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

Abstract: *This paper present 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 Savic". The paper gives an example of how to perform measurement in the field when determining the level of noise. In practice, for relevant datas measurement results are obtained by authorized accredited institutions that deal with measurement noise. In accordance with regulations, this research can serve as basis for future 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 plan; 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.

Paper is presented at the "24 International Conference Noise and Vibration", Faculty of Occupational Safety in Niš, 2014, Niš.

Table 1. *From Protocol on highest appropriate levels of noise in working and living environment [7]*

Zones of noise	Purpose	The highest approved levels of noise (dB) Outdoor / indoor Day/night			
	Recreational				
1.	Residential	50	40	30	25
2.	Predominantly	55	40	35	25
3.	residential	55	45	35	25
4.	Predominantly	65		40	30
5.	business	limit≤ 80		40	30
	Industrial				

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 Zitni 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 Figure1 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 Figure3 shows measurer of noise level.

Figure 3. *Measurer of noise level [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 measument (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:

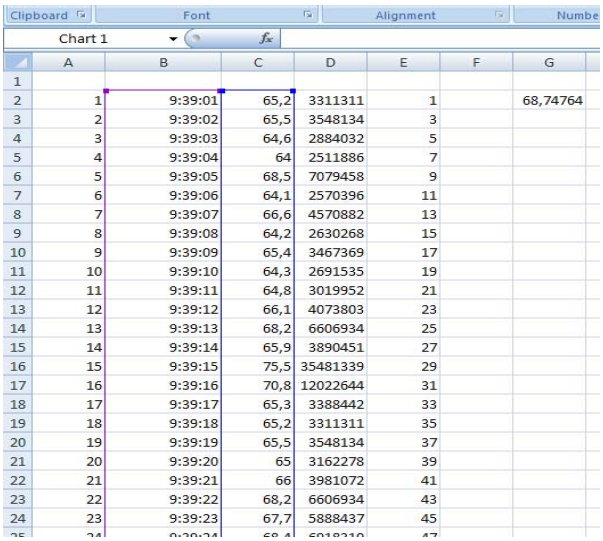
Day: 10:26 h – 10:56 h

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].



	A	B	C	D	E	F	G
1							
2	1	9:39:01	65,2	3311311	1		68,74764
3	2	9:39:02	65,5	3548134	3		
4	3	9:39:03	64,6	2884032	5		
5	4	9:39:04	64	2511886	7		
6	5	9:39:05	68,5	7079458	9		
7	6	9:39:06	64,1	2570396	11		
8	7	9:39:07	66,6	4570882	13		
9	8	9:39:08	64,2	2630268	15		
10	9	9:39:09	65,4	3467369	17		
11	10	9:39:10	64,3	2691535	19		
12	11	9:39:11	64,8	3019952	21		
13	12	9:39:12	66,1	4073803	23		
14	13	9:39:13	68,2	6606934	25		
15	14	9:39:14	65,9	3890451	27		
16	15	9:39:15	75,5	35481339	29		
17	16	9:39:16	70,8	12022644	31		
18	17	9:39:17	65,3	3388442	33		
19	18	9:39:18	65,2	3311311	35		
20	19	9:39:19	65,5	3548134	37		
21	20	9:39:20	65	3162278	39		
22	21	9:39:21	66	3981072	41		
23	22	9:39:22	68,2	6606934	43		
24	23	9:39:23	67,7	5888437	45		

Figure 4. *Microsoft Excel table with measured values [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].

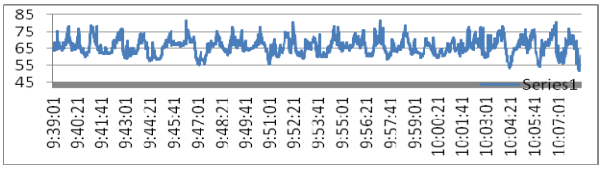


Figure 5. *Graphic chart of results for daily interval measurements for location 1*

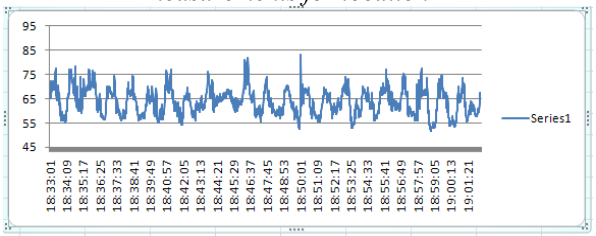


Figure 6. *Graphic chart of results for evening interval measurements for location 1*

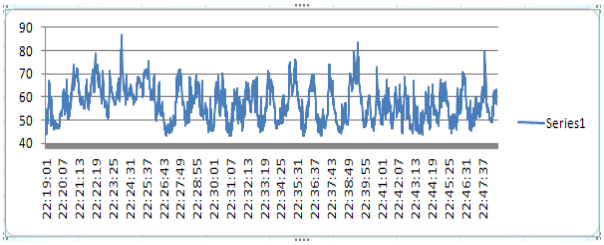


Figure 7. *Graphic chart of results for nightly interval measurements for location 1*

All representative data are for location 1 – Žitni square, Nikola Pašić street corner. Calculation for practical measured values will be presents 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].

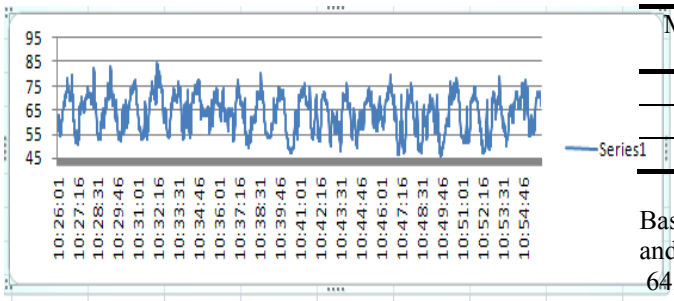


Figure 8. *Graphic chart of results for daily interval measurements for location 2*

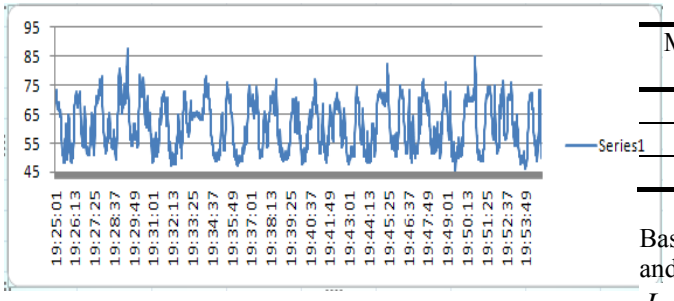


Figure 9. *Graphic chart of results for evening interval measurements for location 2*

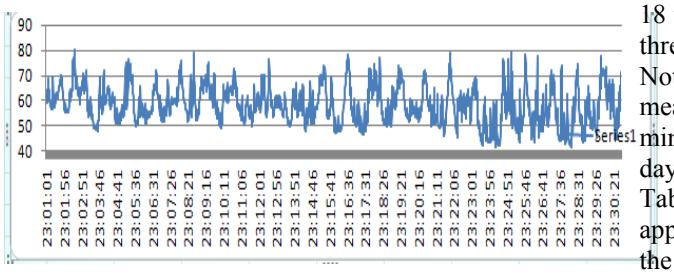


Figure 10. *Graphic chart of results for nightly interval measurements for location 2*

ANALYTICAL CALCULATION OF NOISE

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

$$L_{den} = 10\log\frac{1}{24}\left(12\cdot 10^{\frac{L_{day}}{10}} + 4\cdot 10^{\frac{L_{evening}+5}{10}} + 8\cdot 10^{\frac{L_{night}+10}{10}}\right) \quad (1)$$

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

$$L_{Aeq,T} = 10log\left[\frac{1}{N}\sum_{i=1}^{N} 10^{0,1(L_{Aeq,T})_i}\right] \quad (2)$$

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

Table 3. *Datas for calculation of L_{den} for location 1*

Measurement period	Ruling period	Measured value [dB(A)]
Day	12h	**65,97**
Evening	4h	**63,66**
Night	8h	**56,93**

Based on the previously presented equations 1 and 2 and datas from Table 3, it is calculated :
64,03dB (A)
In Table 4 are shown the values which are read off for all three periods of the measurement for location 2 [3].

Table 4. *Datas for calculation of Lden for location 2*

Measurement period	Ruling period	Measured value [dB(A)]
Day	12h	**63,68**
Evening	4h	**60,8**
Night	8h	**58,41**

Based on the previously presented equations 1 and 2 and datas 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 thre are number of hours for every period.
Note: Parameter Lden 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 5. *Measured values for location 1*

	L_{Aeq} [dB(A)]	$L_{AF\ max}$ [dB(A)]	$L_{AF\ min}$ [dB(A)]
Day	65,97	81,5	51,7
Evening	63,66	83,2	51,7
Night	56,93	86,6	43,1

L_{AFmax} [dB (A)] are maximum measured values of sound pressure
L_{AFmin} [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 6. *Measured values for location 1*

	L_{Aeq} [dB(A)]	$L_{AF\ max}$ [dB(A)]	$L_{AF\ min}$ [dB(A)]
Day	63,68	84,7	45,7
Evening	60,8	87,7	45,5
Night	58,41	80,3	42,1

LAF max [dB(A)] are maximum measured values of sound pressure

LAF 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 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.

Figure 11. *Bypass zone - the most important traffic corridors in Zrenjanin (mark red and blue lines) [9]*

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ZNAČAJ MONITORINGA SAOBRAĆAJNE BUKE ZA AKUSTIČKO ZONIRANJE GRADA ZRENJANINA

Ivana Lakatuš, Živoslav Adamović, Ljiljana Radovanović

Rezime: *Predmet rada je monitoring saobraćajne buke na teritoriji grada Zrenjanina. Cilj istraživanja je da ukaže na probleme izazvane saobraćajnom bukom. Merenja nivoa buke su izvršena na nekoliko lokacija u Zrenjaninu - uz magistralni put, na uglu ulice Nikole Pašića u blizini tržnog centra „Mala varoš“ i duž Bulevara Milutina Milankovića, pored Specijalne bolnice za plućne bolesti „Dr Vasa Savić“. U radu je dat primer postupka merenja na terenu radi određivanja nivoa buke. U praksi se relevantni podaci o rezultatima merenja uglavnom dobijaju od strane ovlašćenih akreditovanih institucija za merenje buke. U skladu sa propisima, ovo istraživanje može poslužiti kao osnova za buduća merenja i monitoring u cilju akustičnog zoniranja teritorije grada Zrenjanina, lakše urbanizacije i kontrole nivoa buke. Akustično zoniranje i mapiranje su od velikog značaja za urbano i strateško planiranje.*

Ključne reči: monitoring, buka, akustično zoniranje.