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## MEASURING AND MAPPING NOISE POLLUTION IN THE CITY OF BANJA LUKA

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### ABSTRACT:

Noise pollution may have negative impacts on human health and environmental. The primary aim of this study is was to determine and mapping the noise pollution in the urban part of the city Banja Luka in Bulevar Cara Dušana by evaluating noise levels in the boulevards. The aim of this investigation is also compare measured noise levels in the boulevards with legislation. The measured values exceeded the level of noise allowed. Because they are at all measuring points at study area mixing two zones I (hospital, rehabilitation) and III (trading, business, housing and housing next to traffic corridors, warehouses excluding heavy transport) it can be concluded that the noise level values in this area are alarming.

Key words: *environmental noise, noise mapping, environmental protection*

### INTRODUCTION

Noise is a specific form of pollution in the modern world. It was observed as a problem at the beginning of urbanization and housing in the cities, and it became a serious ecological problem with the beginning of industrialization at the end of the 18<sup>th</sup> and the beginning of the 19<sup>th</sup> centuries [1]. Noise pollution and air pollution are a significant environmental problem in many urban areas. This problem has not been properly recognized despite the fact that it is steadily growing in developing countries [2,3]. Traffic is also being developed intensively, there is an increased application of technical devices, and it all results in an increase in the number of noise sources, both in the working environment, and in the environment. The safe exploitation of technical structures such as a public road is connected not only with safety of traffic but also with minimization of its negative impact on the environment [4].

The EU Directive on the management of environmental noise [5] adds industrial sites as sources of environmental noise [6]. Noise, defined as 'unwanted sound', is perceived as a pollutant and one type of environmental stressor [7]. Noise research in Banja Luka and neighboring municipalities is rare [8, 9, 10], unlike air pollution [11,12,13,14,15,16,17,18,19,20].

Planning measures against noise require several types of knowledge including noise sources, noise intensity and type, and the spatial propagation/distribution of noise patterns. A typical planning exercise in the struggle against noise is to look at residential areas and identify the critical points where noise intensity may be considered intolerable and hazardous for human health. This information

is then used to propose a series of protection measures which are both economically and humanly acceptable. This information may come in form of numerical listing or written reports, but it is obvious that the most efficient way to convey such information is in a map form. This is not surprising, since noise, like temperature or rainfall, is typically a spatially distributed phenomenon. In fact, the use of maps to convey information about noise is nothing new and has existed for some time [21].

## OBJECTIVES

The primary aim of this study is was to determine and mapping the noise pollution in the urban part of the city Banja Luka in Bulevar (boulevards) Cara Dušana (Republic of Srpska, Bosnia & Hercegovina (B&H)) by evaluating noise levels in the boulevards. The aim of this investigation is also compare measured noise levels in the boulevards with legislation.

## MATERIAL AND METHODS

### Study area:

Subject of the research is determine the noise pollution in Banja Luka, which located in the northwestern part of B&H and one of the two entities in B&H. Banja Luka is located in Vrbas valley and is surrounded by hills 200-600 meters above sea level high. Banja Luka is the second biggest city in B&H with the population of 200,000. Situated in a basin 164 m above sea level, where the Dinaric Alps from the south descend into the Pannonian Basin in the north, Banja Luka has temperate continental climate with the prevailing influences from the Pannonian plain. It belongs to the Central European Time zone (GMT +1) and. The average annual temperature reaches 10.7°C, the average January 0.8°C, whereas the average temperature in July reaches 21.3°C.

The present study on environmental noise pollution was carried out in June 2014. Measurement of noise was measured at measuring points in Bulevar Cara Dušana (Pictures 1). Noise measurement included is part of the Bulevar Cara Dušana from the roundabout at the junction of the Krajiških brigada street, Karađorđeva street and Omladinska street to the traffic light at the intersection with the Jovana Dučića street.



●-sampling points

Picture 1. Location measurements and sampling points

### Noise measurements:

Measurements were performed with a 2260 Bruel & Kjaer type I sound-level meter and with tripod 140 cm, Techno line, EA-3010 Anemometer and Greisinger GFTH 95 Thermo-Hygrometer. Calibration was performed using a 4226 Bruel & Kjaer calibrator. Were used Predictor™ –

LimA™ Software, Suite Type 7810 from version 4.3 and version 5.1 and 7815 Noise Explorer™. Noise is measured by a sound level meter; which is an instrument which responds to sound in approximately the same way as the human ear and which gives reproducible measurements of sound level [22,3]. The equivalent continuous equal energy level ( $L_{eq}$ ) is applied to fluctuating noise level. The  $L_{eq}$  is defined as the constant noise level that expends the same amount of energy as the fluctuating level over the same time period [23,3].

$L_{eq}$  is measured for traffic noise along with the statistical levels  $L_1$  and  $L_{10}$  which are the noise levels exceeded 1% and 10% of the time; respectively. Equivalent noise levels [ $L_{eq}$  (dBA)] were measured on one occasion, in one day intervals (between 9 a.m. and 3 p.m.), one evening interval (between 6 and 10 p.m.), and two night intervals (after 10 p.m.). Three measurements duration 15 minutes daily (during three days) were made at each measuring point on a sample during the day for each period day-evening-night, in accordance with the Directive 2002/49/EC relating to the assessment and management of environmental noise [5], because Rulebook on Allowed Limits for Noise and Hum Intensity [24] does not define evening period.  $L_{day}$  [dB (A)] – is the A-weighted long-term average sound level determined over the day periods of a year,  $L_{evening}$  [dB (A)] – is the A-weighted long-term average sound level determined over the evening periods of a year and  $L_{night}$  [dB (A)] – is the A-weighted long-term average sound level determined over the night periods of a year.

The measurement of noise levels was performed in compliance with the Rulebook on Allowed Limits for Noise and Hum Intensity [24], i.e. Article 4 (external noise is measured at the level of 1.7 meters from the level of the terrain, at the distance of at least 3 meters from noise reflecting obstacles).

#### Noise Levels Allowed

The highest equivalent levels of external noise allowed were determined in accordance with the purpose of the area (zone) and are provided in Table 1. of the Rulebook [24]. In compliance with the purpose of the area monitored, the study area is located in area (zone) I (hospital, rehabilitation) and III (exclusively housing, child-rearing and educational and health institutions, public green and recreation areas).

Table 1. Allowed levels of external noise pursuant to the purpose of the area

Area (zone)	Area purpose	Highest level of external noise allowed (dBA)			
		Equivalent levels		Peak levels	
		daytime	nighttime	$L_{10}$	$L_1$
I	Hospital, rehabilitation	45	40	55	60
II	Tourism, recreation, recuperation	50	40	60	65
III	Exclusively housing, child-rearing and educational and health institutions, public green and recreation areas	55	45	65	70
IV	Trading, business, housing and housing next to traffic corridors, warehouses excluding heavy transport	60	50	70	75
V	Business, administrative, trading, crafts, servicing (utility services)	65	60	75	80
VI	Industrial, warehousing, servicing and traffic, excluding apartments	70	70	80	85

#### NOTE

1) In the context of this Rulebook, daytime lasts from 06.00 to 22.00 hours, while nighttime lasts from 22.00 to 06.00 hours.

2) Peak levels  $L_{10}$  and  $L_1$  are those noise levels that are exceeded in the duration of 10% i.e. 1% of the total period of measurement, i.e. daytime or nighttime.

## RESULTS AND DISCUSSION

In area noise measurement is Banja Luka Gymnasium, University Clinical Center of Republic of Srpska, medical institutions (Institute of Transfusion Medicine of the Republic of Srpska, Institute of

Forensic Medicine of the Republic of Srpska) and near the residential building. Bulevar Cara Dušana the study area is located in zone I (hospital, rehabilitation) and III (exclusively housing, child-rearing and educational and health institutions, public green and recreation areas).

In accordance with Rulebook [24] highest level of external noise allowed for zona I is 45 dB(A), and for zona III 55 dB(A), which means that the values of the measured noise, as compared to allowed, in zona I more than 20.7 to 24.9 dB(A) in day, and zona III more than 10.7 to 14.9 dB(A) (Table 2).

During daily measurements in all three days, Leq is above the allowed values and ranges from 65.7 to 69.9 dB (A).

Table 2. Level of noise in Bulevar Cara Dušana

1 <sup>st</sup> day			2 <sup>nd</sup> day			3 <sup>rd</sup> day		
Day values dB(A)								
L <sub>eq</sub>	L <sub>1</sub>	L <sub>10</sub>	L <sub>eq</sub>	L <sub>1</sub>	L <sub>10</sub>	L <sub>eq</sub>	L <sub>1</sub>	L <sub>10</sub>
65.7	72.6	69.0	65.9	71.5	67.8	69.9	79.8	73.5
Evening values dB(A)								
L <sub>eq</sub>	L <sub>1</sub>	L <sub>10</sub>	L <sub>eq</sub>	L <sub>1</sub>	L <sub>10</sub>	L <sub>eq</sub>	L <sub>1</sub>	L <sub>10</sub>
66.4	76.0	69.2	64.6	74.0	67.9	66.2	75.0	69.7
Night values dB(A)								
L <sub>eq</sub>	L <sub>1</sub>	L <sub>10</sub>	L <sub>eq</sub>	L <sub>1</sub>	L <sub>10</sub>	L <sub>eq</sub>	L <sub>1</sub>	L <sub>10</sub>
58.3	64.9	60.6	65.4	69.6	67.6	62.3	74.4	68.6

Peak level L<sub>1</sub> in all three daily measurements ranges from 71.5 to 79.8 dB(A), and is allowed for zona I 60 dB(A), and for zona III 70 dB(A). Measured values in relation to allowed are more from 11.5 to 19.8 dB(A) (For zona I) and from 1.5 to 9.8 dB(A) (For zona III).

Peak level L<sub>10</sub> in all three daily measurements ranges from 67.8 to 73.5 dB(A), and is allowed for zona I 55 dB(A), and for zona III 65 dB(A). Measured values in relation to allowed are more from 12.8 to 18.5 dB(A) (For zona I) and 2.8 to 8.5 dB(A) (For zona III).

Frequency noise analysis for daily measurement L<sub>eq</sub>=69.9 dB(A) shows that the highest levels of noise at frequencies 500, 1000 and 2000 Hz, over 60 dB(A), and at lower frequencies are above 50 dB(A) (Diagram 1, Table 3), except at 63 Hz where it is above 40 dB(A).

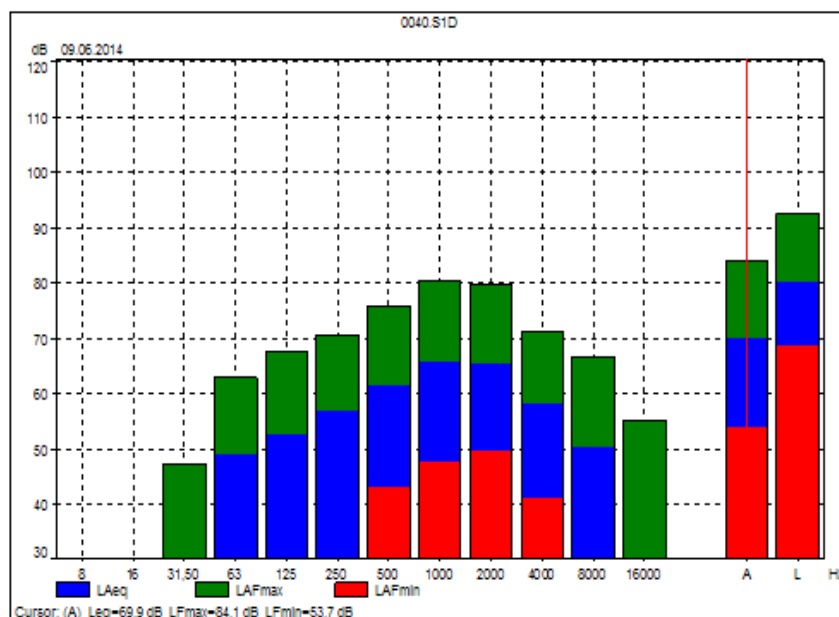


Diagram 1. Frequency noise analysis for L<sub>eq</sub>=69.9 dB(A)

Table 3. Leq values of noise levels depending on the frequency

Hz	31.5	63	125	250	500	1000	2000	4000	8000	16000
dB(A)	-	48.9	52.3	56.6	61.1	65.6	65.2	58	50	-

Rulebook [24] does not define evening period.  $L_{eq}$  for evening is from 64.6 to 66.4 dB(A),  $L_1$  from 74.0 to 76.0 dB(A) and  $L_{10}$  from 67.97 to 69.7 dB(A).

$L_{eq}$  for night is above the allowable values and ranges from 58.3 to 65.4 dB(A), which is in relation to allowed equivalent levels 40 dB(A) (For zona I), higher than 18.3 to 25.4 dB(A), and 45 dB(A), than 13.3 to 20.4 dB(A) (For zona III).

Peak level  $L_1$  in all three night measurements ranges from 64.9 to 74.4 dB(A), and is allowed for zona I 60 dB(A), and for zona III 70 dB(A). Measured values in relation to allowed are more from 4.9 to 14.4 dB(A) (For zona I), and for 7.4 dB(A) (For zona III).

Peak level  $L_{10}$  in all three night measurements ranges from 60.6 to 68.6 dB(A), and is allowed for zona I 55 dB(A) and for zona III 65 dB(A). Measured values in relation to allowed are more from 5.6 to 13.6 dB(A) (For zona I), and for 3.6 dB(A) (For zona III).

All measured values equivalent noise during the day and during the night in all three measurements at the measuring point on the Bulevar Cara Dušana, as well as the value of the peak levels  $L_1$  and  $L_{10}$  exceed the allowable values.

The main source of noise in this area is the communal noise of motor vehicles (Table 4).

Table 4. Vehicle number in Bulevar Cara Dušana

	1 <sup>st</sup> day			2 <sup>nd</sup> day			3 <sup>rd</sup> day		
	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night
Vehicle number	325	210	131	300	228	163	315	253	118
Passenger cars (%)	92.30	94.29	98.47	92.66	94.29	98.17	88.9	94.86	97.45
Buses (%)	2.15	2.38	-	2.34	2.20	-	3.49	2.37	-
Wans (%)	4.30	2.38	1.53	4.00	2.20	0.61	6.66	1.58	0.86
Motorcycles (%)	1.25	0.95	-	1.00	1.31	1.22	0.31	0.79	1.69
Vehicles > 5 t (%)	-	-	-	-	-	-	0.64	0.40	-

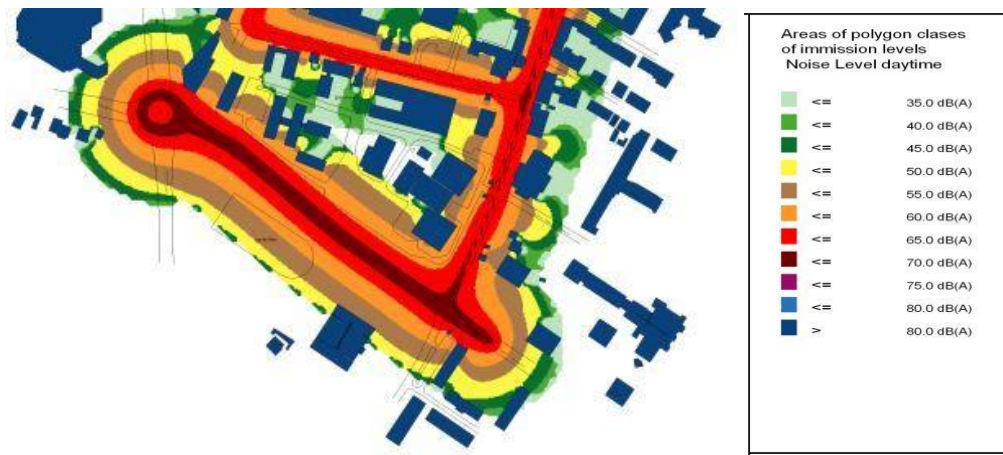
Counting period in fifteen minutes, in which time is measured equivalent noise, Bulevar Cara Dušana passes from 300 to 325 vehicles during the day (about 20 vehicles per minute). During the evening, the number of vehicles decreases from 210 to 253 (about 15 vehicles per minute), and during the night from 118 to 131 vehicles (about 8 vehicles per minute). Based on the above, we get the information that for 24 hours in this street on average passes 25,140 vehicles, about 57.28% in day, 27.44% in evening and 15.28% in night period.

On Bulevar Cara Dušana prevail passenger vehicles at all times of the day (day, evening, night), from 88.9% (day), to 94.29% (evening), and to 98.47% (night) (Table 4). Bus frequency is 2.38% (evening) and 2.34% (day). Wans frequency is 6.66% (day), 2.20% (evening), and 1.53% (night). Motorcycles frequency is 1.25% (day), 1.31% (evening) and 1.22% (night).

All values  $L_{eq}$  (day and night) are exceeded regardless of whether the highest level of external noise allowed for I ( $L_{day}=45$ ;  $L_{night}=40$ ) or III ( $L_{day}=55$ ;  $L_{night}=45$ ) area (zone). Values peak levels  $L_1$  (60 & 70 dB) and  $L_{10}$  (55 & 65 dB) are slightly lower than the limit values or have been exceeded.

Because they are at all measuring points at study area mixing two area (zones) I (hospital, rehabilitation) and III (trading, business, housing and housing next to traffic corridors, warehouses excluding heavy transport) it can be concluded that the noise level values in this area are alarming and this is the noise that is 10 dB (A) exceeds the value of the corresponding zone.

Based on all measured data, a noise map was made (Pictures 2, 3 and 4).



Picture 2. Noise map for Bulevar Cara Dušana (day)



Picture 3. Noise map for Bulevar Cara Dušana (evening)



Picture 4. Noise map for Bulevar Cara Dušana (night)

## CONCLUSIONS

The results of conducted measurements and analyses showed a big problem of noise pollution in Banja Luka city. All measured values  $L_{eq}$  (day and night) are exceeded regardless of whether the highest level of external noise allowed for I ( $L_{day}=45$ ;  $L_{night}=40$ ) or III ( $L_{day}=55$ ;  $L_{night}=45$ ) zone. Values peak levels  $L_1$  (60 & 70 dB) and  $L_{10}$  (55 & 65 dB) are slightly lower than the limit values or have been exceeded and that the noise level values in this area are alarming, as evidenced by the noise map.

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