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ROAD TRAFFIC NOISE IN CLUJ-NAPOCA CITY- TEN YEARS AFTER THE FIRST STRATEGIC NOISE MAP

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***Abstract:** There are currently many assessments and analyzes regarding the road traffic noise, that has proven to be the most serious and annoying source of noise in urban agglomerations. Among these are the reports of the European Environment Agency concerning the noise maps for the years 2007 and 2012. This paper addresses a comparative study of traffic noise in urban areas, especially in the city of Cluj-Napoca, considering two aspects: the measured noise levels, at the same points and the same conditions, in the years 2006 and 2017; results provided by the noise maps in four Romanian cities, regarding the exposure of the population to road traffic noise.*

***Key words:** road traffic noise, noise mapping, exposure to noise, noise indicators, noise measurements*

1. INTRODUCTION

The European Commission Directive 2002/49/EC, also known as The Environmental Noise Directive (END), introduced for the first time a coordinated unitary approach to noise policy for the Member States. The directive defined a pair of noise indicators, to be used to assess annoyance (L_{den} = the day-evening-night level indicator) and sleep disturbance (L_{night} = the night-level indicator). For the first round of noise mapping in Europe (the year 2007), on the basis of these indicators, the END urged member States to develop strategic noise maps for: urban agglomerations having more than 250 thousand inhabitants, 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 [7]. Romania, new Member State that time, had to assess the noise situation and to provide exposure information for nine cities: București, Brașov, Cluj-Napoca, Constanța, Craiova, Galați, Iași, Ploiești, Timișoara, considering for each of them the noise from roads, railways, airports and industrial units. The END also stated that action plants containing noise control programs have to be prepared based on the noise mapping situation, with the

consultation and implication of citizens. The action has to be cyclical: the strategic noise maps have to be updated from five to five years.

2. EXPOSURE TO ROAD TRAFFIC NOISE IN EUROPA

The report of the European Environmental Agency No 10/2014 [7] gives an extended analysis of the environmental noise, based on information provided by the Member States for the first two rounds of noise assessment, in 2007 and 2012, in the unitary format required by the END. Road traffic noise has been designated, in this report, to be “the most widespread noise source in Europa and one causing the most number of people to be exposed above the END action levels for L_{den} and L_{night} . This is true at European scale, at country scale, and both inside and outside the major urban agglomerations”. The analysis was made considering and comparing available data from 164 urban agglomerations in 2007 and 471 in 2012, reported to the European Commission. Summarised data showed that, in 2012, more than 41 million inhabitants from the analysed agglomerations were exposed to road traffic noise above 55 dB. Based on the available data, the authors of the report

estimated that over 90 million Europeans may be in exposure to road traffic noise above 55 dB, inside urban areas, and 35 million of them above 65 dB.

It has to be noticed here that for the noise exercise in 2012 the term urban agglomeration has referred to urban areas with more than 100 thousand inhabitants. Romania was in the lot of countries that reported more than 50% of inhabitants exposed to road traffic noise above 55 dB L_{den} in urban areas, with the following specific situations: Pitești 86%, Oradea 46%, Galați 45%. For Denmark, Norway, Finland, Sweden, United Kingdom, Iceland, Germany and Malta, in descending order, the percentage of exposed population to 55 dB L_{den} or more was under 50% [7].

3. SITUATION OF THE ROAD TRAFFIC NOISE IN CLUJ-NAPOCA CITY

3.1. Characteristics of the road traffic in Cluj-Napoca

The "Sustainable Urban Mobility Plan Cluj-Napoca" [8] shows a reality already known by drivers and pedestrians: the city is suffocated by traffic. In recent years very few actions have been taken to increase the capacity of road infrastructure. The street network of the city is 662 kilometers long, of which only 443 kilometers of modernized road and 324 kilometers of public transport routes. The road network is predominantly radial, the main traffic arteries are in the prolongation of national roads that converge in the city, meeting in the ultra-central area. Unlike other cities of its size, the city does not benefit from fully functioning circular rings. Most roads have not been planned with the possibility of further extension and, at this point, enlargement would mean demolishing of some existing buildings. On the other hand, the trend in the construction sector is to occupy any area available with higher-rise buildings, even if the consequence is the reduction of green spaces in the city. This made the area of green space per capita to be only 19.58 m², with 6.42 m² smaller than European standards requirement.

The number of traffic lanes is reduced compared to the traffic volume, which is steadily increasing, leading to frequent blockages on the main roads of the city. In recent years, the number of cars registered in Cluj County has increased, reaching more than 200 thousands in 2016, according to data provided by the Automobile Registry Service. The car park of the county, as well as that of the country, is an aging one: 51.2% of the cars are older than 12 years (meaning more pollutants and more emitted noise), 24.4% were manufactured 9 - 12 years ago, 18.7 % are aged between 5 and 8 years, and only 5.7% have less than five years of age.

The road sections connecting the west, downtown and the east are the most problematic and crowded at the moment. According to the data available for February 2015, 58660 vehicles are recorded on the western entrance of the city (Calea Florești) in each working day, meaning more than on the busiest entrance From Bucharest: DN 1 from Otopeni, in 2010 (54135 vehicles). This volume of traffic is distributed on streets with level intersections and no more than two lanes on the way.

In [8] it is shown that many intersections are extremely crowded at peak hours, the only solution to solve congestion is the reduction of traffic volumes they served. Examples of such intersections are:

- 21 Decembrie 1989 Bld./ Fabricii Str./ Aurel Vlaicu Str/ Aleea Bibliotecii
- G-ral Dragalina Str./Horea Str./ Dacia Str.
- 21 Decembrie 1989 Bld./ Avram Iancu Sqr./ Cuza Voda Str.
- Calea Manastur/ Câmpului Str.
- Câmpului Str./ Frunzișului Str./Izlazului Str.

An important achievement was the execution of road infrastructure works that allowed the removal of heavy traffic from certain road sectors within the city. Thus, starting with 2009, due to the highway between Turda and Gilău, heavy traffic was redirected from Mănăștur and Zorilor districts. Vâlcele - Apahida belt was completed in 2011, so heavy traffic was banned on Bună Ziua Str., Gheorgheni and Mărăști districts.

Urban passenger transport in Cluj-Napoca includes 45 public transport lines: 36 bus lines, 6 trolleybus lines and 3 tram lines. They are covered and serviced by a total of: 243 buses, 98 trolleybuses, 29 trams and 10 minibuses [9]. The number of people using public transport varies depending on the area, in the large districts of the city public transport is well organized. The entire transport network has been upgraded, restructured and expanded in recent years, to keep up with the expansion of the city and to respond as well to the needs of the inhabitants.

3.2. Urban noise and its evolution over the last ten years

Cluj-Napoca was included in the group of nine cities in Romania that produced strategic noise maps and developed action plans for noise reduction in 2007. Following this analysis, it was concluded that the main source of urban noise is the road traffic. Noise assessments were also available from previous years [2], [3]. The authors of the present paper collaborated with the team that coordinated the project of the first strategic noise map of Cluj-Napoca and performed, between September 12, 2006 and November 30, 2006, the noise and traffic measurements along the city roads, totaling 240 points [4], [5], [6].

To compare the current situation, some of the noise measurements made in 2006 were repeated in 2017, at the same points and complying with the END requirements. Noise measurements were conducted by using a Bruel&Kjaer 2250 sound level meter, calibrated and configured to measure and record the A-weighted Leq. Noise meter was placed in vertical position, with the microphone located at 1.2 – 1.5 meters above the ground, in vertical position. During the three hours noise measurement period, for each measurement point, the numbers of light vehicles and heavy vehicles per hour, passing on the road, were counted, also estimating their average traffic speed.

Table 1 shows the results recorded during 2006 and 2017 at the same four measurement points and same time interval of three hours, on four streets with high traffic. It can be noticed that for Calea Mănăştur and Maramureşului Street, the traffic volume is higher in 2017 for both light vehicles and heavy vehicles. In the second measurement point, heavy traffic is almost tripled in 2017 as compared to 2006. As a result, the equivalent continuous noise level recorded at this two measuring points increased by 3.05 dB and 1.56 dB respectively.

Table 1

Recorded noise levels and traffic volume in Cluj-Napoca, during 2006 and 2017

Measurement point location	Time interval	2006				2017			
		Date	Light vehicles/hour	Heavy vehicles/hour	LAeq [dB]	Date	Light vehicles/hour	Heavy vehicles/hour	LAeq [dB]
Calea Mănăştur	08 ⁰⁰ -09 ⁰⁰	20.10.	2064	182	75.91	19.06. 2017	2690	209	78.96
	09 ⁰⁰ -10 ⁰⁰	2006	1911	150			2713	216	
	10 ⁰⁰ -11 ⁰⁰		1896	153			2660	192	
Maramureşului Str.	08 ⁰⁰ -09 ⁰⁰	25.09.	483	48	71.99	26.06. 2017	1030	119	73.55
	09 ⁰⁰ -10 ⁰⁰	2006	531	42			869	134	
	10 ⁰⁰ -11 ⁰⁰		449	61			942	143	
Fabricii Str.	08 ⁰⁰ -09 ⁰⁰	27.08.	1491	114	75.23	30.06. 2017	1401	220	72.91
	09 ⁰⁰ -10 ⁰⁰	2006	1479	129			1402	255	
	10 ⁰⁰ -11 ⁰⁰		1617	116			1440	256	
Aurel Vlaicu Str.	08 ⁰⁰ -09 ⁰⁰	27.10.	1925	280	80,2	04.07. 2017	2414	248	71.34
	09 ⁰⁰ -10 ⁰⁰	2006	2118	267			2564	250	
	10 ⁰⁰ -11 ⁰⁰		1778	243			2245	228	

For the Fabricii Str., light traffic has a small decrease, but heavy traffic has doubled in 2017. The lower noise level recorded in 2017 can be explained by the very low speed of movement due to excessive clutter during the measurement interval. In addition, as in the case of Aurel Vlaicu Str., for which LAeq measured in 2017 is lower by 8.86 dB, heavy traffic is mainly composed in 2017 by buses and trolleybuses of public transport, lot of them modern and quiet.

It should be noted that the values recorded in the four locations were and remained high, all of them over 70 dB, so it cannot be said that the problem of traffic noise in Cluj-Napoca was solved after the two rounds of noise maps and action plans, in 2007 and 2012. This year, the city's noise map needs to be updated.

4. EXPOSURE OF POPULATION TO ROAD TRAFFIC NOISE

Based on the results of the 2007 and 2012 strategic noise maps, a comparative study of road noise exposure is being carried out, as follows, for four cities in Romania: Cluj-Napoca, Timișoara, București and Craiova. Primary data was retrieved from public reports [9]-[12] posted on city halls websites and made available by companies that have prepared the strategic noise maps and/or action plans for noise reduction (Table 2).

Table 2

Preparation of urban noise maps

Urban agglomeration	Noise Map of urban agglomeration made by:	
Cluj-Napoca	2007	EnviroConsult SRL
	2012	Vibrocomp SRL
Timișoara	2007	VibroComp KFT
	2012	EnviroConsult SRL
București	2007	EnviroConsult SRL
	2012	ACCON-Environmental Consultants SRL
Craiova	2007	EnviroConsult SRL
	2012	Institutul de cercetari în transporturi - Incertrans SA

The charts in Figures 1 and 2 show the percentages of the population in the four cities exposed to daytime road noise, for each exposure class of 5 dB, from 55 dB to over 75 dB Lden, according to the noise maps for the years 2007 and 2012. The percentage calculation was based on the volume of the stable population, shown in Table 3 [1], [9]-[12]. By observing the two charts, the following aspects are deduced:

- For Cluj-Napoca, Timișoara and București, the percentage of the population exposed to road noise in 2012 is lower than in 2007. In contrast, for Craiova, the percentage of the exposed population increased from 34.7% in 2007 to 68.3% in 2012.

Table 3

Values considered for the stable population

City	Number of inhabitants	
	Year 2007	Year 2012
Cluj-Napoca	297600	307136
Timișoara	317660	306466
București	1926334	1883425
Craiova	309358	309436

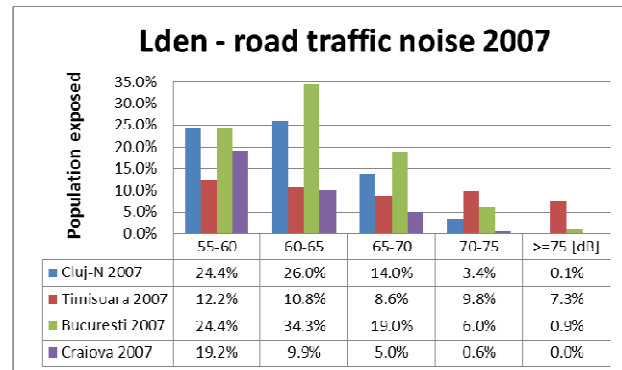


Fig.1 Percentage of people in agglomerations exposed to noise from roads in 2007, during day time

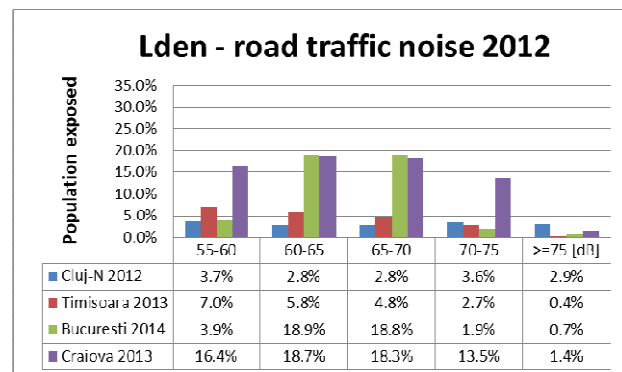


Fig.2 Percentage of people in agglomerations exposed to noise from roads in 2012, during day time

- In 2007, cities with over 50% of inhabitants exposed to road noise $L_{den} > 55$ dB were Cluj-Napoca (67.9%) and București (84.6%). The same indicator in 2012 refers to Craiova.
- The highest percentages are recorded for the exposure classes: 60 - 65 dB and 65 - 70 dB, both in 2007 and in 2012.
- The lowest exposure rate for $L_{den} > 55$ dB is 15.8%, reported for Cluj-Napoca in 2012.
- The exposure class with the highest percentage reported is 60-65 dB, with 34.3% of population exposed, in București, 2007.
- Overall, the variation in the percentage of the population exposed to urban road noise $L_{den} > 55$ dB between 2007 and 2012 is as follows: decrease with: 52.1% Cluj-Napoca, 28% Timișoara, 40.4% București and increase with 33.6% for Craiova.

For the night time, the L_{night} indicator is used to highlight the exposure. The results are shown in Figures 3 and 4, in exposure classes of 5 dB, ranging from 45 dB to over 70 dB. Observations on charts lead to the following conclusions:

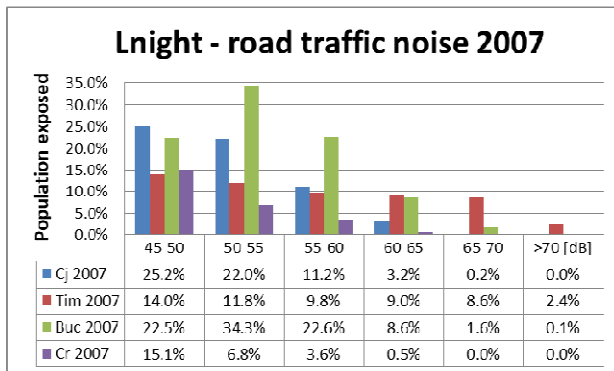


Fig.3 Percentage of people in agglomerations exposed to noise from roads in 2007, sleep disturbance

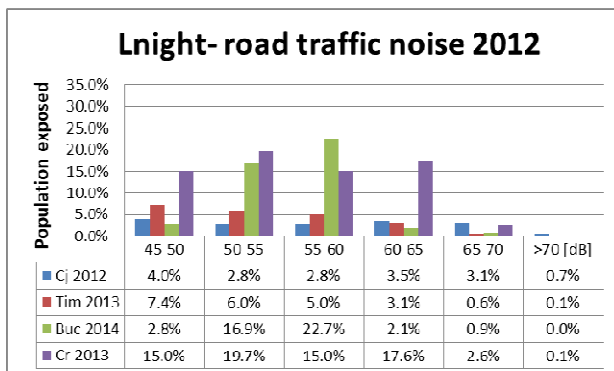


Fig.4 Percentage of people in agglomerations exposed to noise from roads in 2012, sleep disturbance

- Also in the case of L_{night} indicator, the percentage of exposed population dropped between 2007 and 2012 in the cities of Cluj-Napoca, Timișoara and București and increased for Craiova.
- In 2007, three cities reported more than 50% of the population exposed to $L_{night} > 45$ dB: Cluj-Napoca (61.8%), Timișoara (55.6%) and Bucharest (89.7%). The situation is reversed in 2012: Craiova has 70% of the population exposed to $L_{night} > 45$ dB.
- The highest percentages were recorded in 2007, for the exposure classes: 45 - 50 dB and 50 - 55 dB.
- The exposure class with the highest percentage reported is 50-55 dB, with 34.3% of population exposed, in București, 2007.
- The change in the percentage of the population exposed to road noise $L_{night} > 45$ dB between 2007 and 2012 is as follows: decrease with: 44.9% Cluj-Napoca, 33.4% Timișoara, 44.3% București and 44% increase for Craiova.

Other observations:

- The percentage of the population exposed to road noise during the night, for Cluj-Napoca, 2012, is higher than the one for daytime exposure, for exposure classes 60-65 dB and 65-70 dB.
- The data reported in Bucharest in the 2012 noise map exercise show a very high population exposure over the night period compared to the day period for the 55-60dB exposure class: 22.7% for L_{night} versus 3.9% for L_{den} .

It should also be mentioned here that the maximum allowable values for L_{den} and L_{night} indicators for urban roads were set at 70 dB and respectively 60 dB for 2007, with the target to be reached in 2012 for the maximum values of 65 dB (L_{den}) and respectively 50 dB (L_{night}).

5. CONCLUSIONS

The comparative data presented in this paper, both regarding noise measurements and those related to the population exposed to road traffic noise, lead to the following conclusions:

- The problem of traffic and noise generated by it in Cluj-Napoca has improved in recent years but is not yet resolved. It is in the attention of the local government.

- From the group of the four compared cities, it seems that the road noise situation between 2007 and 2012 has the greatest improvement in Cluj-Napoca: the percentage of the exposed population decreased by 52.1% for the L_{den} indicator and by 44.9% for L_{night} .

- The noise maps related to the 2007 and 2012 situations, although all based on the END, have non-unitary approaches. There is no evidence of the relationship between the existing situation and the previous one.

The year 2017 will bring a new update of the noise maps. It would be important and beneficial to include in their reports an evolutionary analysis that takes into account the results presented in the noise maps of previous years, for each urban agglomeration.

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Zgomotul de trafic rutier in Cluj-Napoca – o analiză după zece ani de la prima hartă strategică de zgomot

Rezumat: Există în momentul de față multe evaluări și analize referitoare la zgomotul de trafic rutier, care s-a dovedit a fi cea mai pregnantă și supărătoare sursă de zgomot din aglomerările urbane. Între acestea sunt rapoartele Agenției Europene de Mediu, privind cartările de zgomot aferente anilor 2007 și 2012. Prezenta lucrare abordează un studiu comparativ privind zgomotul datorat traficului din zonele urbane, cu precădere în orasul Cluj-Napoca, având în vedere două aspecte: nivelul de zgomot măsurat, în aceleași puncte și aceleași condiții, în anii 2006 și 2017; rezultate furnizate de hărțile de zgomot realizate pentru patru orașe din România, privind expunerea populației la zgomot de trafic rutier.

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