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INTERPRETATION OF ROAD TRAFFIC NOISE CHANGES WITH NOISE MAPPING

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Abstract

With the advancement of technology and the drastic increase in the number of noise sources, environmental noise emission is increasing year by year. In the case of urban dwellers, noise from road traffic accounts for the largest share of noise pollution, with a number of negative health effects. The aim of our research is to monitor the road noise emission of the city of Debrecen in detail, using hourly traffic data. After data processing, various situations were modeled according to the MSZ 15036:2002 standard with the help of the IMMI noise mapping program. Overall, it can be said that the studies we have carried out support the high level and increasing trend of noise exposure.

Keywords*: traffic noise, noise exposure, noise mapping.*

1. Introduction

Noise pollution is a form of pollution that affects our daily lives, yet it is less talked about than other pollutants with a higher ‘click-hunter value’. This is probably due to the fact that high noise is an inseparable part of the concept of big cities, so many people do not even think that continuous exposure can have negative health effects.

Noise maps usually provide only a state report of the city’s yearly noise pollution. The aim of our research is to obtain a more detailed picture of how the rate of noise exposure varies in a given year, the extent to how the day and night noise emission values differ, and to examine the possible seasonal nature of the noise emission.

In the course of this study, we worked with a wide range of information, providing us with a suitable basis for detailed analysis.

2. Literature overview

2.1. Characteristics of road traffic noise

Traffic noise can arise from aviation; watercraft; train service and of course, cars. It includes not only the noise of the vehicle in motion, but the noise generated during the operation of the vehicle. The urban population is mainly exposed to noise from road traffic.

Road traffic noise is composed of a number of components, including engine noise; noise from tires and contact of the vehicle with the air. However, the noise pollution caused by vehicles is also closely linked to other conditions, such as the volume of traffic, the quality of the road surface, the number and proportion of heavy vehicles in traffic as well as the different topography, weather conditions, road conditions and other individual factors (e.g. intersections; and number of traffic lights) **[1]**.

Problems arising from road noise pollution are constantly occurring in the vicinity of high-traffic road sections, so it is key to address them. In a previous publication, we analyzed the long-term changes in traffic noise through the examples of several road sections and concluded that a very significant increase in the traffic of passenger cars and light commercial vehicles can be observed in the case of the currently studied road

section and in general. We compared the 1995-1997 period average with the 2016-2019 period average [2]. According to the latest noise report 'Noise in Europe-2020' from the European Environment Agency (EEA), the growing trend will continue due to urban sprawl; and the increased demand for mobility [3].

2.2. Data of exposure

According to the interactive map of the *Noise Observation & Information Service for Europe*, 1,133,500 people in Budapest and 104,200 in Debrecen are exposed to high levels of road noise ($L_{den} \geq 55$ dB(A)) [4]. These data are of greater concern when compared to the total population of the cities: compared to the 2016 population data, about 64.6% of Budapest residents and more than half of the residents of Debrecen - 51.45 % -are affected.

The EEA states [5]: "In most European countries, more than 50% of the urban population is exposed to road noise levels of 55 dB or more during the day, in the evening and at night. According to the World Health Organization, this level of noise can already cause health problems. The European Union considers long-term exposure to noise levels above 55 decibels to be high noise levels."

The World Health Organization's (WHO) report 'Burden of disease from environmental noise' [6] which was published in 2011, looked at noise exposure in Western European countries, with data covering a 10-year period. It has been found that at least one million healthy life years are lost in Europe due to noise emissions, and while other forms of pollution are becoming less and less present in the environment; noise exposure is increasing.

Research suggests that among people living on noisy road sections, exposure to noise can cause temporary; or even chronic physiological process changes. This influence, as well as the noise exposure, can be permanent and can lead to major problems such as high blood pressure and consequent heart disease, as well as an increase in hearing threshold [7].

3. Methods

3.1. Area of analysis

The road section with code number 1039 has been designated as the study area, which marks the section of the main road 4 between *Sámsoni út* and *Faraktár utca* in Debrecen. Within the 1039 section, the focus was on the *Kassai út* road section and its immediate surroundings. The traffic passing here can be considered high in terms of the city, each vehicle category appears on the section to a significant extent, so the road section is a valid representation of the other roads in the city with similar characteristics.

A noise map was prepared to examine the surroundings of the 'Kassai út' road section. The buildings in the vicinity of the area were also modeled on the noise map, so the noise-reflecting effects of each building can be examined. In real life, people are affected not only by the noise load from a road section, but also by the noise emission emitted by the total traffic in the given area, but in the case of the study area, the dominance of the Kassai road is clear.

3.2. Traffic data

3.2.1. Acoustic vehicle categories

It is essential for noise assessment methods to classify different types of vehicles into acoustic vehicle categories, as the higher presence of each category on the roads significantly influences the amount of noise load emitted by the road. Traffic data can only be interpreted after classification into acoustic vehicle categories. Class classifications are based on the 93/2007. (XII. 18) KvVM regulation, the following can be read in it: Passenger cars and vans belong to category I; motorcycles and mopeds ; solo buses and light goods vehicles (up to a total weight of 7000 kg) fall into the II. category, III. category includes articulated buses, solo heavy goods vehicles and lorry combinations.[8]

Contrary to Hungarian legislation, the CNOSSOS-EU noise assessment method, created thanks to the European Union's legal harmonization efforts, currently has 5 main categories, which differs from the Hungarian one in that motorcycles and mopeds are in category 4, and there is also a 5., open category to meet future needs [1].

3.2.2. Average Daily Traffic

A record, named 'Az országos közutak XY. évre vonatkozó keresztmetszeti forgalma' can be downloaded from the website of Magyar Közút Nonprofit Zrt. The document contains values for the annual average daily turnover (acronym in Hungarian: ÁNF), which is essential for calculating the so-called $L_{AM,kö}$, values. In order to access the ÁNF data, the cross-sectional traffic data is given a specific code number based on the traffic road category, the location of the road according to the county, the number of the examined sec-

tion and the boundary sections of the examined section.

The aim of the current research was to monitor the distribution of the noise load as a function of the change in traffic, therefore the document issued annually by Magyar Közút Zrt. does not provide us with a sufficiently detailed picture. The amount of information in the report is not sufficient for research purposes because, as its title suggests, it only includes traffic data for each cross-section for the annual situation. We obtained access to the detailed, hourly traffic data after contacting Magyar Közút Zrt.

3.2.3. Hourly traffic data

Detailed hourly traffic data for four years (2015, 2016, 2017, 2019) were available to us. The traffic count on the examined section was performed by a Miniloop measuring instrument in intermittent operation. The tool could only measure the number of vehicles passing through two lanes. For the years under study, the passing vehicle numbers provided by the instrument, registered by the two loops, were given in month/day/hour format. The raw traffic count data sent by Magyar Közút Zrt. were systematized and divided into acoustic categories in order to produce the detailed traffic data required for the noise maps.

3.3. IMMI noise mapping programe

We used one of the market-leading noise mapping programs, IMMI, for noise mapping. The program of German origin offers many possibilities in different areas of noise mapping. During the examination, the program performed a noise calculation based on the entered traffic data (in accordance with the valid Hungarian legislations and the current regulations of CNOSSOS-EU).

The noise load data of the examined road section can be entered into the system in 3 different ways: with hourly distribution data; in the case of outdoor measurements, the ÁNF for the year and the hourly traffic data recorded during the measurement period, and the pre-calculated sound pressure level values can also be entered into the program. Traffic data is always provided for each acoustic vehicle category. In our case, the hourly distribution data proved to be the most suitable for processing the results of the data analysis.

In the basic map, Kassai út is marked as a line source, the buildings close to the measurement point were modeled one by one according to the Debrecen town plan (based on satellite images, we can input more details, such as buildings

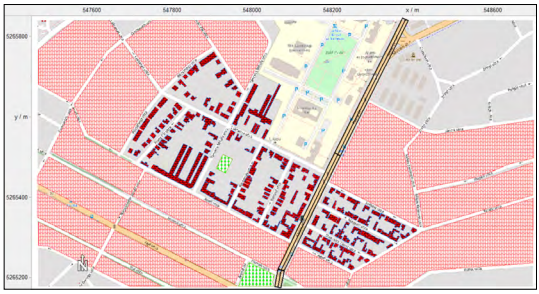

Figure 1. *Modelled image of the test area*

height), the more distant blocks of buildings were depicted as residential areas. In order to be able to examine how the noise emission values acted at a point, we added a measuring point under the number 16 on Kassai út, which is shown on the map with a microphone icon. At this point, we had previously performed road noise measurements in several cases..

4. Results

4.1. Data processing of the hourly traffic

The trafficmeter provides hourly data for the observed area, so daytime and nighttime traffic can be determined, which is advantageous, because the 27/2008. (XII. 3.) KvVM-EüM joint decree sets separate limit values for the day (06-22 hours) and night (22-06 hours) assessment period. According to the law, in the case of motorways and main roads belonging to the national road network, the amount of LAM, ‘kö in residential areas built in large cities may not exceed 65-; and 55 decibels at night.

It was crucial to classify the data into acoustic vehicle categories, which were based on the annual reports issued by Magyar Közút Kft. In the examined years, the distribution data were analyzed, and then the traffic volume data belonging to each class were compared with the total number of vehicles passing through the year, after that the total traffic numbers were divided by the number of persons in each class. Thus, the following ratios were obtained as a result:

Table 1. *Calculated ratios for acoustic vehicle categories*

Acoustic vehicle category	Ratio
I.	0.914
II.	0.0396
III.	0.0462

The hourly vehicle turnover data for the two lanes were summed and then aggregated for the given time of day (day and night). In addition, we determined the total monthly turnover, the monthly average turnover, the minimum - maximum hourly turnover of the given month and the standard deviation of these values. These evaluations were performed for each year examined and then summarized annually for that month. After scaling, the following turnover data were obtained for the examined years, daytime and evening time (In **Table 2** the notation 'D' and 'N' after the examined years refer to the daytime and nighttime assessment periods, respectively):

Table 2. *Average hourly distribution data per day (D: day, N: night) for the studied years by acoustic vehicle categories (unit: vehicle / hour)*

	I. cat.	II. cat.	III. cat.
2015D	877.59	38.02	44.39
2015N	156.83	6.79	7.93
2016D	907.82	39.33	45.92
2016N	162.72	7.05	8.23
2017D	867.19	37.57	43.86
2017N	218.28	9.46	11.04
2019D	1068.14	46.27	54.03
2019N	163.49	7.08	8.27

The information obtained during the data analysis made suitable for processing by the IMMI noise mapping program.

4.2. Noise mapping of the studied years based on the processed traffic data

The noise mapping program is multinational; it also includes the CNOSSOS-EU noise assessment method, which has been developed as a result of EU harmonisation.. The noise mapping was carried out in accordance with standard MSZ 15036: 2002 and was also performed on the basis of CNOSSOS-EU, but it is important to emphasize that the European method is still an adaptation therefore these values may differ in the future.

For the four years studied, the data were entered into the program, so the sound power values L_w or the road section were determined.

Based on **Table 3** it can be stated that the level of noise exposure during the years is similar, but both for daytime; both night values are high.

The highest noise emissions affect residents and passers-by directly along the roads. Moving away from the line source, the amount of noise emission caused by one road section becomes smaller and smaller, the more distant area is no longer affected, the effect of the locally closer line sources must be taken into account.

Table 3. *Sound power level values of the examined years*

Year/L_w' (dB(A))		MSZ	CNOSSOS
2015	Day	82.23	80.6
	Night	75.15	73.1
2016	Day	82.36	80.7
	Night	75.33	73.2
2017	Day	82.19	80.5
	Night	76.59	74.5
2019	Day	82.95	81.4
	Night	75.35	73.3

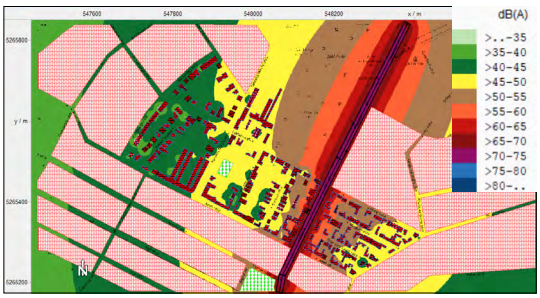

Figure 2. *Daytime noise map for 2015 (from hourly daily averages, according to MSZ 15036: 2002)*

Noise maps were prepared to examine the annual noise propagation properties, however, due to space limitations, only one map is included in the publication (**Figure 2.**) .

4.3. Processing minimum-maximum traffic data

Hourly traffic data has helped us to examine the extent to which noise exposure may deviate within a year. The highest yearly values, and the lowest traffic days were used as the basis for the analysis.

We recorded a noise load point on the map at the 16th location of Kassai út, which used to be a measuring point, so it became possible to determine whether the limit value is exceeded on the minimum and maximum traffic days for the given year and what the difference is.

According to the Hungarian legislation, the measuring point was marked on the map 2 meters in front of the façade, at an assessment height

of 1.5 meters. The results of the sound power level examined on the basis of the minimum-maximum traffic volumes of the obtained years show a large difference. It is worth noting that the L_{Aeq} sound pressure levels for the night always exceeded the 55 dB (A) limit, even at the minimum values.

Of the four years, 2019 has the absolute minimum-maximum value; on the least busiest day, 2306 vehicles passed, while on the busiest day, 27391 vehicles passed section 1039. There is a big difference in the amount of noise emitted by vehicles passing through the road section: 72.8 dB (A) during the minimum day and 62.3 dB (A) at night, and the maximum turnover day. 84.1 dB (A) daytime and 76.6 dB (A) nighttime sound power levels were observed. The difference between the two daytime releases is particularly large; the difference is 11.3 decibels. The contrast between the two values is well illustrated by images of **Figure 3.**

Table 4. *Minimum-maximum traffic day for a given year*

Minimum-maximum traffic day for a given year (vehicle/day)	2015	Date	04.21.
		MIN	4238
		Date	06.05.
		MAX	22252
	2016	Date	04.13.
		MIN	2872
		Date	06.10.
		MAX	23724
	2017	Date	09.14.
		MIN	5048
		Date	12.22.
		MAX	24606
	2019	Date	09.18.
		MIN	2306
		Date	09.13.
		MAX	27391

Table 5. *L_{Aeq} sound pressure levels at minimum - maximum days [dB(A)]*

	Day	**Night**
2015 MIN	62.49	56.55
2015 MAX	69.27	61.95
2016 MIN	60.36	57.39
2016 MAX	68.96	66.18
2017 MIN	63.05	58.52
2017 MAX	69.57	63.35
2019 MIN	58.79	58.29
2019 MAX	70.09	62.51
Limit value	**65 dB(A)**	**55 dB(A)**

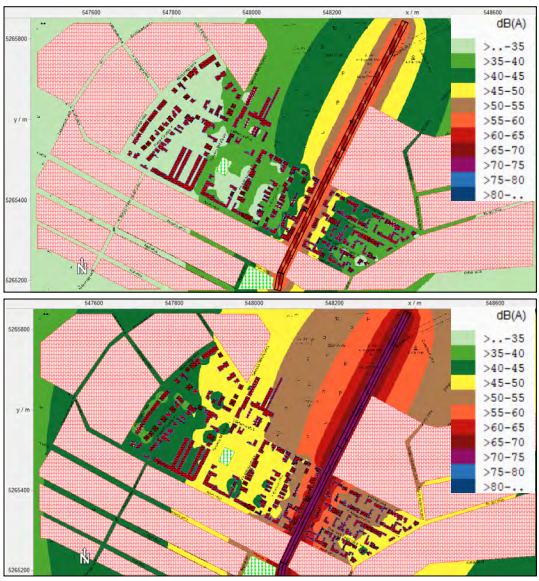

Figure 3. *Noise map of the absolute minimum and maximum traffic days of the examined years*

4.4. Analysis of periodic properties of noise emission

The traffic volume for the winter and summer months of the studied years was also modeled, the main purpose of which was to examine the possible seasonal characteristics of noise emission.

There is no significant difference between the daytime values for January and August but in the night-time load data, there is a bigger difference observed for the summer months. (**Table 6.**) This increased traffic in the summer months is the reason for higher levels of night noise exposure.

4.5. Number of people affected by noise exposure from the road section

The IMMI noise mapping program can be used for various parameters; so-called thematic maps can also be produced. One of these thematic maps also shows the number of people living in certain

Table 6. *Sound power level values for January and August [dB(A)]*

$L_{w'}$ [dB(A)]		January	August
2015	Day	82.16	82.44
	Night	73.53	75.31
2016	Day	81.87	82.69
	Night	73.49	75.51
2017	Day	81.58	82.65
	Night	73.48	75.12
2019	Day	82.46	83.04
	Night	74.23	75.93

residential buildings, which is determined by the IMMI program based on the parameters of the residential buildings. Based on this map, it can be examined the number of people directly affected by the noise load caused by the given road section can be determined.

The software can also run detailed calculations on the topic of involvement; so it can determine how many people are actually affected by noise exposure ranges at a certain distance from the source. In the immediate vicinity of the studied section, approximately 1059 inhabitants in our modeled area - based on the analysis of the program - are involved in the noise load from section 1039.

Most residents are in the 45-50 decibel range, with about 343 people in this category. The maximum load range is 65-70 dB, affecting 24 people. It is worth noting that more people fall into smaller load classes because there are condominiums that can accommodate more residents away from the road section than in the immediate vicinity of the road section.

5. Conclusions

We examined the noise load in the vicinity of the road section that is the subject of our study between 2015 and 2019 based on traffic data from the road operator. In addition to the annual average traffic data, we also produced noise maps for the lowest and highest traffic days using the current Hungarian standard and CNOSSOS-EU. At a set point, we examined compliance with the limit values for road noise. Based on this, we have revealed that the limit value is exceeded even during the lowest traffic days of the year. Comparing the January and August averages, we identified a significant increase in nocturnal noise emission for the summer values of the road section.

As a result of our investigations, we obtained a detailed picture of the development of noise load in the case of a high-traffic, urban road section, determining the daily noise characteristics for each day.

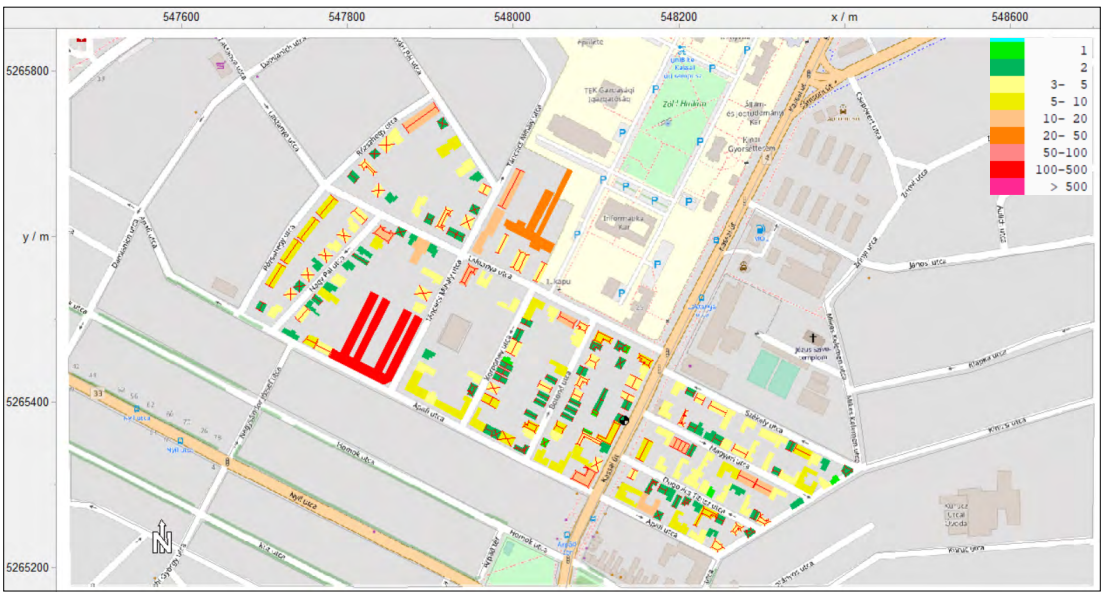

Figure 4. *Population of the immediate environment of section 1039 [persons]*

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