

Research Paper

Case Study of the Environmental Noise and its Perception in the City of Cluj-Napoca, Romania

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The noise perceiving issue is very subjective and depends on several factors, such as: the living environment in which each person has grown and developed, the education they have received, the culture in which their life principles have formed and, last but not least, the social and financial status. Therefore, in order to establish effective actions in multiple directions when it comes to any urban noise analysis, it is very important to know the perception and the subjective reactions of the individuals involved. The paper respects this idea, presenting the results of a sociological study on urban noise, applied in the city of Cluj-Napoca, Romania. The intention was to capture the reactions of the permanent residents of the city, but also of the people in transit, as well as to analyse the changes that occurred as result of the implementation of the Environmental Noise Directive (European Commission). The study shows that 75.2% of the respondents consider that the noise in the city has increased in the last ten years and 58% of them have rated the noise as level 4 or 5 on a five point scale. Information related to noise maps and actions taken to reduce community noise has no sufficient dissemination. There is also a medium to low reaction of the population in correlation to the declared noise annoyance.

Keywords: environmental noise; noise perception; sociological survey; annoyance.

1. Introduction

The process of perception is influenced by several factors that affect its dynamics and completion (STANGOR *et al.*, 2014; ROȘCA *et al.*, 1975). They can be classified into two categories: objective and subjective. Objective factors are considered those related to the neurophysiological support of perception, to the functioning mechanisms of the stimulus analysers. That is, the specific content of sensorial information, characterised by intensity, duration and frequency of the stimulus which directly influence the mechanism of perception. The second category of factors, the subjective ones, are those that depend on the uniqueness of each individual. Different people perceive the same stimuli in different ways. Even more, the same person, at different times, depending on the momentary disposition and the cumulative situation to which he/she is exposed, can perceive the same stimulus differently. What is important to some people is not necessarily important to others. Or what is disturbing at some point may not be disturbing in another context (MISHRA, 2008).

The perception of the environmental noise is influenced by a series of subjective factors that condition the reaction to it, which must be taken into consideration when conducting noise studies in urban areas (BELOJEVIC, JAKOVLJEVIC, 2001; GUSKI, 1999; JOB, HATFIELD, 1998). These factors have a dynamic and situational characteristic and they also have a broad intersection spectrum with the specific dispositions and reactions of different personality types (HEDE, BULLEN, 1981). Mainly, they refer to:

- The context of persistent dispositions of the receiver, which may be of physiological, psychological, or social nature, and which depends on the individual's life experience, the environment in which he/she has formed, received education, his/her financial and social status, etc.
- The mood of the moment, which refers to the individual's expectation horizon (if the action is unexpected, the effect produced by the harmful factor is stronger), to the affective-emotional state, and the influence of the current group or context.

- The need for self-protection and safety (for example, if the person is economically dependent on the noise source, he/she will consider noise less disturbing than the others) (CIK *et al.*, 2016).

A research on this topic has an interdisciplinary character, being situated at the border between psychology, sociology, ethology, and acoustics, the approaches of various authors being diversified (CIK *et al.*, 2016; DZHAMBOV, DIMITROVA, 2015; LAFAY *et al.*, 2019; KOVACIC, 2017). The method of analysis used in this paper is a cross-sectional survey, applied to measure how noise is perceived in one of Romania’s big cities, namely Cluj-Napoca, which has had an accelerated urban development over the past decade.

2. Context of the study

The author has observed the urban environment of Cluj-Napoca since 2001 and periodically carried out both urban noise measurements and monitoring of the urban population reaction and response to environmental noise (POPESCU, MOHOLEA, 2010; POPESCU *et al.*, 2013; 2017a). This made it possible to observe the changes related to the overcrowding and expansion of the city, but also the changes that occurred after the elaboration and implementation of the first Action Plans for the prevention and reduction of urban noise in Cluj-Napoca (POPESCU *et al.*, 2017b), following the Environmental Noise Directive (European Commission).

The research presented in this paper started from the need to find answers to a series of questions about general community noise in the city, such as:

- What has changed in terms of population exposure over the past 12 years of noise mapping? Has the situation improved?
- What was the effect of the noise mapping actions? Has the proposed goal been achieved?
- How does the population perceive urban noise and how do citizens characterise noise evolution over time?

- Did the information related to the city noise map and action plans reach the community?
- Do residents engage in actions designed to reduce noise and increase urban comfort or do they have a passive attitude?

The comparative situation of the road noise exposure based on the results of the 2007 and 2012 strategic noise maps for the city of Cluj-Napoca is presented in Fig. 1. The charts show the percentage of the population – relative to the stable population – exposed to daytime and respectively night time road noise, for an exposure class of 5 dB, calculated from the data available in public reports (The noise map) as presented in (POPESCU *et al.*, 2017a). The noise indicators in Fig. 1, defined by the Environmental Noise Directive (European Commission), are: day-evening-night noise level (L_{den}), designed to assess annoyance, referring to an A-weighted average sound pressure level over all days, evenings, and nights in a year, with an evening weighting of 5 dB and a night weighting of 10 dB; and night noise level (L_{night}), designed to assess sleep disturbance, referring to an A-weighted annual average night period of exposure. One may notice the following aspects:

- The percentage of the population exposed to road noise decreased from 67.9% in 2007 to 15.8% in 2012 for L_{den} and respectively from 61.8% in 2007 to 16.9% in 2012 for L_{night} .
- In the area of high noise levels, the percentage of the exposed population increased in 2012 compared to 2007.
- The percentage of the population exposed to L_{night} , for Cluj-Napoca, 2012, is higher than the one for L_{den} , for exposure classes 60–65 dB (3.5% L_{night} , 2.8% L_{den}) and 65–70 dB (3.1% L_{night} , 2.8% L_{den}).

Cluj-Napoca is one of the eight “national poles of growth” (defined in 2008), having a diversified economy, performance in the IT and financial services, with a complex cultural-historical patrimony – mainly built in the central (historical) area of the city – with

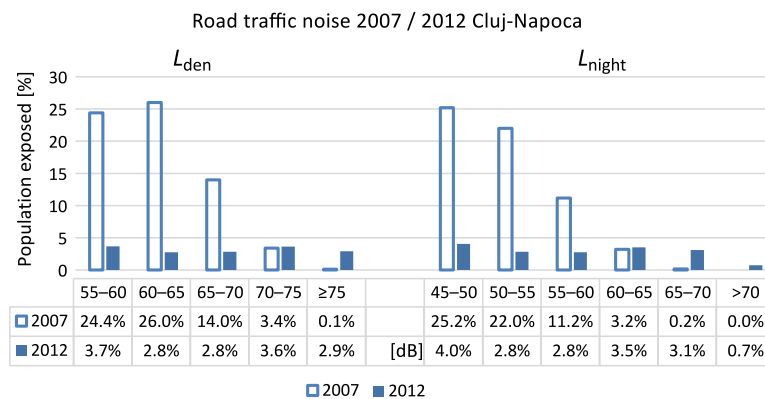


Fig. 1. Population exposed to road related noise in Cluj-Napoca, 2007 and 2012 (from the city noise maps).

old university traditions and a centre of excellence in medicine. Since 2007 the city went through changes on different aspects, a few of them – which are relevant to the present research – will be mentioned in the following section (The noise map; Action plan):

- the city has extended its boundaries and went through a redistribution of the population and focus on different interest zones;
- new residential complexes have been built, a lot of them in the central area of the city, without adapting the circulation arteries, the fact that has led to an increase of the urban traffic and the appearance of traffic congestions;
- the public transport network has been updated and the number of public transport vehicles increased by adding newer, silent models such as electrical busses;
- the pedestrian area inside the city has been increased;
- the practice of using bikes for urban transportation has been supported and implemented by building bicycle tracks and developing public rental bicycle stations;
- redirecting heavy vehicle traffic to avoid highly populated areas of the city;
- and another aspect that shouldn't be omitted, the population's life outlook and the way people claim their rights, which represents the overall social attitude, has changed.

3. The questionnaire and its application

The goal of the research was to assess the noise sensitivity and the noise annoyance from the perspective of subjects that were exposed to noise in the urban environment, to measure the level of information of the population regarding the urban noise, and also to capture people's reaction to annoying noise from two opposite perspectives: passiveness or action. For this purpose, data were collected in a cross-sectional survey carried out in early 2019 for the city of Cluj-Napoca, which included both permanent residents of the city and people in transit. A questionnaire with a total of 32 questions was applied (POPESCU, POPESCU, 2019), the questions being grouped into the following four categories:

- A. How does the noise affect you, in general? (5 questions)
- B. How do you perceive the noise of the city, as a participant of traffic? (6 questions)
- C. Questions for identifying the respondent groups (6 questions)
- D. Questions addressed only to Cluj-Napoca residents (15 questions).

The survey was designed based on previous experience, adapting and supplementing the questions from (POPESCU, MOHOLEA, 2010) and (POPESCU *et al.*, 2013), to capture the analysed aspects as thoroughly as possible.

The current research aimed to consider and analyse responses received from persons who live in the city as well as those from outside the city but involved in the city life because they are studying or working in the city, or simply have an opinion which they want to express regarding the noise of the studied area.

Two methods were used to collect the data:

- Directly contacting persons which were asked to fill the questionnaire printed on paper, this approach leading to a good answer rate;
- By using a Google Forms questionnaire, its link being sent via e-mail or being shared on social media. This modern approach expanded the area from which data were collected and ensured a continuous recording of answers. The Google Form is still active, so the survey still receives answers.

For the study presented in this paper data were collected until the middle of March 2019. A total number of 238 completed questionnaires were validated. The grouping of respondents into different categories is presented in Table 1. Of these, 218 responses were associated with people living in Cluj-Napoca who indicated their residential district and completed section D of the questionnaire.

Table 1. Responses by age, education, and occupational state (2001; 2009; 2019).

Year of the survey	Age				Education			Occupational state				
	18-30	31-50	51-70	over 70	≤10 classes	High school	University	Employed	Retired	Student	Unemployed	Other situation
2001	98	113	21	6	5	132	101	207	12	10	4	5
2009	122	128	70	5	6	114	205	222	42	24	6	31
2019	91	84	57	6	2	73	163	150	9	74	0	5

Having the results analysed in (POPESCU, MOHOLEA, 2010) and (POPESCU *et al.*, 2013) for the previous surveys applied in 2001 and 2009 (Table 1) some comparisons could also be made regarding the changes in noise perception as a result of the application of Environmental Noise Directive and noise mapping in Cluj-Napoca, starting from 2007.

4. Results

The first questions of the survey, the ones from categories A and B, were addressed both to the permanent residents of the city and to persons that pass

through or work/study in the city. Therefore, anyone that had an opinion concerning the urban noise of Cluj-Napoca could express it, through the online questionnaire (with the condition that the person received the information about the existence of the survey).

Category A questions intended to measure noise sensitivity and noise annoyance in general. The received answers are presented by charts in Figs 2, 3, and 4. The charts from Fig. 2 present a parallel between the surveys conducted in 2009 and 2019 regarding the appreciation of the disturbance level generated by the environmental noise. It must be mentioned that in 2019, the question was addressed in a generic way, not only for the residential area of each person. One may notice that compared to 2009, when the share of “Very little disturbed” response was the highest (45.8%), the 2019 study shows more annoyance: 50% of the responses correspond to “Disturbed”.

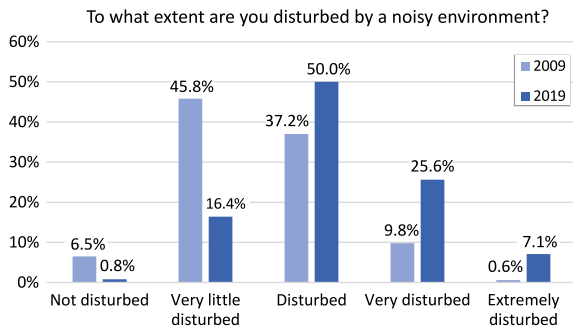


Fig. 2. Proportion of responses describing general noise annoyance (2009 versus 2019).

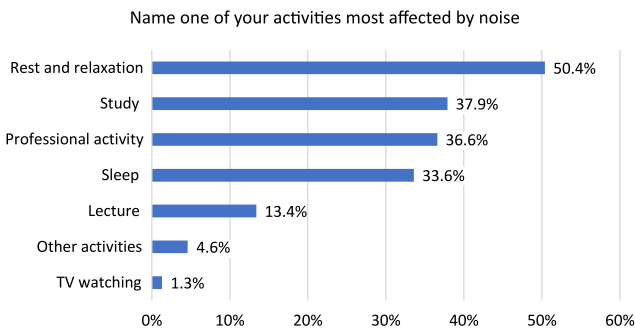


Fig. 3. Proportion of responses naming the daily activity most affected by noise (2019).

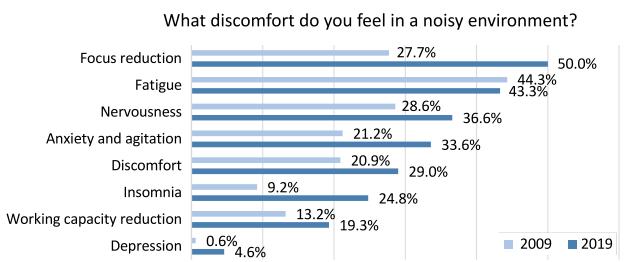


Fig. 4. Proportion of responses describing the effects of noise (2009 versus 2019).

Regarding the time interval of the day when the environmental noise is the most annoying the statistics are as follows: 41.6% of the respondents indicated the afternoon and evening (15.00–22.00), that is the period when they are generally at home; 23.5% indicated the first part of the day (10:00–15:00), that is the period when most people are at work; 21.4% chose the night time (22:00–06:00); and the rest of 13.4% indicated early in the morning (6:00–10:00). The situation is similar with the one obtained ten years ago in the cross-sectional survey. The answers to this question also correspond to the choice of the daily activity of the respondents considered to be the most affected by noise during the daytime: rest and relaxation (50.4% of respondents), study (37.9%), professional activity (36.6%), respectively, as shown in Fig. 3.

The subjects were asked about the kind of discomfort they felt in the presence of the environmental noise. The hierarchy of responses, as shown in Fig. 4, indicates on the first place “Focus reduction” (50% of the respondents) for the survey in 2019 and “Fatigue” (44.3% of the respondents) for the survey in 2009. Multiple responses to this question were allowed. Percentage calculation was made by reference to the total number of respondents and not to the total number of chosen variants.

The responses of 44.5% of the subjects indicated that they often feel the need to retreat to a quiet area, 52.9% feel the need for silence only sometimes, and 2.6% have chosen the answer “never”.

Category B questions asked the interviewees to appreciate the noise from the city of Cluj-Napoca, viewed from the position of being a traffic participant. To the question: “How do you generally appreciate the noise level in Cluj-Napoca?” 45.4% of respondents said “High”, 37.8% “Medium”, 12.6% “Very High”, 3.8% “Low” and 0.4% “Very Low”. In Fig. 5, the responses correlated with those collected in similar studies from 2001 and 2009. It should be mentioned that in the two previous studies the question was formulated slightly differently: “Describe the noise level of your residential area”, considering that it was addressed only to residents. The charts show that the answer “High” has a substantial increase in 2019, reaching 45.4% of the responses. The chart’s maximum area

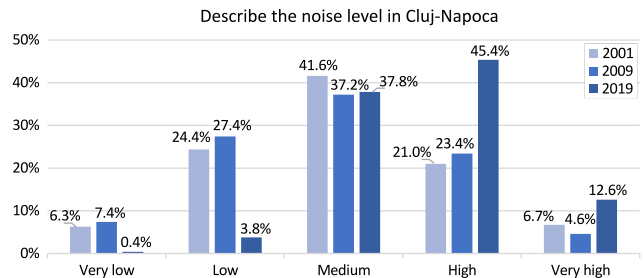


Fig. 5. Proportion of responses describing the noise level in Cluj-Napoca (2001; 2009; 2019).

moved to the right, from “Medium” to “High”, for the year 2019.

Among the respondents, 1.7% believe that the city noise has decreased over the past ten years, 6.3% say the noise remained the same, 75.2% think the noise has increased – which is in accord with the charts in Fig. 5. The rest of 16.8% do not know what answer to choose from the three above.

A linear regression analysis was conducted, intending to find if the noise sensitivity (general noise annoyance) declared by the respondents is in a significant relation with the following two factors:

- the rates given by respondents for the noise level in Cluj-Napoca;
- the opinion of respondents regarding the evolution of noise in the city during the last ten years.

Figure 6a shows the relationship between the rates given by the respondents, on a five point scale, for the noise level in Cluj-Napoca (1 – “Very low”, 2 – “Low”, 3 – “Medium”, 4 – “High”, 5 – “Very high”) – on the y axis – and the noise sensitivity, also rated on a five point scale (1 – “Not disturbed”, 2 – “Very little disturbed”, 3 – “Disturbed”, 4 – “Very disturbed”, 5 – “Extremely disturbed”) – on the x axis. When applying the method, the answers given by all respondents were considered (sample size $n = 238$). The linear regression function indicates a moderate positive correlation between the two variables (Pearson correlation coefficient $r = 0.415$, slope = 2.462), which was the expected outcome. The obtained result represents a validation

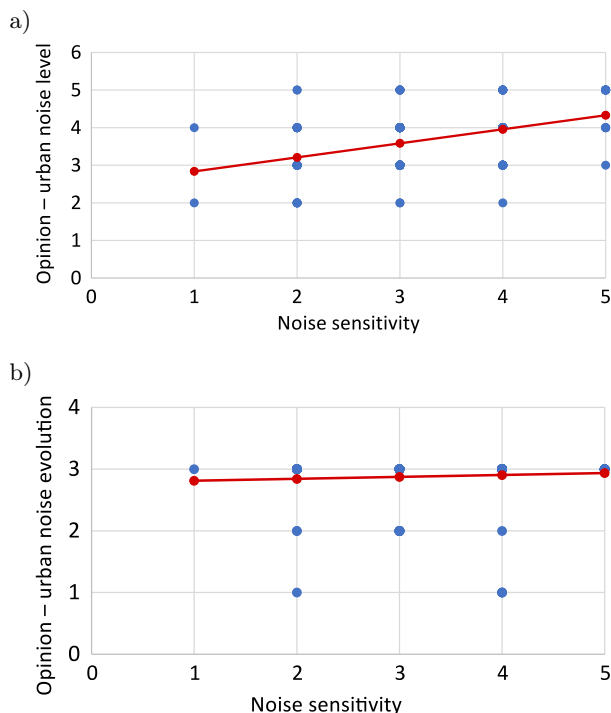


Fig. 6. Linear regressions of noise sensitivity values and the corresponding rates of urban noise level (a) and urban noise evolution over the past ten years (b).

for the fidelity of the answers collected through the applied questionnaire and, on the other hand, indicates that the classification of noise in the city as predominantly “High” (Fig. 5) does not depend exclusively on noise sensitivity of respondents but is also influenced by other factors.

Figure 6b indicates a very low correlation between the rates to the urban noise evolution over the past ten years (1 – “Noise has decreased”, 2 – “Noise is the same”, 3 – “Noise has increased”) – on the y axis – and the five point scale rated noise sensitivity – on the x axis ($r = 0.0659$, slope = 2.781). Because the answers “I don’t know” were eliminated, the questionnaires analysed in this case were $n = 198$.

The questionnaire further asks: “Name the most annoying urban noise sources in Cluj-Napoca” and the answers indicate unequivocally the road traffic (92%), as shown in Fig. 7. The question allowed the choice of multiple responses, so the number of total choices was 549. The percentage of answers was calculated by taking into account the total number of people who completed the questionnaire. In the category “Other noise sources” there have also been mentioned: construction works, neighbours, motorcycles and alarms, especially during the night time.

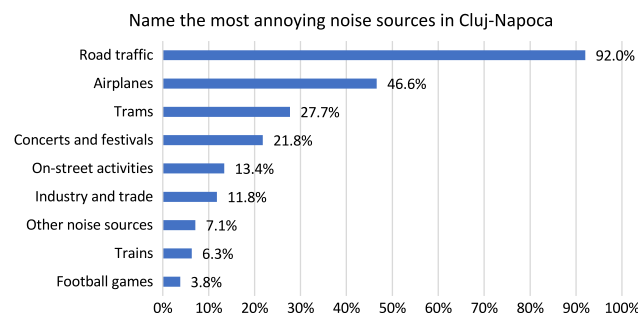


Fig. 7. Proportion of responses for the most annoying noise sources in Cluj-Napoca (2019).

Regarding the awareness of the population the statistics is as follows: 26.9% of the respondents believe that in Cluj-Napoca no measures have been taken to reduce the urban noise and to increase the comfort of the population exposed to noise; 53.8% gave the answer “I don’t know”. Only 19.3% of the respondents knew that such actions had been taken and answered the next question, naming a few of them.

A fact that was also noted in the previous studies is that most respondents do not know that Cluj-Napoca has a noise map since 2007. In the case of the 2019 study 79.4% of them answered that they do not know, 4.1% said that a noise map was never developed and only 16.6% know about the city noise map.

These last two observations raise a question mark on the methods used to transmit information to the population. One may also observe a degree of passiveness coming from the part of the population which

seemed otherwise annoyed and disturbed by the urban noise. Residents generally restrain from taking measures, besides when it comes to protecting their own homes. In the questionnaire the question “Have you taken measures to soundproof your home?” was addressed only to the residents of Cluj-Napoca (category D question). The answers were as follows: 43.1% said “Yes”, 43.6% said “No”, and 13.3% said that it was not necessary.

5. Conclusions

As shown in the public reports accompanying the noise maps, there has been an overall improvement of the situation regarding the exposure of Cluj-Napoca’s population (Fig. 1) as a result of applying the Environmental Noise Directive and equivalent Romanian legislation: the percentage of the population exposed to the road noise decreased to 15.8% in 2012 compared to 67.9% in 2007 for L_{den} and to 16.9% in 2012 compared to 61.8% in 2007 for L_{night} , respectively. However, in the high noise area, the percentage of the exposed population increased in 2012 compared to 2007. Also, it should be mentioned here that, as the author has noted in a previous paper (POPESCU *et al.*, 2017a), the noise maps related to the 2007 and 2012 situations have non-unitary approaches. To ensure continuity and access to the community when presenting the results, the noise maps reports should also show the evolving situation, referring to the previously made urban noise maps and taking into account, where necessary, the change of the methodology.

The measures taken by the Cluj-Napoca local government to improve community noise exposure especially due to road traffic, among which are: removing heavy traffic from the city on bypass routes; limiting the speed of traffic on certain streets; traffic flowing through traffic lights and special lines for urban passenger transport; the purchase of new and silent buses, etc., have been effective. New legislative initiatives that aim to regulate the noise in the residential areas are in the process of being added. However, the noise measurements carried out in 2017 (POPESCU *et al.*, 2017a) show that there are areas in the city where the noise level remains high, especially at certain times of the day.

Despite the efforts made by the local government, the results of the cross-sectional survey carried out in 2019 indicate – as well as the previous studies – that the information on the city noise map and the action plans is not sufficiently disseminated, so only 16.6% of the respondents know about the noise maps and only 19.3% consider that the municipality has taken measures to reduce the urban noise exposure of the inhabitants.

On the other hand, the presented surveys show that the population perceives the noise in the city as louder

and more annoying (Fig. 5). It is a general opinion, already established and it will be very hard to change. It can be explained by the associations people use to make in the daily routine, such as: the city is crowded, the traffic is intense, so the noise level should be high. It is definitely linked to the more agitated and alert context of today’s life, much more intense than it was ten or twenty years ago, and that has made us more sensitive to the stimuli of the surrounding world. For the actions that will be taken in the future regarding the urban noise and the protection of the inhabitants, it will be necessary to take this general view into account, and the goal must be to introduce changes towards a more positive perception.

The way people perceive and react to environmental noise does not only depend on the physical characteristics of sound but also on a series of so called psychological modifiers that affect the individual sensitivity to noise. This should be considered when evaluating noise exposure and developing noise control procedures. Noise is one of the environmental issues that makes people react and make changes, once they become aware of annoyance (Berglund, Lindvall, 1995). For this reason, the issue of urban noise needs to be seen and treated in the context of long term sociological analysis and processes.

References

1. *Action plan for prevention and reduction of environmental noise in Cluj-Napoca*, 2011, 2014, www.primariaclujnapoca.ro/
2. BELOJEVIC G., JAKOVLJEVIC B. (2001), Factors influencing subjective noise sensitivity in an urban population, *Noise Health*, **4**(13): 17–24.
3. BERGLUND B., LINDVALL T. (1995), Community noise, *Archives of the Center for Sensory Research*, **2**(1): 1–195, <https://www.nonoise.org/library/whonoise/se/whonoise.htm>.
4. CIK M., LIENHART M., FALLAST K., MARTH E., FREIDL W., NIEDERL F. (2016), Psychoacoustic indicators of road and rail traffic noise, subjective perception and psychological and physiological parameters, *Inter-Noise 2016*, <http://pub.degaakustik.de/IN2016/data/articles/000272.pdf>
5. DZHAMBOV A., DIMITROVA D.D. (2015), Green spaces and environmental noise perception, *Urban Forestry & Urban Greening*, **14**(4): 1000–1008, doi: 10.1016/j.ufug.2015.09.006.
6. European Commission. Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise, *Official Journal of the European Communities*, L189/12–L189/25.
7. GUSKI R. (1999), Personal and social variables as co-determinants of noise annoyance, *Noise Health*, **1**(3): 45–56.

8. HEDE A., BULLEN R. (1981), Human perception and reaction to noise, *Architectural Science Review*, **24**(3): 58–64, doi: 10.1080/00038628.1981.9696469.
9. JOB R.F.S., HATFIELD J. (1998), Community reaction to noise, *Australian Acoustics*, **26**(2): 35–39.
10. KOVAČIČ M. (2017), Official regulations and perceptual aspects of bell ringing, *Musicology*, **1**(22): 59–73, doi: 10.2298/MUZ1722059K.
11. LAFAY G., ROSSIGNOL M., MISDARIIS N., LAGRANGE M., PETIOT J.F. (2019), Investigating soundscapes perception through acoustic scenes simulation, *Behavior Research Methods*, **51**(2): 532–555, <https://hal.archives-ouvertes.fr/hal-01111782>.
12. MISHRA R. (2008), *Industrial Economics and Management Principles, Part 2: Management principles*, Laxmi Publications (P) LTD, New Delhi.
13. POPESCU D.I., MOHOLEA I.F. (2010), Monitoring the reaction and response of people to urban noise, *Archives of Acoustics*, **35**(2): 237–244.
14. POPESCU D.I., MOHOLEA I.F., MORARIU-GLIGOR R. (2013), Urban noise annoyance between 2001 and 2013 – study in a Romanian city, *Archives of Acoustics*, **38**(2): 205–210, doi: 10.2478/aoa-2013-0024.
15. POPESCU D.I., POPESCU A.D. (2019), Analysis of the Subjective Perception of Noise in Cluj-Napoca, Romania, *Proceedings of the 26th International Congress on Noise and Vibration*, paper no. 541, 6 pages, Montreal.
16. POPESCU D.I., URSU-FISCHER N., MOHOLEA I.F. (2017a), Road traffic noise in Cluj-Napoca City – ten years after the first strategic noise map, *Acta Technica Napocensis, Series: Applied Mathematics, Mechanics and Engineering*, **60**(4): 515–520.
17. POPESCU D.I., URSU-FISCHER N., MOHOLEA I.F. (2017b), Road traffic noise reduction strategy in Cluj-Napoca – A brief analysis, *Acta Technica Napocensis, Series: Applied Mathematics, Mechanics and Engineering*, **60**(4): 521–526.
18. ROȘCA A. *et al.* (1976), *General Psychology* [in Romanian: *Psihologie generală*], EDP, Bucharest.
19. STANGOR C., JHANGIANI R., TARRY H. (2014), *Principles of Social Psychology*, 1st International edition, Victoria B.C.: BCcampus, from <https://opentextbc.ca/socialpsychology/>
20. *The noise map of Cluj-Napoca, Reports 2007, 2012*, <http://www.primariaclujnapoca.ro/>