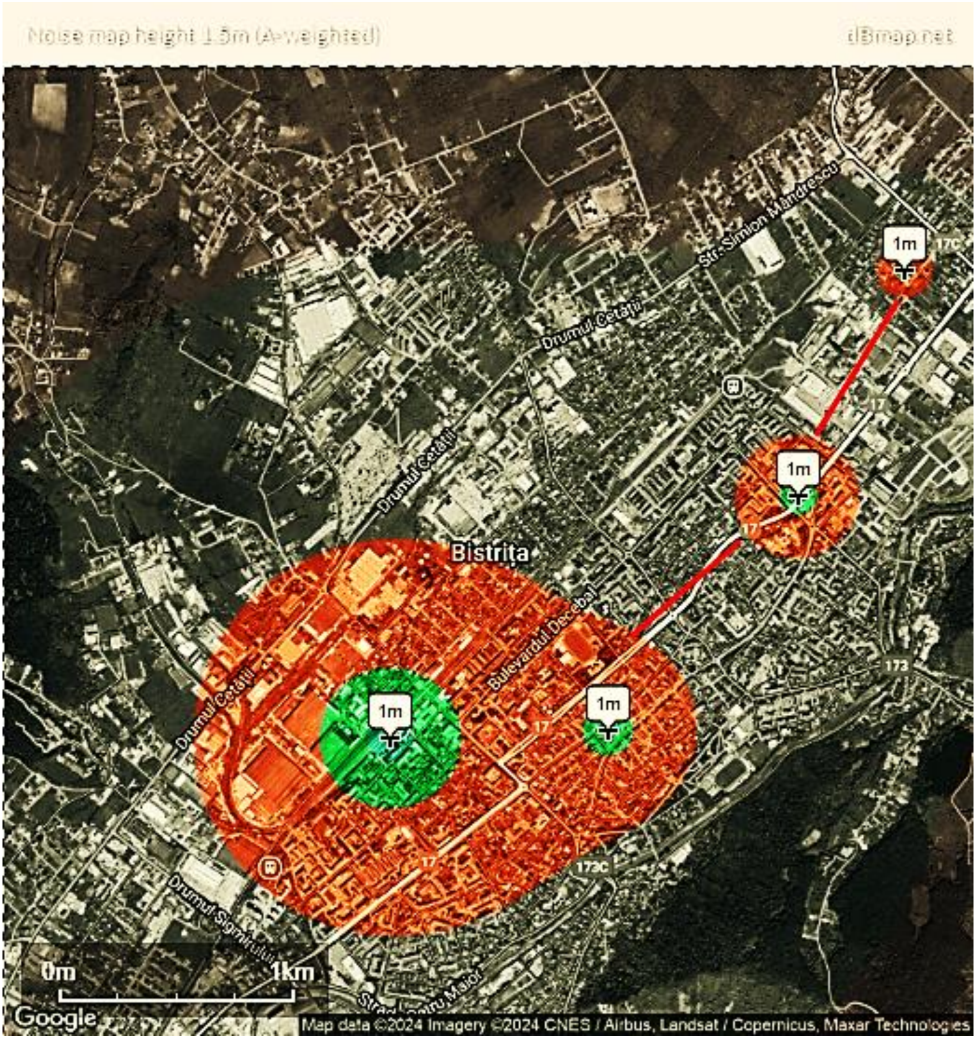

Figure 8. Major noise producing areas measured in the site
(Source: Realised by the author in dBmap.net Noise Mapping Tool)

The center, railway station, National Road 17, and the periphery are marked with green as the nucleus of production, and orange as the land area of the urban space under the immediate impact and influence of the nucleus of production.

The values were taken from Table 1 during the chosen time interval of 15:00-19:00.

It should be noted that there is a connecting corridor marked with a red line between the three areas, indicating disturbances in the sound level meter.

Figure 9. Major noise producing areas measured in the site
(Source: Realised by the author in dBmap.net Noise Mapping Tool)

The center, railway station, National Road 17, and the periphery are marked with green as the nucleus of production, and orange as the land area of the urban space under the immediate impact and influence of the nucleus of production.

The values were taken from Table 1 during the chosen time interval of 15:00-19:00.

In contrast to Bistrița, the measurements in Beclean indicate only one compact area that produces major changes in the sound level meter.

The railway station, National Road 17 D, and suburbs are marked with green as the production nucleus, and orange as the land area of the urban space under the immediate impact and influence of the production nucleus.

The values were taken from Table 1 during the chosen time interval of 15:00-19:00.

In contrast to Bistrița, the measurements in Năsăud indicate only one compact area that produces major changes in the sound level meter, with lower values and a smaller propagation area compared to Beclean.

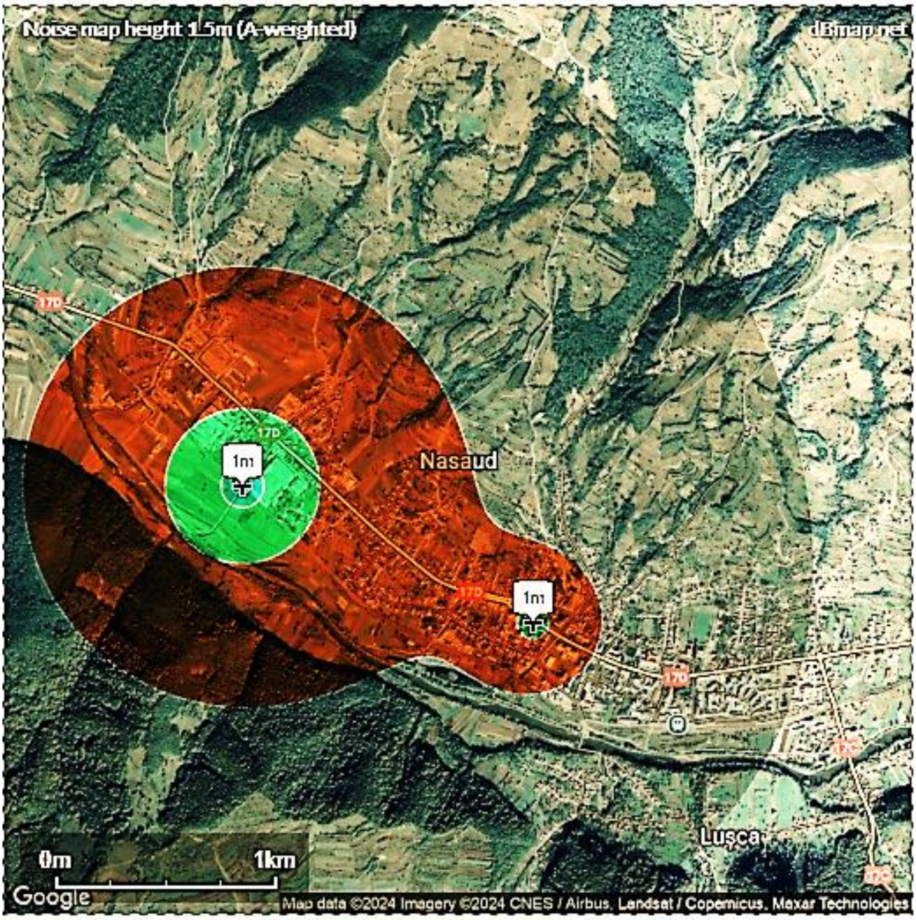

Figure 10. Main noise emitting areas measured
(Source: Realised by the author in dBmap.net Noise Mapping Tool)

The centre, National Road 17 D, and the periphery are marked with green as the production nucleus, and orange as the land area of the urban space under the immediate impact and influence of the production nucleus.

Values were taken from Table 1 during the chosen time interval of 15:00-19:00.In comparison to Bistrița, in Sângeorz-Băi there is, according to the measurements, only one compact area that produces major changes in the sound level meter, the difference with Beclean and Năsăud lower values, smaller propagation area.

III. Decibel levels can vary with the season for several reasons. Summer (June, July, August) is the season with the highest decibel levels. Although decibel levels can vary depending on location and specific activities, summer is generally the season with the highest noise levels due to human and natural activities.

Urban sound propagation is influenced by meteorological conditions, causing refraction and scattering of sound waves (Trikootam & Hornikx, 2019).

Major factors influencing outdoor sound propagation are meteorological effects due to wind, temperature (summer) , turbulence and humidity, causing refraction, scattering and air absorption of sound waves (Trikootam & Hornikx, 2019). The second set of factors influencing urban sound propagation is the urban topology, causing reflection, absorption, and diffraction of sound waves upon interaction with the ground, vegetation, buildings, and other objects.

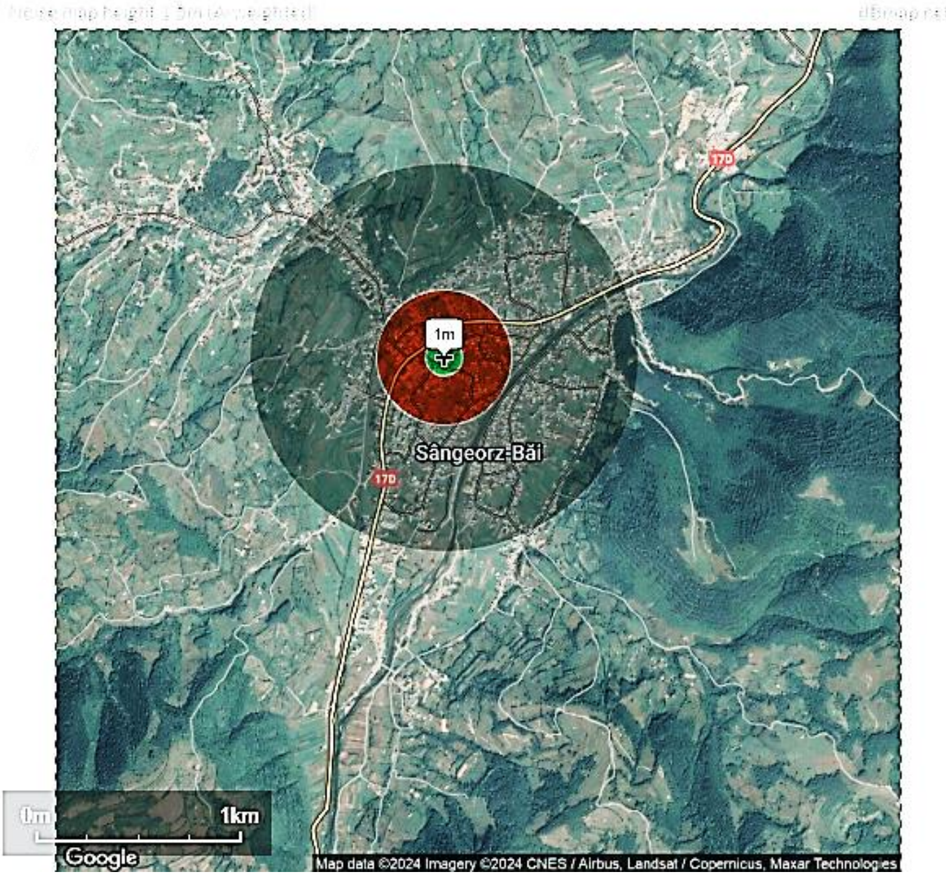

Figure 11. Main noise emitting areas measured in the field
(Source: Realised by the author in dBmap.net Noise Mapping Tool)

In urban areas, many noise sources are typically shielded by buildings, potentially leading to favourable quiet areas. However, due to meteorological ,temperature effects, shielded (distant) noise source may propagate over the urban topology and increase noise levels (Trikootam & Hornikx, 2019).

Through the results of the current study, it was noticed that there is asignificant difference between the sound levels during the summer and its levels in winter, where the readings in the summer were higher than in winter due to the frequent use of air conditioners, fans, generators and other noise-causing devices, in addition to the fact that people are more active in the summer (Qzar, 2022).

In summer, weather conditions can influence sound propagation. For example, heat can create air stratification that amplifies noise. Currently, the frequent occurrence of extreme weather and global warming is significantly affecting the environment, ecosystems, society, and health. These changes also have pressing economic impacts on labor, capital, goods, and services.

Notably, the increasingly severe urban summer high temperatures, exacerbated by urban heat islands, are widely recognized as a major factor that directly or indirectly threatens human health (Huang, Li, Zhao, & Wei, 2022).

Outdoor environmental noise is a major source of discomfort in urban areas and exposure to it can increase the risk of serious health problems (Andargie, Touchie, O'Brien, & Müller-Trapet, 2023). It is higher in summer.

Noise pollution caused by construction activities in urban areas is a serious problem. Construction noise can adversely affect people's health and well-being (Mostafa et al., 2023). During summer, many construction projects are carried out during the summer, increasing the noise levels of machinery.

Transportation activities, especially in urban areas, continue to be a significant source of air and noise pollution (Mansour & Aljamil, 2022).

Many factors contribute to the increase in road traffic noise, particularly on highways, including the noise generated by a vehicle's engine, exhaust fumes, tire contact with the road surface and the interaction between moving vehicles and the passing air, road conditions and traffic management, vehicle speed and traffic composition (Mansour & Aljamil, 2022).

During the summer, many people travel for vacations or leisure activities, which leads to an increase in traffic.

For the cities in the geographical axis Bistrița, Năsăud, Beclean and Sângeorz-Băi, differences in decibel levels can be observed depending on several factors specific to each city:

- Size and urban activity: Bistrița has the highest noise level due to its size and various activities, followed by Beclean, which has an industrial activity;
- Cultural events: Năsăud and Sângeorz-Băi may experience seasonal increases in noise, but in general their levels are lower compared to Bistrița. Although all these cities may experience higher noise levels in summer, Bistrița stands out due to its intense urban activity, while the other cities have more variable noise levels, influenced by their size and specific activities (Table 2).

The results in Table 2 represent the average of the three summer months. The measurements were carried out at the locations identified in the study as the main noise pollution areas (train station, downtown, main road, events).

Table 2. Decibel levels in the summer
(Data source : SNDWAY 523 plus decibel meter)

City	Decibel Level (dB)
Bistrița	81
Beclean	74,1
Năsăud	69,8
Sângeorz-Băi	68,7

Using the arithmetic mean, the average decibel level recorded during summers in the analyzed urban axis is calculated. The result is 73,4dB. A noise level of 73.4 dB for the urban axis Bistrița-Beclean-Năsăud-Sângeorz-Băi (during summers) is considered noise pollution. Prolonged exposure to such levels can lead to stress, sleep disturbances and other health problems.

IV. This indicator offers an overview of the estimated number of people in Europe exposed to environmental noise exceeding the threshold levels established by the Environmental Noise Directive (2002/49/EC) in both urban and rural areas. It also accounts for the number of people exposed to more stringent thresholds set by the World Health Organization (WHO Europe, 2018) Environmental Noise Guidelines in the European Region (WHO Europe & JRC, 2011). In line with the lowest available values used in noise mapping for measuring noise pollution under the END, threshold values of 55dB for the day-evening-night period and 50dB for the night-time period were applied for the indicator. Additionally, since health impacts begin below the thresholds set in the END, an extrapolation of the population exposed to the WHO recommended levels has been calculated for 2022.

The END is the primary EU instrument for monitoring noise emissions and developing actions. It defines environmental noise as 'unwanted or harmful outdoor sound created by human activities, including noise from transport, road traffic, rail traffic, air traffic, and industrial sites.' It requires EU Member States to assess noise levels by creating strategic noise maps for all major roads, railways, airports, and urban areas (European Union law, 2002). Based on these noise-mapping results, Member States must develop action plans with measures to address noise issues and their effects in areas where specific END threshold values (i.e., 55dB averaged over day-evening-night periods (Lden) and 50dB averaged over night-time periods (Lnight)) are exceeded (Ministry of Environment, Waters and Forests, 2021). The study carried out shows that the Bistrița-Beclean-Năsăud-Sângeorz-Băi urban axis exceeds the average decibel level set by the European Union. Measures to combat noise pollution in urban areas are recommended.

CONCLUSIONS

Conducting field research was a crucial aspect of the study. The use of professional tools, such as DBMAP.NET and SNDWAY 523, allowed the collection of accurate and relevant data. Measurements were carried out in the urban axis Bistrita-Beclean-Năsăud-Sângeorz-Băi and times of the day, to capture temporal variations in noise levels. This rigorous methodological approach ensured the accuracy and reliability of the results, providing a solid basis for further mitigation recommendations.

The findings from the study underscore the pressing need for targeted noise mitigation measures in identified hotspots. The consistently high decibel levels in central Bistrița and along main roads in Beclean and Năsăud suggest that these areas are significantly impacted by traffic and urban activities.

Field research has identified a value of 73,4 decibels in the urban area of Bistrița-Năsăud county is significant and can have multiple effects on the health and well-being of residents. This persistent noise pollution not only affects the quality of life for residents but also poses potential health risks, including stress, sleep disturbances, and cardiovascular issues.

The study identified varying noise levels across different locations and times of day. Urban areas, particularly near major roads and intersections, exhibited higher noise levels, often exceeding the recommended limits. Noise levels were generally higher during peak traffic hours, with significant reductions observed during late night and early morning hours. This temporal variation highlights the impact of human activities on noise pollution. Specific areas, such as central Bistrița and main roads in Beclean and Năsăud, were identified as noise pollution hotspots.

These areas consistently recorded higher decibel levels, indicating a need for targeted noise mitigation measures.

To address these challenges, several strategies can be implemented:

- **Traffic Management:** Implementing measures such as traffic rerouting, speed limits, and the promotion of public transportation can help reduce noise levels. Encouraging the use of electric vehicles, which are quieter than traditional combustion engines, can also contribute to noise reduction;
- **Urban Planning**: Incorporating noise barriers, green spaces, and buffer zones in urban planning can help mitigate noise pollution. Green spaces not only absorb sound but also provide a visual and recreational respite for residents;
- **Building Regulations**: Enforcing stricter building codes that require sound proofing materials in construction can help reduce indoor noise levels. This is particularly important for buildings located near major roads and intersections;
- **Public Awareness Campaigns:** Educating the public about the sources and effects of noise pollution can encourage community involvement in noise reduction efforts. Simple actions, such as reducing the use of car horns and maintaining vehicle engines, can collectively make a significant difference;
- **Silent Technology Grants:** Provide subsidies and financial incentives for the purchase of quiet technologies, such as electric vehicles and industrial equipment with low noise levels. These measures can encourage the use of quieter technologies and help reduce noise in urban areas;
- **Use of Smart Building Materials:** Development and deployment of smart building materials that can absorb and reduce noise. These materials may include

nanotechnology acoustic panels that can be integrated into buildings and infrastructure to mitigate noise pollution;

- **AI-Based Noise Control Technologies**: Developing artificial intelligence (AI)-based noise control technologies that can analyze and predict noise levels and implement mitigation measures automatically. These technologies can be integrated into urban infrastructure to optimize noise mitigation. Artificial intelligence-based noise control technologies use advanced algorithms and machine learning techniques to analyze sound patterns and predict noise levels in real time. These algorithms can distinguish between different types of noise, such as traffic, construction and human activities, allowing specific mitigation measures to be implemented;
- **Continuous Monitoring**: Establishing a continuous noise monitoring system using tools like the DBMAP.NET noise mapping tool and the SNDWAY 523 professional sound level meter can help track noise levels and assess the effectiveness of implemented measures.

This data can be used to make informed decisions and adjust strategies as needed.

The use of GIS-based noise mapping in this study has proven to be an invaluable tool in visualizing noise distribution and identifying critical areas for intervention. By providing a clear and detailed representation of noise levels across different locations and times of day, it enables policymakers and urban planners to prioritize actions and allocate resources effectively.

The research highlights the significant impact of human activities on noise pollution and the need for comprehensive and targeted measures to mitigate its effects. By implementing a combination of traffic management, urban planning, building regulations, public awareness, and continuous monitoring, it is possible to create a quieter and healthier environment for the residents of Bistrița, Beclean, Năsăud, and Sângeorz-Băi.

COMPETING INTERESTS

The author declares that they have no conflict of interest

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