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Review Paper

A Study of the Romanian Framework and the Challenges in Implementing the Noise Mapping Legislation

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The Environmental Noise Directive (END), published in 2002, was transposed into Romanian local law in 2005, and it was the starting point for the first urban noise mapping exercises, initially conducted in nine Romanian cities. This paper presents the main evolutionary aspects of the noise assessment process, the development of strategic noise maps, and action plans, dealing with both the legislative side and the practical approach and results obtained. The study considers the specific regulations established by the European Commission regarding environmental noise assessment and deals with the global context at the country level, in which they have been implemented and applied.

Keywords: environmental noise; noise assessment; noise mapping; annoyance; noise exposure; action plans.

1. Introduction

Environmental noise is becoming an increasingly acute problem worldwide, and concerns about reducing its harmful effects have intensified over the last twenty years. It is very possible that many people do not realize its effect on health. Noise is one of the hazards that threatens the health and well-being of urban areas inhabitants. Its consequences may not be immediate; however, it causes disease in the human body over time through gradual changes that affect the auditory organs and induce negative effects in the cardio-respiratory, metabolic and nervous systems (BERGLUND *et al.*, 1999; COBZEANU *et al.*, 2019; World Health Organization [WHO], 2018). The following primary annoying symptoms can be acquired due to daily living in a noisy environment: decreased attention and ability to concentrate, decreased sleep quality and a permanent state of fatigue and stress.

At the level of the European Union, the concern related to the reduction of environmental noise has intensified starting with the Fifth Environment Action Program of the European Commission from 1993, which stated: "no person should be exposed to noise levels which endanger health and quality of life" (European Environment Agency [EEA], 2014, p. 6). In 1996, the European Commission strengthened the idea of prioritizing noise assessment as one of the main factors of environmental pollution through the document "Future Noise Policy – EU Green Paper" (Commission of the European Communities [CEC], 1996). Subsequently, the document that marked a new perspective on the noise policy and a unified approach among Member States was Directive 2002/49/EC (2002), also known as The Environmental Noise Directive (END).

Romania became a member of the European Union on January 1, 2007. The signing of the EU Accession Treaty on April 25, 2005, was followed by a period of preparation for accession and monitoring, during which Romania was concerned with the transposition of European legislation related to noise. In 2006, the preparation of the first noise maps for the main urban agglomerations began.

The aim of this study is to describe the specific framework and review the main aspects related to how the issue of environmental noise in Romania was approached in the context of alignment with the requirements of the European family. The focus of the study is especially on urban noise mapping.

2. Legislative issues on environmental noise

At the time of initiating the process of accession to the European Union, the main law for the control of

noise pollution in Romania was The Law for Environmental Protection, no. 137/1995 (The Law No. 137, 1995), which established the general framework of the national policy on health protection of the population exposed to harmful environmental factors.

In 2005, Romania transposed into its national legislation the content of The Environmental Noise Directive (Commission Directive 2002/49/EC, 2002), by the Government Decision HG 321 (2005)7 on the assessment and management of environmental noise. The document defined environmental noise as: "unwanted or harmful sound from the environment, created by human activities, which includes noise emitted by means of transport, road, rail, air traffic and from locations where industrial activities are carried out" (HG 321, 2005). It introduced the noise indicators L_{den} (day-evening-night noise level) and L_{night} (night-time noise level), which could be evaluated by interim calculation methods or measurement during the noise mapping process. To avoid, prevent and reduce the harmful effects caused by the exposure of the population to environmental noise, including discomfort, the law required the implementation of action plans for areas affected by excessive noise levels. HG 321 (2005) was subsequently amended and completed by the following Government Decisions: HG 674 (2007), HG 1260 (2012), and HG 944 (2016). The law has also been supplemented by a series of Ministerial Orders, to clarify its implementation.

Based on the obligations arising from its membership in the European Community, Romania has subsequently adapted the legislation in the field, so that currently the assessment and management of ambient noise is regulated by The Law No. 121 (2019). The new law contains the provisions corresponding to the Commission Directives 2002/49/EC (2002) and 2015/996 (2015), establishing the obligation to use common noise assessment methods at the EU level. Thus, the new law transposes into national legislation the consolidated version of Commission Directive 2002/49/EC (2002) by setting out: the scope, reporting/drafting/approval obligations of strategic noise maps and action plans under the responsibility of various authorities, evaluation methods for determining the noise indicators, provisions regarding the abrogation of the Government Decision HG 321 (2005) with subsequent amendments and completions, the agglomerations to which it applies, and the contraventions. According to Law no. 121 (2019), the limit date for updating all strategic noise maps in Romania is June 30, 2022. The strategic noise maps must present the situation from the previous year for all agglomerations, roads, railways and the country's main airports.

The Romanian government approved (on February 25, 2022) a draft normative act proposed by the Ministry of Environment, which amends and completes Law No. 121 (2019), on the assessment and management of ambient noise. The draft law mainly contains the provisions of Commission Directive 2020/367 (2020) of March 4, 2020, amending Annex III to Directive 2002/49/EC (2002) of the European Parliament and of the Council, as regards the establishment of methods for assessing the harmful effects of environmental noise and the responsibilities of public administration authorities.

3. The environmental noise context in Romania. Practical approach

According to the END (Commission Directive 2002/49/EC, 2002, p. 14), noise mapping means: "the presentation of data on an existing or predicted noise situation in terms of a noise indicator, indicating breaches of any relevant limit value in force, the number of people affected in a certain area, or the number of dwellings exposed to certain values of a noise indicator in a certain area". For the first noise mapping exercise, in 2007, Romania had to provide noise exposure information for urban agglomerations with more than 250 thousand inhabitants, for major roads with more than 6 million vehicles per year, major railways with more than 60 thousand trains per year and major airports with more than 50 thousand air traffic movements per year. As it did not have national calculation methods for noise indicators, the interim calculation methods recommended by the European Commission were used, in accordance with the requirements of HG 321 (2005). Noise maps were prepared for 9 cities: Bucharest, Braşov, Cluj-Napoca, Constanţa, Craiova, Galaţi, Iaşi, Ploieşti, Timişoara, for 31 sections of national roads totaling 274.4 km, for 2 main railway sections: Bucharest North – Chitila, Saligny – Palas, and for the railway stations: Ploieşti Sud, Arad, Simeria Călători, representing a total of 68 km. Regarding the noise due to air traffic, Henri Coandă International Airport in Bucharest was analyzed, which had registered 55 430 air traffic movements during 2006. Noise mapping for Bucharest Băneasa, Cluj-Napoca, Iaşi, and Craiova airports was treated as part of the respective urban agglomerations.

It can be said that this first round of noise mapping in Romania was a pioneering one, even if some previous studies related to the noise inside urban agglomerations have been made before 2006, and also there were periodic assessments and measurements made by the environmental agencies. The main challenges encountered were:

- the relatively short time for transposing European legislation and adapting national legislation;
- lack of a national methodology and strategy for assessing and predicting noise in agglomerations and its impact on the population;

– lack of digital maps for most areas to be analyzed;
– finding the material, financial, and human resources to be allocated to this action;
– the need to train people involved in the use of software for noise mapping and more.

This first round opened a profitable market for companies specialized in consulting and noise analysis in Romania and the EU. The strategic noise maps, and later the action plans for the different objectives, were made by various companies by contracting services. They used specialized software for noise prediction and sets of measurements to validate the results of the calculation models. Although their approaches have a common base, they have been pretty much different.

Strategic noise maps produced in the context of the END are generated every five years, the aim being to obtain an updated and retrospective representation of the environmental noise climate. Thus, 2012 is linked with the second round of noise mapping, whose main feature was the expansion of the analysis area and data required. The threshold for agglomerations went down from 250 thousand to 100 thousand inhabitants and the number of target cities increased from 9 to 19, as specified in (HG 1260, 2012). The main roads targeted were those with over 3 million vehicles per year, totaling 3269 km in 270 road segments. The legislation (HG 1260, 2012) also indicates the other areas to be analyzed: 51.4 km of railways, Henri Coandă International Airport in Bucharest, and 9 other urban airports identified within the targeted agglomerations.

The last modification and completion of HG 321 (2005) were made by Government Decision HG 944 (2016). It clarified the responsibilities for drawing up strategic noise maps and action plans for the railways inside the agglomerations and the deadline by which interim calculation methods can be used. The agglomerations, main roads, main railways, and major airports associated with the third round of noise mapping were specified, for which the completion deadlines were set: June 30, 2017 for strategic noise maps and July 18, 2018 for action plans (HG 944, 2016). This third round was characterized in Romania by stability. A sufficiently good knowledge of the working procedures and a high enough level of expertise were reached, which generated a certain continuity and confidence in the obtained results. The areas targeted for noise analysis remained approximately the same: 20 urban agglomerations, 261 sections of main roads totaling 3382.6 km, 488.2 km of railway, Henri Coandă International Airport in Bucharest, and 10 other urban airports identified within the selected agglomerations.

4. Data on noise exposure

The strategic noise maps and the action plans that followed them were available for a while on the websites of the local public administrations and the authorities responsible for their elaboration. Gradually the documents were replaced with their new variants, now with those related to the third round of noise mapping. The numerical data presented as follows were obtained from the reported data on noise exposure covered by Directive 2002/49/EC (2021), provided by the EEA. They are part of the data submitted by EEA member countries until January 1, 2021. Using the available data, the EEA has conducted comprehensive analyzes of the noise exposure situation in Europe associated with the three rounds of noise mapping (EEA, 2014; 2019).

In the data presented in Tables 1 to 3, one may observe that in Romania, most people are exposed to the noise generated by road traffic inside urban areas as it is observed in other European Union countries. The highest number of people are exposed to the two lowest noise bands mapped: 55–59 dB and 60–64 dB L_{den}, 50–55 dB and 55–59 dB L_{night}. This is a predictive result, as far as the used calculation models agree on the rate and type of noise attenuation during propagation from the source, implying the increase of the

Table 1. Population exposed to noise from different sources in Romania, 2007.

	Number of people exposed to different noise bands (L_{den})					Number of people exposed to different noise bands (L_{night})				
	55–59	60–64	65–69	70–74	>75	50–55	55–59	60–64	65–69	>70
Inside agglomerations										
Roads	943 800	1 052 300	607 300	223 900	51 700	1 021 500	664 800	285 400	71 300	13 500
Railways	153 300	100 600	17 300	1 700	200	144 200	53 000	7 900	700	200
Airports	9 400	10 000	5 600	400	400	14 300	9 500	3 200	400	300
Industry	42 200	24 000	13 000	10 300	900	28 300	8 200	4 200	9 600	100
Outside urban areas										
Major roads	22 700	15 400	21 900	5 700	1 100	17 900	13 200	8 000	2 600	300
Major railways	3 900	1 000	0	0	0	3 400	700	0	0	0
Major airports	2 400	500	100	0	0	3 900	1 300	100	100	0

Table 2. Population exposed to noise from different sources in Romania, 2012.

	Number of people exposed to different noise bands (L_{den})					Number of people exposed to different noise bands (L_{night})				
	55–59	60–64	65–69	70–74	>75	50–55	55–59	60–64	65–69	>70
Inside agglomerations										
Roads	543 800	843 400	775 800	268 700	79 400	790 200	830 100	329 000	124 900	16 700
Railways	120 400	118 100	32 900	4 000	0	119 000	98 500	21 500	2 600	0
Airports	30 000	10 000	4 000	300	0	19 000	6 000	1 300	0	0
Industry	141 600	73 100	15 200	700	0	56 800	6600	500	0	0
Outside urban areas										
Major roads	356 800	275 300	254 900	149 300	38 100	301 500	264 100	209 300	86 300	8 100
Major railways	19 000	4 500	1 300	400	0	8 100	1 700	600	100	0
Major airports	6 400	100	0	0	0	200	0	0	0	0

Table 3. Population exposed to noise from different sources in Romania, 2017.

	Number of people exposed to different noise bands (L_{den})					Number of people exposed to different noise bands (L_{night})				
	55–59	60–64	65–69	70–74	>75	50–55	55–59	60–64	65–69	>70
Inside agglomerations										
Roads	1 076 600	828 600	583 400	230 800	33 300	1 005 400	599 000	271 800	76 600	3 900
Railways	48 300	41 000	7 100	300	0	40 800	46 800	5 800	100	0
Airports	3 300	200	0	0	0	11 600	1 600	100	0	0
Industry	13 200	2 300	300	0	0	5 400	1 400	300	0	0
Outside urban areas										
Major roads	350 200	326 300	325 500	160 000	34 200	324 900	331 700	215 700	63 900	4 500
Major railways	28 700	16 000	5 200	300	0	24 700	13 300	3 300	200	0
Major airports	14 700	600	100	0	0	5 300	200	0	0	0

exposed people over the propagation distance as the noise level decreases. This intuitive result is confirmed by the numerical values presented for industrial noise in 2007, 2012, and 2017 for all noise bands. In the case of the other three categories of noise sources, there are some discrepancies: the greater number of exposed people is in the band of 60–64 dB than in 55–59 dB L_{den} in Table 1 (roads and airports noise) and Table 2 (roads noise), the greater number of exposed people is in the band of 55–59 dB than in 50–55 dB L_{night} in Table 2 (roads noise) and Table 3 (railways noise). It should also be mentioned that similar observations can also be made, for some other EU agglomerations, by studying the previously mentioned database provided by the EEA.

The results presented in Tables 1, 2, and 3 cannot be compared between years in terms of the number of people affected at the country level because the analyzed objectives were not identical, and the analysis methods were approached quite differently in the three rounds of noise mapping.

The comparative diagram in Fig. 1 presents, by percentage, the noise exposure results for the three rounds in noise bands. The calculations were made considering the number of inhabitants in urban agglomerations for each noise mapping round. We may say that the situation has improved in recent years for exposure to noise over 60 dB. However, in the noise band of 55–59 dB L_{den} and 50–55 dB L_{night}, the percentage of the exposed population increased in 2017. Figures 2 and 3 show the percentage of reported results on the traffic noise exposure for each agglomeration. One may observe that there are quite large differences between the individual agglomerations and that some of them have missing data.

In some of the agglomerations, the fluctuating evolution of the reported data is noticeable:

– decrease in 2012 compared to 2007 and then increase in 2017 (Figs. 2 and 3) – L_{den} and L_{night} for Cluj-Napoca and Timişoara;
– increase in 2012 compared to 2007 and then decrease in 2017 (Figs. 2 and 3) – L_{den} and L_{night} for Craiova, Iaşi, and Ploieşti.

The main reason for discrepancies is the lack of continuity and the lack of connection between the three stages of the noise mapping process conducted in Romanian urban areas (Popescu *et al.*, 2017). Like any

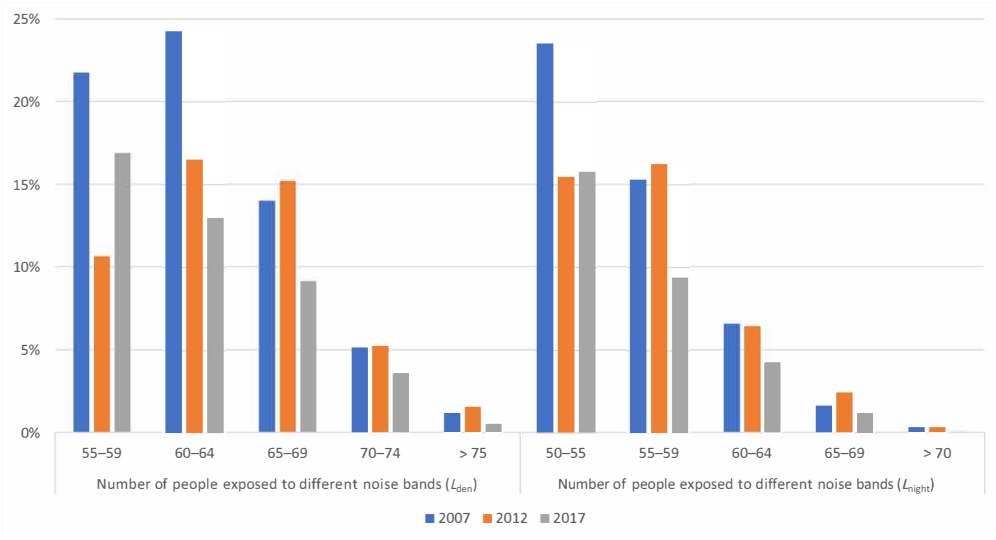

Fig. 1. Percentage of people exposed to different noise bands from roads inside agglomerations.

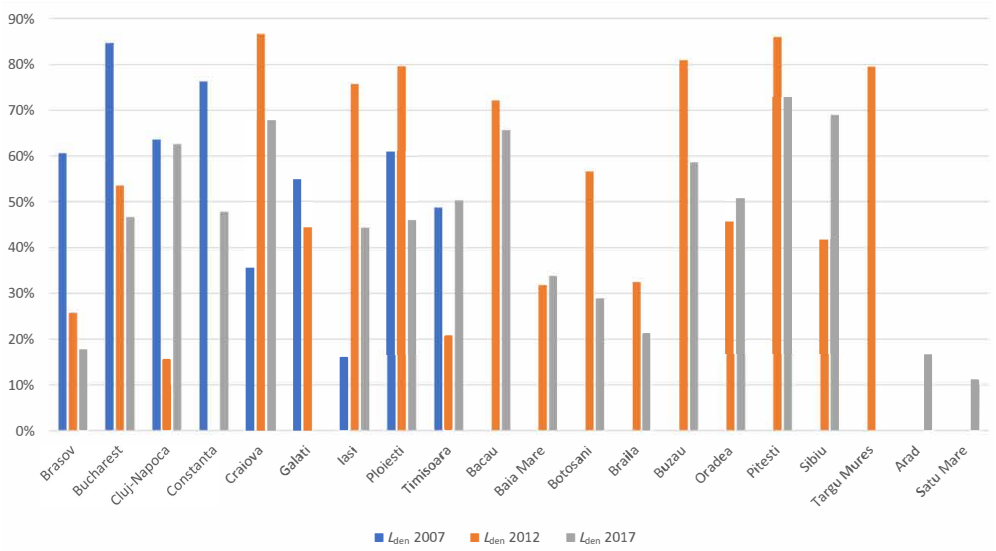

Fig. 2. Percentage of people in agglomerations exposed to road traffic noise, $L_{\text{den}} \geq 55$ dB.

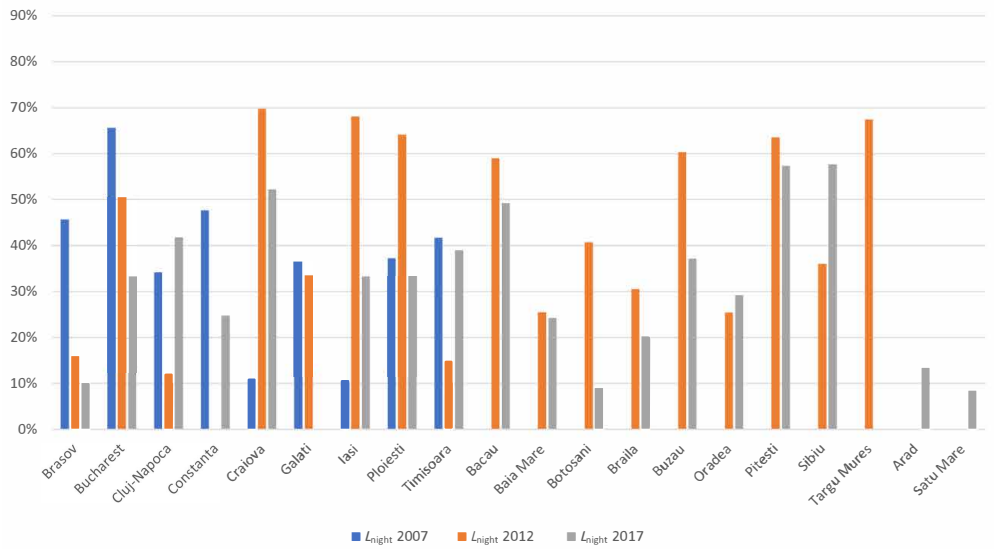

Fig. 3. Percentage of people in agglomerations exposed to road traffic noise, $L_{\text{night}} \geq 50$ dB.

analysis, those related to noise in urban agglomeration should have started from a better knowledge of the existing situation and the previously obtained results. This would have allowed the newly obtained results to be correlated with the previous ones or the correction of the previous ones, accompanied by appropriate explanations of the changes that occurred.

This lack of connection between stages generated the summation of a number of methodological factors and different approaches regarding noise mapping software, which could induce the distortion of the results (Bennett *et al.*, 2010; Probst, 2005), especially if the problem is the lack of experience in use or less careful coordination. Some of the aspects whose different approaches, from case to case, could influence the generated models leading to the irregular aspects mentioned above, are the following:

- the sources used for the input data, their complexity and accuracy, estimation and approximation of missing data;
- the volume of input data, which also determined the complexity of the model obtained in each case, with influence on the need for computing resources, working time and accuracy of results;
- the punctual way of interpreting some situations from reality that are not covered by the unitary work methodology;
- significant changes in actual conditions compared to the estimation made due to uncontrollable factors;
- some uncertainties introduced by the numerical methods used by different noise prediction software, model parameters, and software calibration (Wierzbicki, Batko, 2008).

5. Noise abatement measures included in the action plans

According to the EEA's report (EEA, 2019), various measures have been taken in each EU country to reduce and manage noise levels, but their benefits in terms of positive health outcomes are difficult to assess. Here also comes the fact that the opportunity of the proposed measures is supported mainly by theoretical arguments, and they are not formulated based on previous analyzes or research.

On the other hand, the measures proposed in the noise reduction plans must have financial support to be implemented, and the allocation of the budget is a matter that depends more on the policy area, being controlled by each local government or entity responsible for enforcing noise legislation.

For urban agglomerations in Romania, noise reduction plans included the following main categories of measures:

a) Traffic management measures aimed to streamline and calm traffic and clear road congestion, such as: intelligent traffic lights and traffic control systems that consider the variations of the flow of traffic throughout the day, the reconfiguration of routes and directions on different streets in correlation with the size of the road and traffic needs, Park & Ride systems developed on the main access roads in urban areas, clearing the streets of cars parked on the roadway and sidewalks, redesign of the road network by modifying and adapting the configuration of the cross-section of the street (if there is an available area). It is worth mentioning the need to develop an overall traffic management concept adapted to each urban agglomeration based on the initial analysis of the conditions in which road traffic can be obtained with the maximum flow, with the highest possible operating speed, in conditions of maximum safety and minimum pollution.

b) Measures aimed at reducing noise and creating quiet areas, such as: creating pedestrian areas by banning road traffic, imposing speed limitation measures on certain streets, finding alternative routes for heavy traffic, and establishing a program of access for cars that supply markets and shops or perform various urban works.

c) Development and modernization of public transport services to reduce travel by personal car between home and locations with major functions: work, school, shopping areas, and recreation areas. There are four main directions of action:

- improving the quality and comfort of public transport vehicles;
- increase the speed of the transportation service by introducing dedicated lanes and traffic lights in intersections with priority for public transport;
- reducing noise at the source by purchasing modern and quiet means of transport (e.g., electric buses);
- increasing the quality of roads by repairing damaged areas and using materials with special sound-absorbing qualities.

d) Promoting the use of non-motorized means of transport in the urban area, even if they are personal or with public access. This target involves the following actions:

- set up dedicated routes to provide traffic safety for non-motorized vehicles (e.g., bicycles);
- an appropriate adaptation of urban transport legislation;
- arrangement of parking spaces for non-motor vehicles;
- creating a fleet of vehicles available on loan and providing the service for their maintenance.

e) Noise reduction on the transmission route through measures such as sound rehabilitation of

buildings, placement of sound-absorbing panels, and curtains of vegetation.

f) Redesigning the general urban plan bearing in mind the goal of solving the problem of noise exposure of the inhabitants and following the desire to prevent the aggravation of noise pollution in the coming years. The general idea is to separate the noise sources from the residential areas, as well as to separate the local traffic from the transit ones.

g) Increasing the information and awareness of the population regarding the effects of noise exposure and sustaining education in the spirit of anti-pollution attitudes and behavior.

6. Conclusions

Among the first actions Romania took during the preparation for accession to the European Union was the transposition of European legislation regarding the assessment of environmental noise. The action of making the strategic noise maps was practically started in autumn of 2006, a few months before the finalization of the accession process. The first round of noise mapping meant a stage of learning and accommodation, and the results could be analyzed together with those from the rest of the European countries (EEA, 2014). Road traffic has been identified as the main source of environmental noise in Romania and the most significant exposure corresponds to urban areas, where pollution has increased rapidly in recent years.

From the reports prepared by the EEA as well as by analyzing the EEA databases containing information on noise exposure covered by the END, one may conclude that there were deficiencies in data reporting and that the situation of exposure to environmental noise in Romania was not significantly improved between the 2007 and 2017 noise mapping rounds. Certain fluctuations in the existing data at the level of urban agglomerations may be due to different approaches and the lack of continuity between the three stages of noise analysis. In order to resolve the observed discrepancies, it is important that the noise mapping at the level of each agglomeration includes a mandatory preliminary study of the reports and results on the previous noise assessments, which would allow the correlation of the working methodology. The newly obtained results should be presented compared to the previous ones, accompanied by explanations and interpretations of the changes that have occurred, including relation to the established action plans.

Regarding the implementation of the noise reduction action plans, it has been partially done. It is obvious that the planned measures need financial support and must be correlated with the zonal development policy, and this involves actions that may extend over a longer period of time. The unfinished activities were reconsidered in the phase of updating the noise reduction plans with the necessary modifications and adaptations.

For the fourth round of noise mapping, in 2022, the new methods provided by European legislation will be applied to assess the harmful effects induced by exposure to air, road, and rail noise. Their unitary application by EU Member States will lead to results that can be easily compared with each other. Noise pollution is expected to increase in the future (EEA, 2019) due to the tendencies of urban sprawl and mobility demand. This means increasing attention to be paid to both noise assessments and noise reduction plans.

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