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ANALYSING AND MAPPING NOISE IN THE CITY OF BANJA LUKA (SIME MATAVULJA STREET)

Abstract: *Noise, defined as ‘unwanted sound’, is perceived as an environmental stressor and nuisance. Noise pollution is a significant environmental problem in many urban areas. Noise is serious ecological problem with the beginning of industrialization at the end of the 18th and the beginning of the 19th centuries. Urbanization, economic growth and transport are some of the driving forces for environmental noise exposure and health effects. There are a small number of noise researches in our country. The aim of this study is was to analysing and mapping noise pollution in the urban part of the city Banja Luka in Sime Matavulja Street by evaluating noise levels in the street. The aim of this investigation is also compare measured noise levels with legislation. The measured values level of noise in this area is alarming. Based on the measurements, analysis and created noise maps, it is necessary to reduce the speed of the vehicle, increase control of vehicle exhaust systems and prohibit motorcycle riding without built-in silencers.*

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

JEL classification: *Q51, Q53*

INTRODUCTION

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 (Barboza et al. 1995; Jamrah et al. 2006; Ilić et al. 2012). Non-auditory effects of noise can be defined as ‘all those effects on health and well-being which are caused by exposure to noise’ (Stansfeld and Matheson 2003). It is estimated that more than 100 million people in the EEA (European Environment Agency)-33 member countries are exposed to L_{den} (annual average day, evening and night period of exposure) from road traffic that are above 55 dB. Of these, 32 million are exposed to very high noise levels above 65 dB L_{den} . In addition, many people are also exposed to rail, aircraft and industrial noise, particularly in towns and cities in the EEA-33: railways noise: 19 million people exposed above 55 dB L; aircraft noise: more than 4.1 million people exposed above 55 dB L; industrial noise: approx. 1.0 million people exposed. More general impacts of exposure to harmful levels of environmental noise include annoyance, stress reactions, sleep disturbance and an increase in the risk of hypertension and cardiovascular disease, which can lead to premature death (Adams 2017). Environmental noise is unwanted sound from different

sources, e.g. road (Kanjo 2010). With the rapid increase in the level of cars, utilities, primarily noise pollution has also increased (Ozer et al. 2009).

The EU Directive on the management of environmental noise (Directive 2002/49/EC) adds industrial sites as sources of environmental noise. Noise, defined as 'unwanted sound', is perceived as a pollutant and one type of environmental stressor (Stansfeld, 2000). Noise research in Banja Luka is rare (Ilić et al. 2012), unlike air pollution (Ilić and Preradović, 2009; Lammel et al. 2010; Lammel et al. 2010; Gasic et al. 2010; Lammel et al. 2011; Preradović et al. 2011; Ilić et al. 2012), but the data indicate elevated levels of noise in the environment.

1. OBJECTIVES

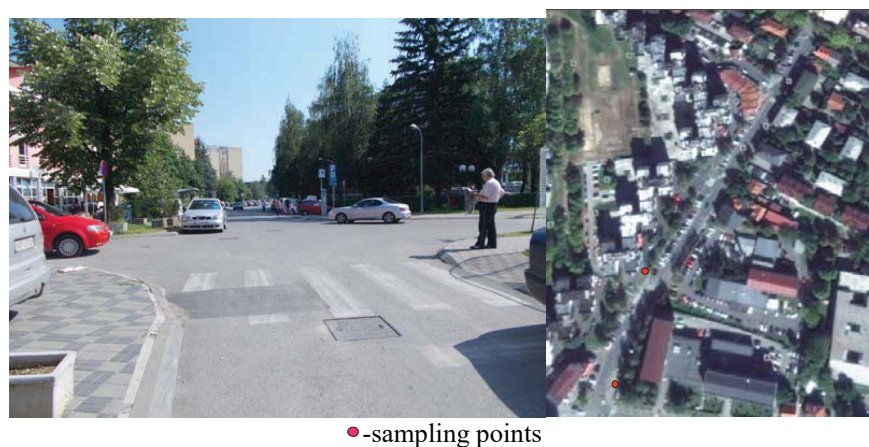
The primary aim of this study was to research and mapping the noise pollution in the urban part of the City of Banja Luka in Sime Matavulja Street (Republic of Srpska, Bosnia and Hercegovina (B&H)) by evaluating noise levels in the street. The aim of this research is also to compare the measured noise levels in the street with legislation.

2. MATERIAL AND METHODS

2.1. Study area

Subject of the research is to determine the noise pollution in Banja Luka, which 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. Banja Luka is the second biggest city in B&H with the population of 180,000. 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). 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 the measuring points in Sime Matavulja Street (Pictures 1). Noise measurement included is location from the intersection with Zdrave Korde Street to the intersection with Branko Radičević Street.



Picture 1. Location measurements and sampling points (Author)

2.2. Noise measurements

Measurements were performed with 2260 Bruel & Kjaer type I sound-level meter and with tripod 140 cm. 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™. 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 (Jamrah et al. 2006).

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 one night interval (after 10 p.m.). Three measurements that lasted 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, because Rulebook on allowed limits for noise and hum intensity (Rulebook 46/89) does not define evening period.

The measurement of noise levels was performed in compliance with the Rulebook on allowed limits for noise and hum intensity (Rulebook 46/89), 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).

2.3. 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 (Rulebook 46/89). In compliance with the purpose of the area monitored, the study area is located in area (zone) 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 (Author)

Area (zone)	Area purpose	Highest level of external noise allowed (dBA)			
		Equivalent noise		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-bearing 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

3. RESULTS AND DISCUSSION

In area noise measurement is residential building, Pension and disability insurance fund of the Republic of Srpska, Health Center Banja Luka, and rare catering facilities. Sime Matavulja Street the study area is located in zone III (exclusively housing, child-rearing and educational and health institutions, public green and recreation areas).

During daily measurements in all three days, L_{eq} is above the allowed values and ranges from 59.8 to 64.6 dB(A). In accordance with Rulebook [Rulebook, 46/89] highest level of external noise allowed for the zone III is 55 dB(A), which means that the values of the measured noise, as compared to allowed, in zone III more than 4.8 to 9.6 dB(A) (Table 2).

Table 2. Level of noise in Sime Matavulja street (Author)

1 st day			2 nd day			3 rd day		
Day values dB(A)								
L_{eq}	L_1	L_{10}	L_{eq}	L_1	L_{10}	L_{eq}	L_1	L_{10}
59.8	67.5	63.1	60.0	67.8	63.5	64.6	74.5	68.1
Evening values dB(A)								
L_{eq}	L_1	L_{10}	L_{eq}	L_1	L_{10}	L_{eq}	L_1	L_{10}
60.2	71.0	62.3	61.1	70.6	63.5	56.7	68.1	59.4
Night values dB(A)								
L_{eq}	L_1	L_{10}	L_{eq}	L_1	L_{10}	L_{eq}	L_1	L_{10}
56.9	69.9	59.0	58.4	69.1	61.6	58.1	68.7	64.4

Peak level L_1 in all three daily measurements ranges from 67.5 to 73.5 dB(A), and is allowed for the zone III 70 dB(A). Measured values in relation to allowed for the zone III in two measurements, the peak level values are measured within the allowed limits and in one measurement is more from 4.5 dB(A). Peak level L_{10} in all three daily measurements ranges from 63.1 to 68.1 dB(A), and is allowed for the zone III 65 dB(A). Measured values in relation to allowed for the zone III in two measurements, the peak level values are measured within the allowed limits and in one measurement is more from 3.1 dB(A). Frequency noise analysis for daily measurement $L_{eq}=64.6$ dB(A) shows that the highest levels of noise at frequencies 250, 500, 1000, 2000 and 4000 Hz, over 50 dB(A), and at lower frequencies are above 40 dB(A) (Diagram 1, Table 3).

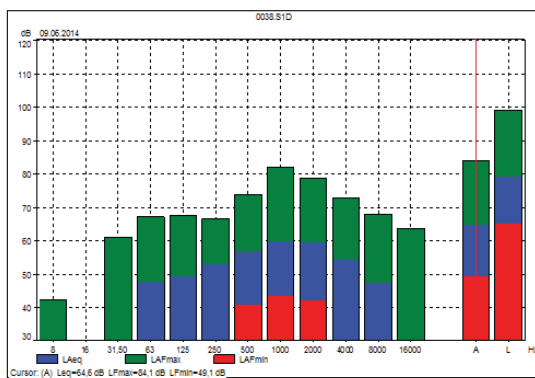


Diagram 1. Frequency noise analysis for $L_{eq}=64.6$ dB(A) (Author)

Table 3. L_{eq} values of noise levels depending on the frequency (Author)

Hz	31.5	63	125	250	500	1000	2000	4000	8000	16000
dB(A)	-	47.5	49.3	52.6	56.8	59.6	59.3	54.1	47.1	-

Rulebook [Rulebook, 46/89] does not define evening period. L_{eq} for evening is from 56.7 to 61.1 dB(A), L_1 from 68.1 to 71.0 dB(A) and L_{10} from 59.4 to 63.5 dB(A).

L_{eq} for night is above the allowable values and ranges from 56.9 to 58.4 dB(A), which is in relation to allowed equivalent levels 45 dB(A), higher than 11.9 to 13.9 dB(A) (for the zone III).

Peak level L_1 in all three night measurements ranges from 68.7 to 69.9 dB(A), and is allowed for the zone III 70 dB(A). Measured values in relation to allowed are within the allowed limits (for the zone III).

Peak level L_{10} in all three night measurements ranges from 59.0 to 64.4 dB(A), and is allowed for the zone III 65 dB(A). Measured values in relation to allowed are within the allowed limits (for the zone III).

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

Table 4. Vehicle number in Sime Matavulja Street (Author)

	1 st day			2 nd day			3 rd day		
	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night
Vehicle number	65	24	43	66	40	36	81	30	46
Passenger cars (%)	89.23	91.66	88.38	90.90	95.00	88.88	83.33	89.13	88.88
Buses (%)	-	-	-	-	-	-	-	-	-
Vans (%)	3.08	-	9.30	4.55	5.00	7.41	16.67	8.70	7.41
Motorcycles (%)	6.16	8.34	2.32	4.55	-	2.47	-	2.17	2.47
Vehicles > 5 t (%)	1.53	-	-	-	-	1.24	-	-	1.24

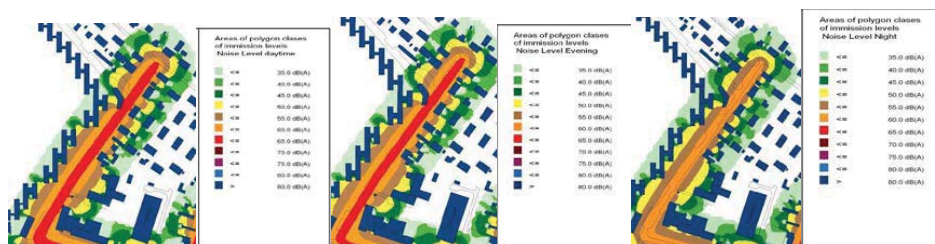
Counting period in fifteen minutes, during which time at the measured equivalent noise, Sime Matavulja Street passes from 65 to 81 vehicles during the day (about 5 vehicles per minute). During the evening, the number of vehicles decreases from 24 to 40 (about 2 vehicles per minute), and during the night from 36 to 46 vehicles (about 3 vehicles per minute). On the basis of the above, we get the information that the average of 4,800 vehicles passes in this street for 24 hours, about 75.00% in day, 10.00% in evening and 15.00% in night period.

Passenger vehicles prevail in Sime Matavulja Street at all times of the day (day, evening, night), from 90.90 (day), to 95.00% (evening), and to 91.67% (night) (Table 4). Frequency of the vans is 7.41% (day), 16.77% (evening) and 8.70% (night). Motorcycles frequency is

6.16% (day), 8.34% (evening) and 5.56% (night). It is characteristic for this street that traffic in the evening reduced by about a third, and in the night by about half.

Because they are at street are mixed activity characteristic of area III and they can not be separated, it can be concluded that the noise level values in this area are alarming and this is the noise that by 10 dB(A) exceeds the value of the corresponding zone.

Based on all measured data, a noise map was made (Picture 2).



Picture 2. Noise map for Sime Matavulja street (day, evening and night) (Author)

CONCLUSIONS

The results of measurements and analyses showed a big problem of noise pollution in Banja Luka city. Based on the measurements, analysis and created noise maps, it is necessary to reduce the speed of the vehicle, increase control of vehicle exhaust systems and prohibit motorcycle riding without built-in silencers. Since in Republic of Srpska does not define evening period L_{eq} , it is necessary to harmonize our legislation. It is also necessary to pay more attention to this issue through the preparation of studies and preventive measures in the Banja Luka and other cities of the Republic of Srpska.

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