IMPORTANCE OF MONITORING OF TRAFFIC NOISE FOR THE ACOUSTIC ZONING OF ZRENJANIN

Abstract: This paper presents monitoring of noise as a product of traffic in Zrenjanin. The purpose of this research is to point out the problems caused by the traffic noise. Measurements of sound levels were performed at several locations in Zrenjanin, along the main road: The corner of Nikola Pašić street near the shopping centre, Mala Varoš”, Milutin Milankovic Boulevard next to the Special hospital for pulmonary diseases „Dr Vasa Šavic”. The paper gives an example of how to perform measurement in the field when determining the level of noise. In practice, for relevant measurement results are obtained by authorized accredited institutions that deal with measurement noise. In accordance with regulations, this research can serve as basis for further measurements and monitoring for the purpose of acoustic zoning of Zrenjanin, easier urban planning and controlling of noise level. Acoustic zoning and making zoning maps are of great importance for many urban and strategic planning.

Key words: monitoring, noise, acoustic zoning.

INTRODUCTION
Noise is a loud, unpleasant or unexpected sound and it can be continual, uneven or impulse. It can have different levels, durations and time distribution. It has no proper definition, therefore it has to be accepted as subjective evaluation and feeling. Main sources of noise in human environment are traffic, industry, civil and construction works, recreation, sports and entertainment. Levels of noise are increasing as the life tempo is rapidly accelerating in large urban environments [1], [2].

The problem of environmental pollution has inflicted itself on us in the last decade of the last and at the beginning of current century which alarmed the whole human race and especially the developed countries to make greater steps in sustainment and protection of the environment from further degradation. Since noise is one of the problems of above mentioned pollution, more or less, this paper presents basic theoretical phenomena of noise and some of its physical characteristics and given measurement results make a solid base for evaluation of impact of traffic noise on environment in specific locations in Zrenjanin [3].

MEASUREMENT AND EVALUATION OF NOISE
Relevant acoustic data on noise characteristics which are obtained by measuring of acoustic amplitude and frequency are necessary for the control and evaluation of noise. Results of the measurement must have attribute of repeatability. Therefore, it is necessary to choose the appropriate instruments. In this paper, due to the large amount of data, it will only show data for one measurement (in one day) for day, evening and night. Basic attributes of noise which determine the choice of the measuring instrument are:
- Levels of noise
- Time-dependency of noise:
  - Invariable noise - (up to 5 dB)
  - variable noise - (above 5 dB)
- Incoherent noise - source of noise has cycles, such as passing by of one car or a plane; the level of noise decreases and increases very fast
- Impulse noise - explosive or impulse noise is a noise consisting of single bursts with a duration of less than 1s
- Frequency of noise:
  - Broadband noise - a noise with even distribution of sound energy in broad frequency interval (several contiguous octaves)
  - Narrowband noise - noise which energy is in limited frequency band (an octave or third of an octave)
  - Tonal noise - noise which sound energy is in discreet frequencies [4], [5].

According to European Environment and Health Committee, in Serbia there are several difficulties with regard to noise such as inadequate legislation and lack of standards for levels of noise, inappropriate monitoring of noise in city areas, poor zoning of noise in urban planning, poor locations for industrial areas, limited projects for noise protection, insufficient traffic noise control, as well as inadequate traffic management [6].

In Table 1 are given appropriate sound levels.
Table 1. From Protocol on highest appropriate levels of noise in working and living environment [7]

<table>
<thead>
<tr>
<th>Zones of noise</th>
<th>Purpose</th>
<th>The highest approved levels of noise (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Outdoor / indoor Day/night day/night</td>
</tr>
<tr>
<td>1.</td>
<td>Recreational</td>
<td>50 / 40 / 30 / 25</td>
</tr>
<tr>
<td>2.</td>
<td>Residential</td>
<td>55 / 40 / 35 / 25</td>
</tr>
<tr>
<td>3.</td>
<td>Predominantly</td>
<td>55 / 45 / 35 / 25</td>
</tr>
<tr>
<td>4.</td>
<td>Predominantly</td>
<td>65 / 40 / 35 / 25</td>
</tr>
<tr>
<td>5.</td>
<td>Industrial</td>
<td>limit ≤ 80 / 40 / 30</td>
</tr>
</tbody>
</table>

In Table 2 are given levels of traffic noise.

Table 2. Levels of traffic noise

| Main city roads (high traffic) | 75 dB |
| Crossroads in the city centre (high traffic) | 75 dB |
| Local roads (65% truck traffic) | 70 dB |
| Local main roads               | 55 dB |
| Residential area streets       | 55 dB |

LOCATIONS OF MEASUREMENT

Location 1 is situated next at Žitni trg to the business building „Mala Varoš“ where several city owned companies are situated and 50 meters from the building is a residential building which has several businesses in the ground floor. Picture in Figure 1 is taken during measurement.

Figure 1. The corner of Nikola Pašić street, Žitni square - view from the other corner [3]

Location 2 is situated at Milutin Milankovic boulevard on part of the main city road next to a wall approximately 50 meters from the building of the hospital for pulmonary diseases „Dr Vasa Savić“. Picture in Figure 2 is taken during measurement.

Figure 2. Part of the city main road near the hospital for pulmonary diseases [3]

The following equipment was used during measurement:

- **Sound Level Meter with associated microphone**
  Manufacturer: Voltcraft
  Type: SL - 400
  Class 2 according to IEC 61672-1

- **The acoustic calibrator**
  Manufacturer: Bruel & Kjaer, Denmark
  Type: 4231
  Sound level: (94 ± 0.2) dB and (114 ± 0.2) dB
  Frequency: (1,000 ± 1) Hz

Calibration of the measuring chain, measuring noise levels and a condenser microphone made acoustic calibrator is listed on: 30.03.2014 year.
Comparison of characteristics of the measuring chain was carried out internal audits using the following equipment:

- A measurer of the noise level
  Manufacturer: Bruel & Kjaer, Denmark
  Type: BK 2250
  Serial number: 2506333
  Measuring range (20 - 140) dB
  Measurement of the levels of noise for the purposes of this paper was held on March 31st, 2014 [3].

For both locations instrument was 5m from the road and altitude on which the instrument was: 1,5 m.

Time frame for each measurement (day, evening and night): 30 minutes.

Hourly measurements for Location 1:
Day: 09:39 h – 10:09 h
Evening: 18:33 h – 19:03 h
Night: 22:19 h – 22:49 h

Hourly measurements for Location 2:
Day: 10:26 h – 10:56 h
Evening: 19:25 h – 19:55 h
Night: 23:01 h – 23:31 h

RESULTS

When the measurement is performed, in the set time intervals, values measure by the instrument are methodised, sorted, and analysed. Process for the equipment used for this paper is following: computer is connected to the instrument by the cable which is the part of the equipment, and the previously installed software on the computer processes the data that instrument measures. Measured values for every second of the process are entered in Microsoft Excel table, which displays all measured values. Programme then calculates mean value for every measurement and makes a graphical chart of measured values. At Figure 4 is present only an example of how the table looks after the Microsoft Excel program read data from the instrument for easy insight into the process of calculating (every table has approximately 1700 rows) [3].

X-axis of the graphs indicates measurement time in seconds and the y axis indicates the measured sound pressure level in decibels. Amplitude show oscillation between the maximum and minimum values of the sound pressure, while for analytical calculation taking the average value.

Results for daily, evening and nightly interval measurements for location 1 are given in Figures 5-7 [3].
All representative data are for location 1 – Žitni square, Nikola Pašić street corner. Calculation for practical measured values will be presented later in the paper after data for Location 2, for clarity of data and better analysis of calculated values of both locations.

Results for daily, evening and nightly interval measurements for location 2 are given in Figures 8-10 [3].

**ANALYTICAL CALCULATION OF NOISE**

Level of noise for day-evening-night $L_{den}$ (d – day, e – evening, n – night) in decibels dB(A) is defined by the equation below [8], [2]:

$$L_{den} = 10 \log \left( \frac{1}{T} \sum_{t=1}^{N} 10^{\frac{L_{Aeq,T}}{10}} \right)$$  \hspace{1cm} (1)

A - Weighted average for long-term levels of noise for specific periods of day is defined by the equation (2).

$$L_{Aeq,T} = 10 \log \left( \frac{1}{N} \sum_{t=1}^{N} 10^{\frac{L_{Aeq,t}}{10}} \right)$$  \hspace{1cm} (2)

In Table 3 are shown the values which are read off for all three periods of the measurement for location 1 [3].

<table>
<thead>
<tr>
<th>Measurement period</th>
<th>Ruling period</th>
<th>Measured value [dB(A)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day</td>
<td>12h</td>
<td>65.97</td>
</tr>
<tr>
<td>Evening</td>
<td>4h</td>
<td>63.66</td>
</tr>
<tr>
<td>Night</td>
<td>8h</td>
<td>56.93</td>
</tr>
</tbody>
</table>

Based on the previously presented equations 1 and 2 and data from Table 3, it is calculated:

$L_{DEN} = 62.04$ dB(A)

In Table 4 are shown the values which are read off for all three periods of the measurement for location 2 [3].

<table>
<thead>
<tr>
<th>Measurement period</th>
<th>Ruling period</th>
<th>Measured value [dB(A)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day</td>
<td>12h</td>
<td>63.68</td>
</tr>
<tr>
<td>Evening</td>
<td>4h</td>
<td>60.8</td>
</tr>
<tr>
<td>Night</td>
<td>8h</td>
<td>58.41</td>
</tr>
</tbody>
</table>

Based on the previously presented equations 1 and 2 and data from Table 4, it is calculated:

$L_{DEN} = 62.04$ dB(A)

Standard period is a period of 24 hours and it refers to daytime lasting from 6 till 18h, evening lasting from 18 till 22h and night lasting from 22 till 6h. In the table there are number of hours for every period.

Note: Parameter $L_{den}$ was calculated based on 1.5 h measurement. This was calculated by summing 30 minute intervals for every period of measurement – day, evening and night.

Table 5 shows the values read from the graphs of appropriate measurement - day, evening and night for the minimum and maximum values of the sound pressure for location 1 [3].

<table>
<thead>
<tr>
<th>Measurement period</th>
<th>$L_{Aeq}$ [dB(A)]</th>
<th>$L_{AF\ max}$ [dB(A)]</th>
<th>$L_{AF\ min}$ [dB(A)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day</td>
<td>65.97</td>
<td>81.5</td>
<td>51.7</td>
</tr>
<tr>
<td>Evening</td>
<td>63.66</td>
<td>83.2</td>
<td>51.7</td>
</tr>
<tr>
<td>Night</td>
<td>56.93</td>
<td>86.6</td>
<td>43.1</td>
</tr>
</tbody>
</table>

$L_{AF\ max}$ [dB(A)] are maximum measured values of sound pressure

$L_{AF\ min}$ [dB(A)] are minimum measured values of sound pressure
Table 6 shows the values read from the graphs of appropriate measurement - day, evening and night for the minimum and maximum values of the sound pressure for location 2 [3].

<table>
<thead>
<tr>
<th></th>
<th>( L_{\text{Aeq}} ) [dB(A)]</th>
<th>( L_{\text{AF max}} ) [dB(A)]</th>
<th>( L_{\text{AF min}} ) [dB(A)]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Day</strong></td>
<td>63,68</td>
<td>84,7</td>
<td>45,7</td>
</tr>
<tr>
<td><strong>Evening</strong></td>
<td>60,8</td>
<td>87,7</td>
<td>45,5</td>
</tr>
<tr>
<td><strong>Night</strong></td>
<td>58,41</td>
<td>80,3</td>
<td>42,1</td>
</tr>
</tbody>
</table>

\( L_{\text{AF max}} \) [dB(A)] are maximum measured values of sound pressure
\( L_{\text{AF min}} \) [dB(A)] are minimum measured values of sound pressure

Noise measurement and result analysis were performed in accordance with standards SRPS ISO 1996 – 1 Acoustics -- Description and measurement of environmental noise -- Part 1: Basic quantities and procedure and SRPS ISO 1996 – 2 Acoustics -- Description, measurement and assessment of environmental noise -- Part 2: Determination of environmental noise levels. Calculation of results was also performed in accordance to the above standards above [4], [5].

**ACOUSTIC ZONING IN ZRENJANIN**

Traffic parameters that are taken into account while discerning levels of noise are: Car frequency, tractor frequency, heavy vehicle frequency, bus frequency, motorcycle frequency.

Bypass zone – bypass is one of the most important traffic corridors in Zrenjanin, Fig.11. Realisation of the road connecting southeast entrance to the city from the Belgrade-Zrenjanin main road, following east and north border of the General urban planning project to the Novi Sad-Zrenjanin main road, will allow transferring transit traffic outside of the city and direct it towards the corridor.

Planning of the bypass area (petrol station, gas station etc.), will completely adapt this traffic corridor to the planned activities. Corridor is connected to the city streets by means of existing feeding roads exiting the town. There are no plans for connecting other streets to the corridor.

The measured values impose a conclusion that we should have necessary measures in order to decrease those values. Systematic monitoring of levels of noise determines acoustic pressure thus creating condition for acknowledging the problem of noise and incorporating it in the urban planning of new and reconstruction of existing residential areas. Construction and certificates of acceptance for residential, investment, industrial, small business buildings, and city infrastructure should comply with determined technical regulations which guarantee with quality of acoustic insulation. In this specific case, for Zrenjanin, based on measured values and levels of traffic noise and in opinion of the authors the best solution for the city would be finishing the bypass around the city, especially for the heavy vehicles that should not be allowed to use main city road, albeit city centre [3], [9] and [10].

**CONCLUSION**

In order to determine acoustic zones in the city, it is necessary to measure all sources of noise– traffic, industry etc. on the referent locations where results can reflect the level of noise in that zone. This way, certain areas of the city can be organised and planned, noise can be easily monitored, and inspections and supervising authorities can have better overview of the natural or legal person or persons who produce noise of the certain level, especially those who breach appropriate limits. This would establish a system of monitoring of noise within the city territory with purpose of long-term solution to the problems caused by noise, especially a problem of noise as health hazard.

Therefore, there is a possibility to perform acoustic zoning in Zrenjanin (which haven’t been done before), give greater significance to noise monitoring, finish the bypass around the city which was mentioned in this paper.

There are excellent solution which could be applied in the shortest period, of course with appropriate funding and engagement of experts and institutions.

In Serbia, in addition to compliance with the European legislation and limit values for noise, it should be worked on noise monitoring in urban areas, the activities of the zoning noise in the spatial planning process.
REFERENCES


**ZNAČAJ MONITORINGA SAOBRAĆAJNE BUKE ZA AKUSTIČKO ZONIRANJE GRADA ZRENJANINA**

Ivana Lakatuš, Živoslav Adamović, Ljiljana Radovanović


Ključne reči: monitoring, buka, akustično zoniranje.