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NOISE AS FACTOR OF LIVING IN URBAN AREAS

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ABSTRACT

The noise in urban areas as influential factor to quality of life is considered in this paper. Basic theoretical considerations are presented, at first, to establish relevant measurement methodology for research. Brief overview of characteristics and properties of instrument that was selected for research is presented in this paper with focus to its specific characteristics in order to identify relevancies of measuring and analyses. The results of noise measurement at different zones of urban areas are analyzed and compared to related levels that are allowed by regulations. Also, the different sources of noise are identified and considered in this paper. It is implicated that, from the aspect to improve quality of life in urban areas, noise must be considered with great care. The guidelines for noise reduction procedures that are related to noise characteristics, generated by specific sources are listed altogether with its correlation to quality of life in urban areas.

Key words: *noise, urban areas, quality of life, ecology.*

INTRODUCTION

Sounds and noises are compositional elements of living environment with very significant and complex influences to quality of life, especially in urban areas. The term noise is related to high intensity sound, monotonous sound, and sound of unpleasant frequencies or related to combinations of sounds mentioned above.

From the technical aspect, sound (noise) is generated as consequence of local pressure variations from the direction of sound source. Spreading of sound from the source can be compared to spreading of spherical weaves of liquids caused by impact of rigid body into it. Acoustically, sound pressure superimposed with environmental atmospheric pressure that is about 10^5 Pa.

The analysis of noises and sounds present very important source of relevant information and data that are done for different causes, among which the most important are listed:

- noise can point out to potential problem that could cause damage and failure of technical systems,
- to evaluate the influence of noise to humans that are exposed and to estimate the risk of hearing damage,
- present standards and regulations order that during development of new product, constructional solution that generate lowest level of noise must be selected,
- to estimate if noise levels are outside define limits,
- to evaluate the influence of noise to quality of human life and
- in order to identify and insolate sources of noise.

For ordinary human, hearing diapason is between 20 μPa to 200 Pa, when pain occurs, so diapason is in range of $1{:}10^6$. As intensity of sound is proportional to square of pressure, the diapason is in range of $1{:}10^{12}$. With existing ranges, it is implicated to define amplitude of sound pressure at logarithmic scale. For measuring of noise, sound pressure level (SPL) is used and it is expressed in units called decibel (dB) and it is defined as [1]:

$$L_p = 10\log_{10}\left(\frac{p_1}{p_0}\right)^2 = 20\log_{10}\frac{p_1}{p_0}, \tag{1}$$

where are: *Lp*, dB – sound pressure level; p_1, Pa – amplitude of sound pressure and p_0 = 20 μPa – referent pressure.

As unit decibel (dB) is based on logarithmic scale, two levels of noises can be added arithmetically According to above mentioned, the resultant level of sound pressure L_{pr} that resulted as interaction of noses generated by different sources, L_{p1}, L_{p2}, ... can be calculated by following relation [1]:

$$L_{pr} = 10\log_{10}\left[\left(\frac{p_1}{p_0}\right)^2 + \left(\frac{p_2}{p_0}\right)^2 + \ldots\right], \tag{2}$$

while by addition of two identical noises, when is $L_{p1} = L_{p2} = L_p$, it is:

$$L_{pr} = 10\log_{10}\left[2\cdot\left(\frac{p_1}{p_0}\right)^2\right] = 10\log_{10}\left(\frac{p_1}{p_0}\right)^2 + 10\log_{10}2 = L_p + 1.3\ [\mathrm{dB}] \tag{3}$$

Duplication of sound intensity rise level of sound pressure by 3 dB. That means, for example, that to identical sounds of 90 dB act as one sound of 93 dB.

NOISE MEASURING IN URBAN AREA

Human ear, fundamentally, react on sound pressure with sensitivity that very with sound frequency, so the highest sensitivity is within frequency range of 1÷5 kHz, while the sensitivity decrease at lower and higher frequencies. This fact provoked development of filtering frequency functions that simulate sensitivity of human ear at different frequencies. Also, response of human ear to time dependent signals and impulses caused development of instruments with defined time dependent estimation functions. As result of presented characteristics of human ear the measuring device for sound pressure level phonometers were developed. Phonometers uses specific filters that correspond to characteristics of human ear and that are regulated by International standard IFC 651.

Phonometer measures the characteristics of sound that is registered by microphone. Signal is amplified and filtered before the measured value of sound level is displayed at analog or digital display. In dependence of device characteristics and properties, different filters can be used (1/1 or 1/3 octave) with different scales A, B or C for balance. Those tree balance scales simulate the response of human ear to low, middle and high frequency sounds, respectively. The dynamic of response of measuring device can be also selected as fast or slow. Phonometers must be calibrated to standardized sources of sound. Producers of phonometers usually use calibration instruments that are placed at phonometer microphone. Calibration instruments generate sound with defined intensity (usually 94 dB and/or 114 dB) with defined frequency (usually 1 kHz).

The appearance of phonometer - sound level meter - Type 2270 producer Brüel & Kjær that is used for measuring of level of communal noise in urban area is presented at Figure 1 [2].

Figure 1. Sound Level Meter – Brüel & Kjær Type 2270

The used instrument is dual-channel, hand-held analyzer and sound level meter that perform high-precision, Class 1 measurement tasks in environmental for occupational and industrial applications. It is multipurpose, modular platform with many optional application modules such as frequency analysis, FFT, advanced sound profiling and sound recording. Its two measurement channels allow it to perform sound intensity measurements according to IEC 61043, sound power measurements, and two-channel building acoustics measurements. The predicted uses of selected instrument, according to producer information are:

13. General-purpose Class 1 sound measurements to the latest international standards,
14. occupational noise assessment,
15. environmental noise assessment and logging,
16. product development and quality control,
17. FFT analysis of sound and vibration,
18. sound power determination and sound intensity,
19. two channel building acoustics measurements and
20. noise reduction

The features of selected Sound Level Meter – Type 2270 producer Brüel & Kjær are:

- Dual-channel input (microphone, sound intensity probe, accelerometer or direct signal),
- 4.2 Hz-22.4 kHz broadband linear frequency range with supplied microphone Type 4189,
- 16.6 - 140 dB A-weighted dynamic range with supplied microphone Type 4189,
- inputs: AC or CCLD, External Trigger,
- outputs: Generator and Headphone,
- communication via USB, LAN, or GPRS/3G modems,
- USB 2.0 host for connection to printer, GPS, weather station, modem,
- plug-in rechargeable Li-ion battery and
- photo observations with built-in camera.

RESULTS OF NOISE MEASURING

Measuring and analyses of communal noise level were done during March 2013 in Kragujevac at selected representative locations with determination of noise levels allowed by regulations for days and for nights. Measuring of noise in living environment was done according following regulations: Norm for indicators of noise, allowable limits, methods for estimation and evaluation of noise indicators, disturbance and damaging effects of noise in living environment (Republic Serbia, Official Periodical No. 75/10), National standard SRPS ISO 1996-2: Definition, measure and evaluation of noise in living environment and Law of protection from noise in living environment (Republic Serbia, Official Periodical No. 36/09) [3 and 4].

Measuring and evaluation of communal noise levels during day and night ware done by using of define methodology. For the measuring of noise level precise device, phonometer that is presented, sound level meter – Brüel & Kjær Type 2270 was used with 1/3 octave filter set. Calibrations ware done before and after measuring. Descriptions of measuring locations with related potential sources of noise are presented at Table 1 [5 and 6].

Table 1: Locations of measuring with potential noise sources

Location		Description	Potential noise sources
1.	Area Sušica-Restaurant „Merkur“	Measuring position is parking place in front of the restaurant. The stadium is behind of restaurant, while residential houses are across the street.	The source of noise is traffic of motor vehicles at neighboring streets and parking places.
2.	Area Aerodrom – Restaurant „La Boem“	Parking place between buildings is measuring position in direction from Atinska street. Neighborhood is mainly consisting of buildings.	Noise is generated by traffic of motor vehicles.
3.	Primary School „Sent Sava“	Measuring position is parking place at Vlada Bagata street in direction from school. The area is formed of school with yard and residential houses at other side.	Noise is generated by traffic of motor vehicles and from school yard.
4.	Area Denino Hill – Church „Sent Petka“	Measuring was done at parking place in front of church. The residential houses are around at distance of 50 to 100 m.	The source of noise is traffic of motor vehicles at neighboring streets and parking places.
5.	Area Petrovac – Pertol Station „Rade šped“	Measuring position is parking place near petrol station in direction of road Kragujevac – Topola. Surrounding is uncultivated land without of high vegetation, few houses, car washing place and shop at other side of street	Traffic of motor vehicles at streets in the area is source of noise.
6.	Area Petrovac – street „Queen Milice“	Street with residential houses at one side and small industrial zone at other side of street is measuring location	Traffic of motor vehicles at streets in the area is source of noise.

Before measuring of communal noise level, microclimate parameters, that were relevant to measuring results, were determined: air temperature, relative air humidity, air pressure, wind speed. Those microclimate parameters were adopted from data provide by Local hydrometeorological Center that is part of National hydrometeorological institute (Tab. 2) [5 and 6].

Table 2: Microclimate parameters at location of measuring

Microclimate parameter	Day			Night	
Time of measuring	09-12h	13-16h	18-21h	23-02h	03-06h
Wind speed, m/s	1,2	3,8	2,6	1,8	1,3
Temperature, ^{o}C	8	12	9	7	4
Relative air humidity, %	59	51	56	60	64
Air pressure, mbar	975	988	988	982	979

The results of communal noise measuring and its related allowed levels are presented at Table 3. Criteria of allowed noise level can be evaluated from two aspects: noise limits at interior and noise limits at exterior places. Allowable level of noise at residential rooms (bedrooms and living rooms) with closed windows are 50 dB during days and 40 dB during nights, according to Regulation for noise measuring methods and definition (Republic Serbia, Official Periodical No. 72/10), Law of protection from noise in living environment (Republic Serbia, Official Periodical No. 39/09) and National standard JUS U.J6. 205 2007, SRPS ISO 1996-1 Part: Basic values and procedures SRPS

ISO 1996-2 Acoustics: Description and measuring of noise in environment – Part 2: Information about purpose of urban zone.

Table 3: Results of noise measuring with related allowed levels

Measuring location		Noise level, dB						
		Day				Night		
		09-12h	13-16h	18-21h	Allowed level	23-02h	03-06h	Allowed level
1	Restaurant „Merkur“	56	57	60	65	53	51	55
2	Restaurant „La Boem“	52	52	55	55	51	49	45
3	School „St. Sava“	49	55	50	55	55	50	45
4	Church „St. Petka“	52	55	55	55	47	47	55
5	Petrol station „Rade šped“	65	64	68	65	58	60	55
6	Petrovac	57	58	48	55	46	38	45

Relevant level of noise was determined according to National standard SRPS ISO 1996-1 - Part 1: Basic values and procedures SRPS ISO 1996-2 Acoustics: Description and measuring of noise in environment - Part 2: Information about purpose of the area that regulate methods of acoustic zones mapping in relation to purpose. Allowed nose levels according to those regulations are presented at Table 4.

Table 4: Allowed noise levels in respect to area

Purpose of zone	Allowed levels, dB	
	Day	Night
Recreation and rest zones, hospital zones and spa zones, schools, Cultural and historical monuments, parks	50	40
Touristic zones, camps and school zones	50	45
City center, trade, shopping, administrative – official zones with apartments, zones near highways, main roads and city streets	65	55
Business – residential zones, trade – business zones, playgrounds	60	50
Residential zones	55	45
Industrial, depot and service zones, transport terminals	Noise at borders of those zones must be under limit for related neighboring zone	

Results of noise measuring with allowed levels during days and nights with allowable limits are presented at Figure 2 and 3.

Figure 2. Results of noise measuring with allowed levels during day

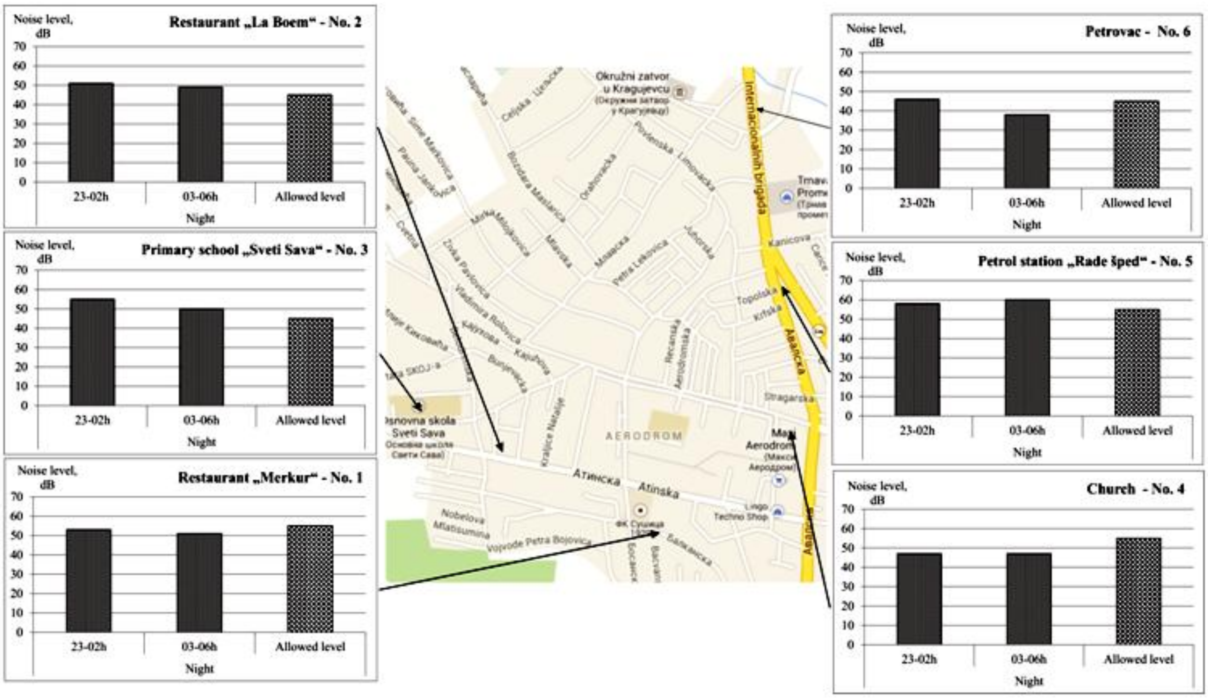

Figure 3. Results of noise measuring with allowed levels during night

CONCLUSIONS

Evaluations of obtained results implicate conclusions and identify procedures for reduction of noise level at every considered location that are presented at Table 5.

Table 5: Results analysis and noise reduction guidelines at specific measuring positions

Measuring location	Conclusion and recommendation for noise reduction
1	Measured noise is time dependent and by frequency analysis belongs to wide range by fast measuring dynamics and do not consist of major tone of frequency, so no specific procedures for noise reduction is indicated. Measured noise levels during days are from 56 to 57 dB, in the evenings 60 dB, and during nights are from 51 to 63 dB. Equivalent noise level is equal to relevant noise level. Average number of vehicles is 120/5 (car/track).
2	Measured noise is time dependent and it is generated by traffic. The noise is wide frequency range measured by fast measuring dynamics and do not consist of major tone neither sound information, so reduction procedures are not indicated. Equivalent noise level of 52 dB is measured during days, 55 dB during evenings and 49 to 51 dB during nights. Average number of vehicles is 302/10 (car/track).
3	Traffic is source of measured noise and it is time dependent, with wide frequency range by fast measuring dynamics and do not consist of major tone, neither sound information, so reduction procedure is not indicated. Measured equivalent noise levels during days are from 49 to 55 dB, in the evenings 50 dB, and during nights are from 50 to 55 dB. Average number of vehicles is 1/0 (car/track).
4	Measured noise is time dependent generated by traffic and wide frequency range by fast measuring dynamics and do not consist of major tone of frequency, so no specific procedures for noise reduction is indicated. Measured noise levels during days are from 52 to 55 dB, in the evenings 55 dB, and during nights 47 dB. Equivalent noise level is equal to relevant noise level. Average number of vehicles is 196/25 (car/track).
5	Traffic generate time dependent noise, with wide frequency range by fast measuring dynamics and do not consist of major tone neither sound information, so reduction procedures are not indicated. Measured equivalent noise levels during days are from 64 to 65 dB, in the evenings 68 dB, and during nights are from 58 to 60 dB. Average number of vehicles is 509/102 (car/track).
6	Measured noise is time dependent generate by traffic, wide frequency range by fast measuring dynamics and do not consist of major tone of frequency, so no specific procedures for noise reduction is indicated. Measured equivalent noise levels during days are from 57 to 58 dB, in the evenings 48 dB, and during nights are from 38 to 40 dB. Average number of vehicles is 54/20 (car/track).

On the basis of the obtained results at measuring position No. 1 and No. 5 it could be concluded that at places classified as main roads, main streets and big crossroads, the noise level during day do not overcome related allowable levels. Noise levels during evenings do not overcome allowable limits at measuring position No. 1, but do at measuring position at measure position No. 5.Also, noise levels during nights do not overcome allowable limits at measuring position No. 1, but do at measuring position at measure position No. 5.

On the basis of the obtained results at measuring positions classified as residential zone (measuring positions No. 2, 3, 4 and 6 it is implicated that noise level overcome allowable limits during day only at measuring position No. 6. At all measuring locations, noise levels during evenings stay within allowable limits. During nights, noise levels at measuring positions No. 2, 3 and 6 overcome allowable limits, while noise levels overcome those limits only at measuring position No. 4.

Analysis of the obtained results can provide relevant information and data for future research in the area. Those results can be used to identify effective procedures for reduction of noise level and put them into allowable limits.

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