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# Noise Pollution Near Health Institutions

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**Abstract:** Environmental noise pollution, a form of air pollution, is a threat to health and well-being. The primary aim of this study was to determine noise pollution in the urban part of the city of Banja Luka in Jovana Dučića Street (Republic of Srpska, Bosnia and Herzegovina (BiH)) 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. The measured values exceeded the level of noise allowed. Results indicated that noise level values in this area near health institution are alarming.

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

## INTRODUCTION

Noise is defined as an unwanted sound. Environmental noise consists of all the unwanted sounds in our communities except from the one which originates in the workplace. Environmental noise pollution, a form of air pollution, is a threat to health and well-being. It is more severe and widespread than ever before, and it will continue to increase in magnitude and severity because of the population growth, urbanisation and the associated growth in the use of increasingly powerful, varied and highly mobile sources of noise. It will also continue to grow because of the sustained growth in highway, rail and air traffic, which remain the major sources of environmental noise. (Goines & Hagler, 2007). The existing evidence indicating that noise pollution may have negative impacts on human health has justified research in order to provide a better understanding of noise pollution problems and control (Georgiadou *et al.*, 2004; Jamrah et al., 2006). Noise pollution and its consequent influence over the environment and life quality of human beings may be considered a ''hot topic'' in scientific research (Zannin et al., 2002). Traffic is the dominating source of noise (Jamrah et al., 2006).

One of serious social problems is environmental noise. In the European Union, about 80 million people suffer from noise levels that are considered to be unacceptable. Furthermore, 170 million people live in "gray areas" where they are exposed to noise causing serious annoyance. The predominant contribution to this high burden by environmental noise arises from transportation on road, on rail and in the air. The costs caused by noise pollution are estimated to be 0.2 to 2 percent of the gross domestic product. Using the lower value, this estimate means annual financial losses due to environmental noise of more than 12 billion Euros (Prascevic & Cvetkovic, 2006). Noise research in Banja Luka and neighboring municipalities is rare (Ilić et al., 2012; Janjuš et al., 2015; Janjuš et al., 2015), unlike air pollution (Ilić & Janjuš, 2008; Ilić & 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; Ilić et al., 2013; Ilić et al., 2014; Ilić, 2015). During the processes of planning and designing, and after the construction of new roads, it is of major importance to determine the level of traffic noise which is going to occur or which has already occurred (Pozder, 2013). Environmental noise, also known as noise pollution, is among the most frequent sources of complaint regarding environmental issues in Europe, especially in densely populated urban areas and residential areas near highways, railways and airports. In comparison to other pollutants, the control of environmental noise has been ham-

pered by insufficient knowledge of its effects on humans and of exposure–response relationships, as well as a lack of defined criteria (WHO, 2011).

## OBJECTIVES

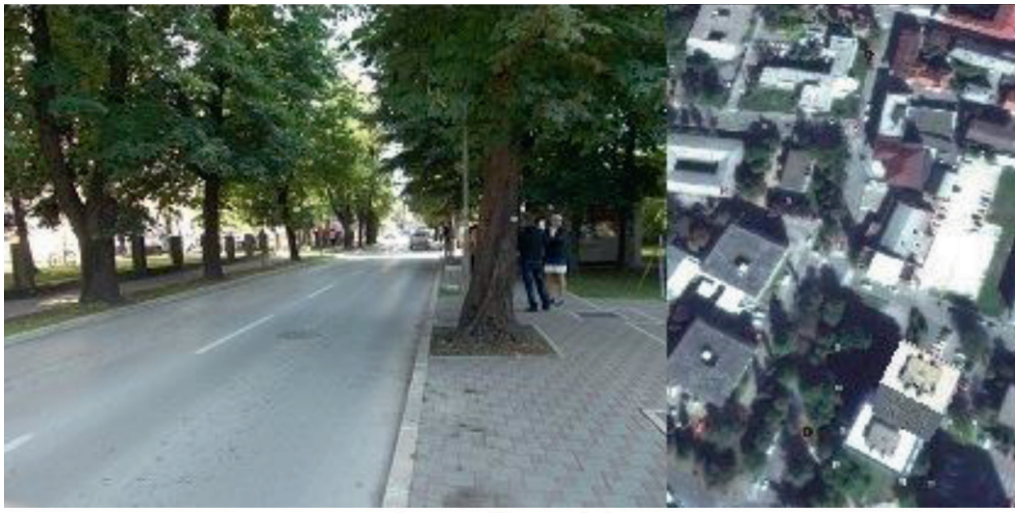
The primary aim of this study was to determine noise pollution in the urban part of the City of Banja Luka, in Jovana Dučića Street (Republic of Srpska, Bosnia and Hercegovina (BiH)), by evaluating noise levels in the street. The aim of this research is also to compare the measured noise levels in the street with legislation.

## MATERIAL AND METHODS

### Study area:

Subject of the research is to determine the noise pollution in Banja Luka, which is located in the northwestern part of BiH and in one of the two entities in BiH. 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 Bosnia and Herzegovina 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 a 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 0.8ºC, whereas the average temperature in July reaches 21.3ºC.

The present study on environmental noise pollution was carried out in June 2014. Measurement of noise was measured at the measuring points in Jovana Dučića Street (Picture 1). Noise measurement included location in Jovana Dučića Street, from the intersection with Cara Dušana Boulevard to the intersection with Milana Tepića Street.




**Picture 1.** Location measurements and sampling points

### Noise measurement:

Measurements were performed with a 2260 Bruel & Kjaer type I sound-level meter and with tripod 140 cm. Calibration was performed using a 4226 Bruel & Kjaer calibrator. 7815 Noise Explorer™ was also used. Noise is measured by a sound level meter; which is an instrument that responds to a sound in approximately the same way as the human ear and which gives reproducible measurements of a sound level (Mato

and Mufuruki, 1999; Jamrah et al., 2006). The equivalent continuous equal energy level ($L_{eq}$) is applied to a fluctuating noise level. The $L_{eq}$ is defined as the constant noise level that expands the same amount of energy as the fluctuating level over the same time period (Davis and Masten, 2004; 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 interval (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 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 of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise, because the Rulebook on Allowed Limits for Noise and Hum Intensity (Official Gazette of SR BiH, 46/89) does not define an 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 (Official Gazette of SR BiH, 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 the 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 on Allowed Limits for Noise and Hum Intensity (Official Gazette of SR BiH, 46/89). In compliance with the purpose of the area monitored, the study area is located in the area (zone) I (hospital, rehabilitation) and III (exclusively housing, child-bearing 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 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, warenhouses excluding heavy transport | 60 | 50 | 70 | 75 |
| V | Business, administrative, trading, crafts, servising (utility services) | 65 | 60 | 75 | 80 |
| VI | Industrial, warehousing, servicing and traffic, excluding apartments | 70 | 70 | 80 | 85 |

## RESULTS AND DISCUSSION

Noise measurement covers the area with residential buildings, recreational facilities (Sokolski dom), business facilities (Krajina Insurance), health institutions (surgery, Public Health Institute (Institute); health center and several different clinics) and catering facilities.

Jovana Dučića Street, being the study area, is located in the zones I (hospital, rehabilitation) and III (exclusively housing, child-bearing and educational and health institutions, public green and recreation areas).

In accordance with the Rulebook on Allowed Limits for Noise and Hum Intensity (Official Gazette of SR BiH, 46/89), the highest level of external noise allowed for the zone I is 45 dB(A), and for the zone III 55 dB(A), which means that the values of the measured noise, as compared to the allowed, in the zone I are more than 19.9 to 22.7 dB(A) during a day, in the zone III more than 9,9 to 12.7 dB(A) (near the surgery) (Table 2); in the zone I more than 17.6 to 22.5 dB(A) during a day, and in the zone III more than 7,6 to 12.5 dB(A) (near the Institute) (Table 3).

**Table 2.** Level of noise in Jovana Dučića street (near surgery)

| 1st day | | | 2nd day | | | 3rd day | | |
|---|---|---|---|---|---|---|---|---|
| **Daily values dB(A)** | | | | | | | | |
| $L_{eq}$ | $L_1$ | $L_{10}$ | $L_{eq}$ | $L_1$ | $L_{10}$ | $L_{eq}$ | $L_1$ | $L_{10}$ |
| 64.9 | 70.9 | 67.7 | 64.9 | 71.5 | 67.8 | 67.7 | 76.2 | 71.1 |
| **Evening values dB(A)** | | | | | | | | |
| $L_{eq}$ | $L_1$ | $L_{10}$ | $L_{eq}$ | $L_1$ | $L_{10}$ | $L_{eq}$ | $L_1$ | $L_{10}$ |
| 64.3 | 72.5 | 67.3 | 66.8 | 73.0 | 67.1 | 62.9 | 71.0 | 66.2 |
| **Night values dB(A)** | | | | | | | | |
| $L_{eq}$ | $L_1$ | $L_{10}$ | $L_{eq}$ | $L_1$ | $L_{10}$ | $L_{eq}$ | $L_1$ | $L_{10}$ |
| 60.2 | 68.3 | 63.2 | 64.1 | 71.9 | 67.8 | 61.1 | 69.7 | 65.4 |

**Table 3.** Level of noise in Jovana Dučića Street (near the Institute)

| 1st day | | | 2nd day | | | 3rd day | | |
|---|---|---|---|---|---|---|---|---|
| **Daily values dB(A)** | | | | | | | | |
| $L_{eq}$ | $L_1$ | $L_{10}$ | $L_{eq}$ | $L_1$ | $L_{10}$ | $L_{eq}$ | $L_1$ | $L_{10}$ |
| 65.0 | 71.8 | 67.9 | 62.6 | 70.4 | 65.5 | 67.5 | 72.6 | 68.7 |
| **Evening values dB(A)** | | | | | | | | |
| $L_{eq}$ | $L_1$ | $L_{10}$ | $L_{eq}$ | $L_1$ | $L_{10}$ | $L_{eq}$ | $L_1$ | $L_{10}$ |
| 63.2 | 73.5 | 66.5 | 62.2 | 71.7 | 66.6 | 62.9 | 71.0 | 66.2 |
| **Night values dB(A)** | | | | | | | | |
| $L_{eq}$ | $L_1$ | $L_{10}$ | $L_{eq}$ | $L_1$ | $L_{10}$ | $L_{eq}$ | $L_1$ | $L_{10}$ |
| 55.1 | 66.5 | 56.3 | 56.2 | 65.7 | 59.7 | 60.6 | 71.5 | 64.3 |

During daily measurements in all three days, $L_{eq}$ is above the allowed values and ranges from 64.9 to 67.7 dB (A) (near the surgery) and 62.6 to 67.5 dB (A) (near the Institute).

Peak level $L_1$ in all three daily measurements ranges from 70.9 to 76.2 dB(A) (near the surgery) and from 70.4 to 72.6 dB(A) (near the Institute), and is allowed for the zone I 60 dB(A), and for the zone III 70 dB(A). Measured values in relation to the allowed are higher 10.9 to 16.2 dB(A) (for the zone I), 0.9 to 6.2 dB(A) (for the zone III) (near surgery), 10.4 to 12.6 dB(A) (for the zone I) and from 0.4 to 2.6 dB(A) (for the zone III) (near the Institute).

Peak level $L_{10}$ in all three daily measurements ranges from 67.7 to 71.1 dB(A) (near the surgery) and from 65.5 to 68.7 dB(A) (near the Institute), and is allowed for the zone I 55 dB(A), and for the zone III 65 dB(A). Measured values in relation to the allowed are higher 7.7 to 16.1 dB(A) (for the zone I), 2.7 to 6.1 dB(A) (for the zone III) (near the surgery), 10.5 to 18.7 dB(A) (for the zone I) and 0.5 to 3.7 dB(A) (for the zone III) (near the Institute).

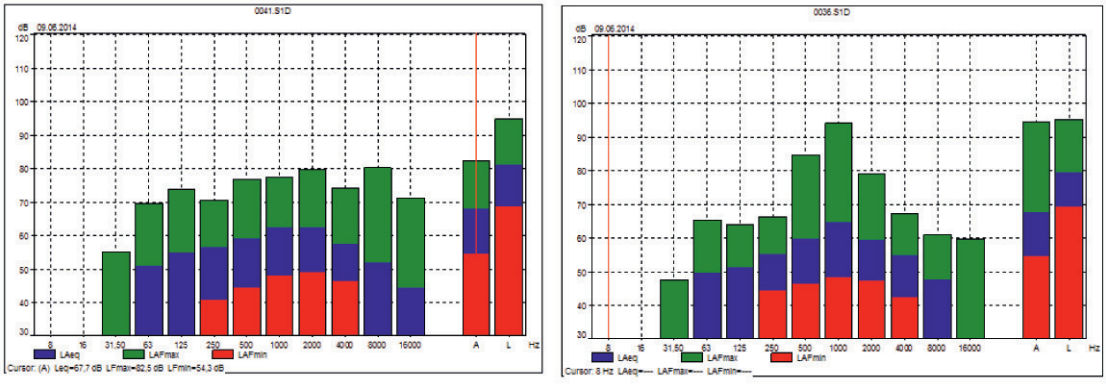


**Diagram 1.** Frequency noise analysis for $L_{eq}$=67.7 dB(A) (near the surgery) and $L_{eq}$=67.5 dB(A) (near the Institute)

**Table 3.** $L_{eq}$ values of noise levels depending on the frequency (near the surgery)

| Hz | 31.5 | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 | 16000 |
|---|---|---|---|---|---|---|---|---|---|---|
| dB(A) | - | 50.7 | 54.8 | 56.2 | 59.0 | 62.3 | 62.4 | 57.4 | 51.9 | 44.1 |

**Table 4.** $L_{eq}$ values of noise levels depending on the frequency (near the Institute)

| Hz | 31.5 | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 | 16000 |
|---|---|---|---|---|---|---|---|---|---|---|
| dB(A) | - | 49.6 | 51.2 | 55.2 | 59.7 | 64.7 | 59.2 | 54.8 | 47.5 | - |

Frequency noise analysis for daily measurement $L_{eq}$=67.7 dB(A) shows that the highest levels of noise at the frequencies 1,000 and 2,000 Hz, over 60 dB(A), and at the lower frequencies are above 50 dB(A), except at 16,000 Hz where it is above 40 dB(A) (Diagram 1, Table 3) (near the surgery) and frequency noise analysis for daily measurement $L_{eq}$=67.5 dB(A) shows that the highest levels of noise at frequencies 1,000 Hz, over 60 dB(A), and at the lower frequencies 125, 250, 2000 and 4000 Hz are above 50 dB(A), except at 16,000 Hz where it is above 50 dB(A) (Diagram 1, Table 4) (near the Institute).

Rulebook on Allowed Limits for Noise and Hum Intensity (Official Gazette of SR BiH, 46/89) does not define an evening period, $L_{eq}$ for evening. Noise level in the evening is from 62.9 to 66.8 dB(A), $L_1$ from 71.0 to 73.0 dB(A) and $L_{10}$ from 66.2 to 67.3 dB(A) (near the surgery) and from 62.2 to 63.2 dB(A), $L_1$ from 71.0 to 73.5 dB(A) and $L_{10}$ from 66.2 to 66.6 dB(A) (near the Institute).

$L_{eq}$ for night is above the allowable values and ranges from 60.2 to 64.1 dB(A), which is in relation to the allowed equivalent levels 40 dB(A) (for the zone I), higher than 20.2 to 24.1 dB(A), and 45 dB(A), than 15.2 to 19.1 dB(A) (for the zone III) (near the surgery) and from 55.1 to 60.6 dB(A), which is in relation to the allowed equivalent levels 40 dB(A) (for the zone I), higher than 15.1 to 20.6 dB(A), and 45 dB(A), than 10.1 to 15.6 dB(A) (for the zone III) (near the Institute).

Peak level $L_1$ in all three night measurements ranges from 68.3 to 71.9 dB(A) (near the surgery) and from 65.7 to 71.5 dB(A) (near the Institute), and is allowed for the zone I 60 dB(A), and for the zone III 70 dB(A). Measured values in relation to the allowed are higher 8.3 to 11.9 dB(A) (for the zone I), 1.9 db(A) (for the zone III) (near the surgery), 5.7 to 11.5 dB(A) (for the zone I) and for 1.5 db(A) (for the zone III) (one measurement) (near the Institute).

Peak level $L_{10}$ in all three night measurements ranges from 67.7 to 71.1 dB(A) (near the surgery) and from 56.3 to 64.3 dB(A) (near the Institute), and is allowed for the zone I 55 dB(A) and for the zone III 65 dB(A). Measured values in relation to the allowed are higher 12.7 to 16.1 dB(A) (for the zone I), and

from 2.7 to 6.1 dB(A) (for the zone III) (near the surgery) and at the location of the Institute are within the allowed limits.

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

**Table 4.** Number of vehicles in Jovana Dučića Street

| | 1st day | | | 2nd day | | | 3rd day | | |
|---|---|---|---|---|---|---|---|---|---|
| | Day | Evening | Night | Day | Evening | Night | Day | Evening | Night |
| **Near the surgery** | | | | | | | | | |
| Vehicle number | 210 | 88 | 71 | 197 | 96 | 76 | 224 | 105 | 74 |
| Passenger cars (%) | 94.29 | 94.32 | 95.78 | 93.90 | 94.80 | 94.73 | 93.75 | 89.53 | 94.60 |
| Buses (%) | - | - | - | - | - | - | - | - | - |
| Vans (%) | 4.76 | 2.28 | 2.82 | 4.06 | - | 5.27 | 5.37 | 5.71 | 4.05 |
| Motorcycles (%) | 0.95 | 3.40 | 1.40 | 2.04 | 5.20 | - | 0.44 | | |
| Vehicles > 5 t (%) | | | | | | | 0.44 | 4.76 | 1.35 |
| **Near the Institute** | | | | | | | | | |
| Vehicle number | 126 | 48 | 36 | 143 | 68 | 58 | 126 | 108 | 69 |
| Passenger cars (%) | 96.82 | 97.91 | 97.22 | 94.40 | 92.65 | 98.27 | 95.23 | 94.44 | 92.75 |
| Buses (%) | - | - | - | - | - | - | - | - | - |
| Vans (%) | 2.38 | 2.09 | - | 4.20 | 2.94 | 1.73 | 4.77 | 2.78 | 4.35 |
| Motorcycles (%) | 0.80 | - | 2.73 | 1.40 | 4.41 | - | - | 2.78 | 2.90 |
| Vehicles > 5 t (%) | - | - | - | - | - | - | - | - | - |

Counting period was fifteen minutes, during which time at the measured equivalent noise location near the surgery passes from 197 to 224 vehicles during the day (about 14 vehicles per minute) (near the surgery) and 126 to 143 vehicles during the day (about 8 vehicles per minute) (near the Institute). During the evening, the number of vehicles decreases from 88 to 105 (about 7 vehicles per minute) (near the surgery) and from 48 to 108 (about 6 vehicles per minute) (near the Institute), and during the night 71 to 76 vehicles (about 5 vehicles per minute) (near the surgery) and from 36 to 69 vehicles (about 4 vehicles per minute) (near the Institute). On the basis of the above, we get the information that the average of 14,160 vehicles passes in this street for 24 hours, about 71.18% in a day, 11.86% in an evening and 16.94% in a night period (near the surgery) and 9,120 vehicles, about 63.15% in a day, 15.8% in an evening and 21.05% in a night period (near the Institute).

Passenger vehicles prevail in Jovana Dučića Street at all times of the day (day, evening, night), from 94.29 (day), to 94.32% (evening) and to 95.78% (night) (near the surgery), and from 96.82 (day), to 97.91% (evening), and to 98.27% (night) (near the Institute) (Table 4). Frequency of the vans is 5.37% (day), 5.71% (evening) and 5.27% (night) (near the surgery) and 4.77% (day), 2.94% (evening) and 4.35% (night) (near the Institute). Frequency of the motorcycles is 2.04% (day), 5.2% (evening) and 1.4% (night) (near the surgery) and 1.4% (day), 4.41 (evening) and 2.9 (night) (near the Institute).

It is characteristic for this street that the traffic in evening and night hours is reduced by about half.

All measured values equivalent noise during the day and during the night in all three measurements at the measuring point in the Jovana Dučića Street and partly the value of the peak levels $L_1$ and $L_{10}$ exceed the allowable values.

Due to this fact, all measuring points at the study area are located mixing two areas (zones) I (hospital, rehabilitation) and III (exclusively housing, child-bearing and educational and health institutions, public green and recreation areas), and 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.

## CONCLUSIONS

The results of the conducted measurements and analyses showed that the problem of noise pollution in the City of Banja Luka is a very realistic for the residents. All the measured values equivalent noise during the day and during the night in all three measurements at the measuring point in Jovana Dučića Street and partly the value of the peak levels $L_1$ and $L_{10}$ exceed the allowable values.

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