Noise pollution and quality of life

Simion Sorin [1*], and *Vlad* Lăutaru[1]

[1] National Institute for Research and Development in Mine Safety and Protection to Explosion – INSEMEX Petroşani, 32-34 G-ral Vasile Milea Street, Petroşani 332047, Romania

Abstract. A direct consequence of accelerated urbanization, which—alongside its benefits—also brings significant environmental challenges, is the growing issue of noise pollution. In Romania, noise pollution has become an increasingly pressing concern, with high levels of noise exposure being pervasive, particularly in urban areas. Environmental noise pollution, primarily resulting from excessive ambient sound generated by traffic, industrial activities, and other anthropogenic sources, adversely affects human health and overall quality of life, as well as the environment. Persistent, high-intensity noise can lead to chronic activation of the nervous system, which, over time, may contribute to the onset of serious health conditions, including hypertension, cardiovascular diseases, and even stroke. Furthermore, long-term noise exposure has been shown to impair cognitive functions, diminishing concentration, memory, and workplace performance. Directive 2002/49/EC on the assessment and management of environmental noise obliges EU Member States to monitor and manage noise in urban areas, as well as in the vicinity of airports, railways, and major roads. Permissible noise limits vary depending on national or international regulations and the specific context in which noise is assessed. In Romania, acceptable environmental noise levels are established by the national standard SR 10009:2017. These limits are defined according to zones and functional areas, as outlined and regulated in local urban planning and environmental protection documents.

1 Introduction

Noise is an invisible, odourless, and tasteless hazard for population, which cannot be eliminated or purified like ordinary waste.

Noise pollution is defined as unwanted, unpleasant, or disturbing sound that causes discomfort to all living beings, also placing ecological stress on urban wildlife. Urban noise pollution represents a major concern for people living and working in cities, acting as a stress factor that affects both physical and mental health, reduces the quality of life of those impacted, and has repercussions on work efficiency, causing stress and discomfort. [1]

Noise pollution is one of the main issues faced by urban communities, having harmful effects on the urban environment and generating high costs for its mitigation.

Urban areas are noisier than rural ones because of higher population density and higher frequency of production-related activities. Urban noise levels are a complex mix of sounds,

* Corresponding author: sorin.simion@insemex.ro

with the main sources of noise pollution being vehicular traffic, factories, industries, and various anthropogenic activities.

The continuously increasing number of vehicles in urban agglomerations, along with the noise generated by car engines and exhaust systems of cars, trucks, buses, and motorcycles, is the primary source of noise pollution in urban areas.

Each individual reacts to or perceives noise differently, depending on factors such as age, gender, and emotional state. Adults and children are not equally affected by noise, with children being more susceptible to developing hearing impairments because of noise exposure. People with hearing impairments, the elderly, and children are more vulnerable to noise interference with verbal communication.

The main descriptor that defines the impact of noise in residential environments is introduced by Directive 2002/49/EC [1,4], namely the day-evening-night level (L_den), which is an annual average over a 24-hour period. The World Health Organization (WHO) [2] recommendations for assessing the health impacts of noise also consider the average annual equivalent nighttime noise level, L_night. In Romania, the formula for determining L_den is as follows:

$$L_{zsn} = 10\lg\left[\frac{1}{24h}\left(t_{zi} * 10^{0.1L_{zi,12}} + t_{seară} * 10^{0.1(L_{seară4}+5\ dB)} + t_{zi} * 10^{0.1(L_{noapte,8}+10\ dB)}\right)\right] dB \quad (1)$$

Where [6,7]

- L_{zsn} – day-evening-night weighted sound pressure level
- L_{zi} – equivalent sound level for the daytime reference interval
- $L_{seară}$ – equivalent sound level for the evening reference interval
- L_{noapte} – equivalent sound level for the night time reference interval
- t_{zi} , $t_{seară}$, t_{noapte} are expressed in hours, with the sum: și $t_{zi} + t_{seară} + t_{noapte} = 24h$

In Romania, the default time intervals are 12h (day), 4h (evening), and 8h (night).

To quantify the effects and establish measures for reducing urban noise pollution, the following aspects must be considered:

- Identification of major noise sources and the neighbouring areas affected;
- Establishing noise levels using sound level determinations in accordance with applicable standards;
- Evaluating the obtained noise level values by comparing them with the maximum values allowed under national legislation;
- Proposal of measures and actions to reduce noise levels;
- After applying noise reduction measures, the effectiveness of the measures applied must be assessed by repeating noise level measurements.

Applying the limits defined in the SR 10009:2017 standard, locations where there may be excessive noise exposure – beyond the maximum values allowed at the functional area boundary – were identified and noise level measurements were carried out in the areas of these locations where noise reduction measures were deemed necessary. [4,3]

Noise pollution has a negative impact on human health, affecting residents of urban areas daily. A common problem that exposure to ambient noise causes is hearing impairment, with some neuropsychological and physical effects, such as:

High blood pressure

- Central nervous system damage - headaches, dizziness, stress
- Stomach disorders - gastritis
- Circulatory system damage - myocardial infarction
- Disturbance of rest and recovery periods
- Reduced concentration capacity which can also generate memory problems
- It can also generate behavioural disorders increasing aggression and irritability [7]

2 Working instruments

The noise levels were analyzed with the BZ 5503 analysis software, the measured values were obtained with a Bruel & Kjaer type 2250 sound level meter, equipped with 1 octave and 1/3 octave bandpass filters, and a Bruel & Kjaer type 4231 calibrator was used for calibration.

To guarantee the quality of the measurement results, only sound level meters and calibrators verified in accordance with the metrological legislation in force are used. For environmental measurements, metrological verification is recommended every 2 years [3,12].

Fig. 1. Sound level meter type 2250 Acoustic calibrator type 4231 [1]

The type 2250 sound level meter (Fig. 1) used for performing point determinations and for series of measurements complies with the standard requirements for both field and laboratory determinations.

The type 4231 calibrator (Fig. 1) is used for checking the sound level meters both before and after each set of measurements, to guarantee the functionality of the equipment, before and after the measurements.

The type 4231 acoustic calibrator provides a stable sound pressure of 94 dB at a frequency of 1 kHz being minimally affected by environmental factors, so if the values resulting from two successive calibrations differ by more than ±0.5 dB, the sound level meter must be inspected for metrological compliance. [8,12]

The test report must also contain an estimate of the measurement uncertainty, having as main factors:

- Uncertainty of the measuring equipment (sound level meter, calibrator)
- Uncertainty generated by the microphone placement
- Minimum number of determinations
- Uncertainty generated by meteorological conditions
- Temporal and spatial variation of noise generating sources

3 Case study

As part of the research conducted by INCD INSEMEX Petrosani on urban noise pollution, a series of noise measurements were carried out to assess the level of noise pollution generated by road traffic in the eastern area of the Jiu Valley. The monitoring points were located at

major intersections, especially along national roads (DN 66) and boulevards such as 1 Decembrie 1918.

Table 1 presents the measured noise levels for each monitoring point (expressed as LAeq dB(A)).

Table 1. Noise level values obtained during the monitoring period

No.	Location	February	March	April	May
1	Roundabout General Trans	72.3	69.6	71.3	71.4
2	Livezeni street	65.2	72.2	72.1	73.1
3	Airplane roundabout	71.3	69.3	69.8	71.2
4	University	55.3	54.2	55.6	58.5
5	Piața Victoriei roundabout	63.2	70.1	71.2	72.3

Graphical representation of the comparison of the obtained results (table.1) with the maximum legal limit values specified by SR 10009:2017 (fig.2) for the 5 monitoring points.[5]

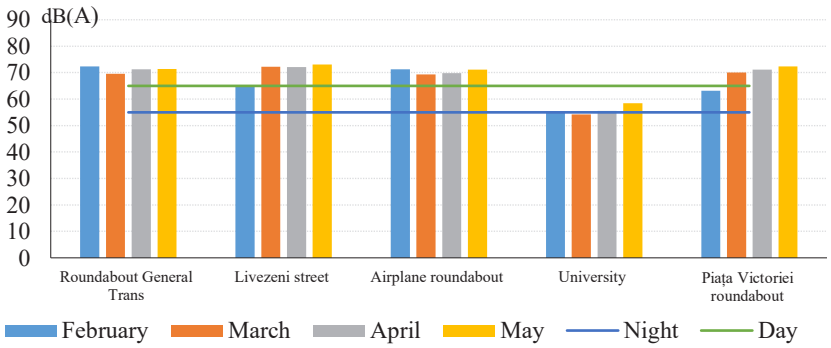

Fig. 2. Graphical representation of the results obtained and the limits established by current legislation for the respective night and day periods

It is observed that the level of noise exposure is high, exceeding the limits set by current legislation. Thus, exposure to ambient noise represents a health risk factor. It has been found that low-intensity, disturbing noise—caused by permanent or semi-permanent action, both day and night—that propagates into homes, constitutes a risk factor for the human body by having an irritating effect. [9]

Insomnia caused by exposure to urban noise contributes to the occurrence or worsening of cardiovascular diseases and nervous disorders by inducing a feeling of fear and/or increasing aggression.

It is necessary to ensure a low noise level in learning spaces, so as not to affect the learning process, because noise creates difficulties in learning, affecting attention.

Since we are surrounded by sounds all the time, by adapting to them, in most cases activities can continue ignoring these "sounds", but as their level and respectively their intensity increases overlapping with other sound sources, the sensation of "noise" appears,

which is defined as an unpleasant sound becoming a polluting factor for the living environment. [1,10]

The effects on the human body, generated by exposure to environmental noise, can be aggravated by several factors:

• the physical characteristics of the noise: continuous or intermittent; frequency, intensity, duration.

• the sensitivity / adaptability to noise of the exposed persons influenced by: activity performed, level of fatigue, age, habit, mood, sensitivity, state of health;

• Environmental factors: atmospheric pressure, humidity, size of the space in which the activity is carried out, acoustic characteristics of the rooms, etc.

Within the European Union, almost 40% of the population is exposed to road traffic noise levels exceeding 55 dB(A), measured as A-weighted sound pressure over a 24-hour period, and 20% of the population is exposed to levels exceeding 65 dB(A). If noise from all types of transport is taken into account, it emerges that almost half of the EU population lives in areas where acoustic comfort is not ensured. [11]

During nighttime, it is estimated that more than 30% of the population is exposed to levels exceeding 55 dB(A), which disturb sleep. [11]

In particular, environmental noise contributes to the increase in urban pollution, influencing the health of the population; therefore, monitoring external noise levels around buildings and assessing the impact on health are essential components of preventive activities.

In order to avoid excessive exposure to ambient noise, the Order of the Ministry of Health no. 119/2014, Chapter I, Article 16 [1] stipulates:

a) During the day, the equivalent continuous A-weighted sound pressure level (AeqT), measured outside the home according to the SR ISO 1996/2 standard, at a height of 1.5 m from the ground, must not exceed 55 dB [7].

b) During the night, between 23:00–07:00, the equivalent continuous A-weighted sound pressure level (LAeqT), measured outside the home according to the SR ISO 1996/2-18 standard, at a height of 1.5 m from the ground, must not exceed 45 dB. [6,7,8]

4 Conclusions

After carrying out the determinations and interpreting the results presented above, the following conclusions can be expressed:

• Noise measurements show that the noise exposure level exceeded the 65 dB(A) limit with values ranging between 0.2 ± 7.2 dB(A) at most of the monitored points during the 4-month monitoring period for the daytime value.

• The reduction of urban noise, mainly road traffic noise, is a complex problem that requires the allocation of long-term financial resources. The ultimate goal is to reduce the number of people affected by noise, by improving acoustic comfort by reducing the level of noise generated by urban activities. The main challenges raised by the implementation of a noise exposure reduction system are the choice of optimal solutions applicable to the particular acoustic characteristics of each case and the financial resources necessary to implement the solutions.

To establish an effective system for reducing the population's exposure to urban noise, the first step involves adopting relatively inexpensive technical and organizational measures, such as:

- Paving roads to reduce rolling noise;
- Reducing vehicle speed limits and/or weight restrictions in urban areas;
- Introducing one-way traffic on side streets;
- Promoting electric vehicles;

- Soundproofing homes near traffic arteries;
- Planting ornamental shrubs.

Where these measures cannot be applied or noise levels are very high, more costly measures are required, such as:

- Installing noise barriers;
- Building bypass roads to relieve urban traffic congestion;
- Constructing overpasses or underpasses, etc.

In conclusion, road traffic represents a general problem in most localities that do not have detour alternatives for redirecting transit traffic, the crossing by national and/or European roads increasing noise pollution, - not only in large urban agglomerations (according to Law no. 121 of July 3, 2019) with populations of over 100,000 inhabitants.

Noise reduction measures must be uniformly applied in all localities so that road traffic noise affects as few people as possible and the ecological stress on urban fauna is minimized. These measures should not be applied only in large cities, which are subject to ambient noise monitoring via noise maps developed according to Law 121/2019.

This work was carried out through the "Nucleu" Program within the National Plan for Research, Development and Innovation 2023-2026, with the support of the Romanian Ministry of Research, Innovation and Digitalization, project no. 23 32 01 01, title: Modernization of the research infrastructure for complete investigation of both physical and chemical parameters of environmental components' quality in situ within landfills as well as in work environments in order to increase the degree of safety and health.

References

1. S. Simion, M. Kovacs, L. Toth - *Urban noise, a source of discomfort*, MATEC Web of Conferences 389, 00043, 2024.
2. S. Simion, A.N. Găman, A.F. Simion, M.E. Kovacs, L. Toth, *Exposure of Workers to Occupational Noxae*, MATEC Web of Conferences 343:10008, 2021
3. S. Simion; C. Vreme; M. Kovacs; et al. *Exposure of workers to noise in mining industry* Edited by: Herisanu, N; Marinca, V Conference: 12th International Symposium Acoustics and Vibration of Mechanical Structures (AVMS 2013) Location: Timisoara, Romania, Date: May 23-34, 2013
4. ***LAW no. 121 of July 3, 2019 regarding the assessment and management of ambient noise, issued by the Parliament of Romania Published in the Official Gazette no. 604 of July 23, 2019
5. ***SR 10009:2017/C91:2020 Acoustics. Admissible limits of the noise level in the ambient environment
6. SR ISO 1996-1:2016 Acoustics - Description, measurement and evaluation of environmental noise - Part 1: Fundamental quantities and evaluation methods
7. ***SR ISO 1996-2:2018 Acoustics. Description, measurement and evaluation of environmental noise. Part 2: Determination of environmental noise levels
8. ***SR 6161-1:2022 Acoustics in construction. Part 1: Determination of the noise level in civil constructions and urban settlements. Methods of determination
9. *** https://www.eea.europa.eu/ims/exposure-of-europe2019s-population-to
10. *** https://stratos.ro/en/poluarea-fonica-ce-este-si-care-sunt-cauzele/
11. ***https://www.ajol.info/index.php/johasam/article/view/272063/256782
12. ***https://www.hbkworld.com/en/services-support/support/support-bksv/downloads/2250-maintenance/user-manuals