FACTA UNIVERSITATIS
Series: **Working and Living Environmental Protection** Vol. 11, N° 1, 2014, pp. 1 - 11

NOISE INDICATORS DETERMINATION BASED ON LONG-TERM MEASUREMENTS

UDC 534.61:534.836

Momir Praščević, Darko Mihajlov

University of Niš, Faculty of Occupational Safety in Niš, Serbia

Abstract. *European Union Environmental Noise Directive 2002/49/EC and the new Serbian regulations in the scope of environmental noise introduce two basic indicators for environmental noise assessment:* L_{den} *and* L_n*. In addition, the use of the additional indicators* L_d *and* L_e *is recommended. For the purposes of strategic noise mapping and assessment of noise announcement it is necessary to determine the annual value of these indicators. The annual values of noise indicators can be determined by short-term or long-term measurements, or by a combination of these measurements. Short-term measurements are carried out under specified noise source operating and meteorological conditions whereas the annual value of a noise indicator are determined by calculation. On the other hand, long-term measurements include measurements during the time interval long enough to include changes in the source operating and meteorological conditions. These measurements are more accurate and can be used with fewer corrections than those of the short-term measurement. Two noise monitoring terminals for continuous noise measurement were installed in the central city area of Niš in order to determine the annual value of noise indicators and the optimal time interval for conducting long-term measurement. The basic features and capabilities of used noise monitoring terminals and the first results of the noise indicators obtained for the period January-June 2014 will be presented in this paper.*

Key words: *noise indicators, noise measurements, noise terminal*

1. INTRODUCTION

European cites have grown by 20% in size and their population has increased by 6% in the past 20 years [1]. Environmental noise caused by traffic, construction, industrial and recreational activities is the main local environmental problem and the source of an increasing number of complaints from the public. Worldwide, 130 million of people are exposed to environmental noise levels above 65dB(A), while another 300 million live in

Received September 16, 2014 / Accepted September 24, 2014
Corresponding author: Momir Praščević
Faculty of Occupational Safety in Niš, Čarnojevića 10A, Serbia
Phone: +381 249 962• E-mail: momir.prascevic@znrfak.ni.ac.rs

uncomfortable environmental noise levels (55dB(A)-65 dB(A)) [2]. According to the estimations from the European Community document called "Green Paper", 20% of the population (or 80 million people) are exposed to noise levels that cause sleeping disturbances, population annoyance and negative influence on human health. Beside that, 170 million of citizens of Europe (or 42%) live in the areas where noise levels cause serious annoyance during the day [3]. The estimates from 2004 show that nearly 100 million European citizens are exposed to unnacaeptable noise levels, and that nearly 300 million people live in the gray zones where noise causes serious interference [4].

In addition to the estimates presented in this paper, the other estimates different from those shown can be found in the literature. The different estimates are due to impact of the following factors:

- different noise level tolerance of the population;
- different types of environmental noise sources;
- different methods for obtaining noise exposure information, and
- different noise indicators.

Although the same noise indexes (the rating level for industrial noise and the equivalent noise level for road and railway traffic) were in use in the most European countries, there were exceptions. For example, Belgium used L_{95} noise index for industrial noise, Great Britain used L_{10} noise index for road traffic noise and Denmark used L_{Amax} noise index for railway noise [3].

In addition, there were significant differences in:

- correction for tonal and impulse noise;
- reference time intervals;
- meteorological corrections;
- determination of measuring positions; and
- averaging time.

Regarding the state of the used noise indexes in European countries, there was a need to harmonize noise indicators. By adopting the Directive on the Assessment and Management of Environmental Noise, 2002/49/EC [5], the basic principles of a harmonized European noise policy were defined. One of the key elements of the Environmental Noise Directive is the assessment of environmental noise by common noise indicators and common assessment methods.

The Environmental Noise Directive has been transposed in Serbian legislation by the Law on Environmental Noise Protection, adopted in 2009 (revised in 2010) [6] and several national sub-laws adopted in 2010. Regulation on noise indicators, limit values, assessment methods, noise annoyance, noise effects, impact on health, collecting data for noise assessment [7] introduce the noise indicators in the Environmental Noise Directive.

Adopting the Environmental Noise Directive and the common noise indicators, the environmental noise assessment in different countries could be compared. The latest data related to the environmental noise pollution [8], collected from the first round of strategic noise mapping for the EU agglomerations indicate that 54% of the population of urban areas (56,001,200 inhabitants) is exposed to L_{den} noise levels above 55dB(A), whereas 15% of the population (15,754,500 inhabitants) is exposed to L_{den} noise levels above 65dB(A). Besides this, an additional 33,437,244 inhabitants outside agglomerations live in areas where L_{den} noise levels are above 55dB(A) and 7,657,083 live in areas where L_{den}

noise levels are above 65dB(A). Out of the total of 89,438,444 inhabitants exposed to L_{den} noise levels above 55dB(A), almost 89 million people are exposed to the traffic noise [9].

The current practice for noise monitoring and assessment in Serbia is to conduct 15-min noise level measurements together with the general traffic and site information recorded [10]. The measurement period is extended to 1 h in some cases. Twenty-four hour continuous noise level measurements have lately been out in some cities (for example: Novi Sad, Belgrade). Also, the long-term noise measurements with measurement intervals of several days, weeks or months have been carried out lately in Novi Sad [11] and Nis. The first results of long-term noise measurements in Nis will be given in this paper.

2. Noise Indicators

2.1. Definition

Noise indicators shall mean a physical scale for the description of environmental noise, which has a relationship with a harmful effect [5]. Noise indicators shall be used to determine the environment noise level, for the assessment and prediction of noise level and its effects, development of strategic noise maps and noise protection measures planning. Bearing in mind the use of different noise indicators in some European countries, the criteria for selection of a noise indicator, alternatives and a set of possible indicators of noise, Directive [5] requires the use of harmonized noise indicators in member countries of the European Union as physical quantities that describe the noise that is, in the environment, created by different sources of noise in the open, and that to some extent adversely affect human health.

Directive [5] and Serbian legislation [6,7] require the use the common and supplement noise indicators. The common noise indicators are:

- the day-evening-night noise indicator, L_{den}[dB(A)] – indicator describing the annoyance caused by noise within 24 hours, i.e. for the day-evening-night;
- the daily noise indicator, L_d [dB(A)] – indicator describing the annoyance caused by noise within the day (day lasts 12 hours);
- the evening noise indicator, L_e [dB(A)] – indicator describing the annoyance caused by noise during the evening (evening lasts 4 hours);
- the night-time noise indicator, L_n [dB(A)] – indicator describing the annoyance caused by noise at night (evening lasts 8 hours).

In terms of Serbian regulation [6,7], the 24-hour-period shall be divided into three periods: the day period from 6 a.m. to 6 p.m., the evening period from 6 p.m. to 10 p.m. and the night period from 10 p.m. to 6 a.m.

The day-evening-night noise indicator is defined by the following formula:

$$L_{den} = 10\log\frac{1}{24}(12\cdot 10^{0.1\cdot L_d} + 4\cdot 10^{0.1\cdot(L_e+5)} + 4\cdot 10^{0.1\cdot(L_n+10)}) \quad (1)$$

where:

L_d – the A-weighted long-term average sound level determined over all the day periods of a year,

L_e – the A-weighted long-term average sound level determined over all the evening periods of a year,

L_n – the A-weighted long-term average sound level determined over all the night periods of a year.

A year is a relevant year as regards the emission of sound and an average year as regards the meteorological circumstances [5]. Applying the above correction values for different day periods is a consequence of different reactions of people to noise at specific time periods during the day.

The height of the assessment point depends on the application [5]:

- in the case of computation for the purpose of strategic noise mapping in relation to noise exposure in and near buildings, the assessment points must be 4,0 ± 0,2 m (3,8 to 4,2 m) above the ground and at the most exposed façade; for this purpose, the most exposed façade will be the external wall facing onto and nearest to the specific noise source;
- in the case of measurement for the purpose of strategic noise mapping in relation to noise exposure in and near buildings, other heights March be chosen, but they must never be less than 1,5 m above the ground, and results should be corrected in accordance with an equivalent height of 4 m,
- for other purposes such as acoustical planning and noise zoning other heights may be chosen, but they must never be less than 1,5 m above the ground, for example for:
  - rural areas with one-story houses,
  - the design of local measures meant to reduce the noise impact on specific dwellings,
  - the detailed noise mapping of a limited area, showing the noise exposure of individual dwellings.

The A-weighted long-term average sound levels for different day periods of a year are defined by the following formulas:

$$L_{\mathrm{d}} = 10\log\left[\frac{1}{N}\sum_{i=1}^{N}10^{0.1\cdot L_{\mathrm{d},\,i}}\right] \tag{2}$$

$$L_{\mathrm{e}} = 10\log\left[\frac{1}{N}\sum_{i=1}^{N}10^{0.1\cdot L_{\mathrm{e},\,i}}\right] \tag{3}$$

$$L_{\mathrm{n}} = 10\log\left[\frac{1}{N}\sum_{i=1}^{N}10^{0.1\cdot L_{\mathrm{n},\,i}}\right] \tag{4}$$

where N is the number of days in a year, N = 365.

The values of noise indicators for i-th day in year are determined based on the continuous measurement of the equivalent noise level in day periods, or by sampling techniques during day periods and the equivalent noise level determination based on the following equation:

$$L_{\mathrm{d},i} = 10\log\left[\frac{1}{N}\sum_{i=1}^{N}10^{0.1\cdot (L_{\mathrm{Aeq},\,T})_i}\right] \tag{5}$$

The similar equations are applied for $L_{\mathrm{e},i}$ and $L_{\mathrm{n},i}$.

2.2. Measurement principles for noise indicators determination

Measurement principles for determination of noise indicators are described in IMAGINE document [12] developed in the scope of IMAGINE project [13]. Also, the revision of ISO 1996-2 standard is in progress. The revised standard will provide the guidelines for noise indicators determination.

The guidelines given in IMAGINE document [12] describe how to determine L_{den} and L_{n} by direct measurement or by extrapolation of measurement results by means of calculation. The measurement method is intended to be used outdoors as a basis for assessing environmental noise and verifying the quality of predictions.

Two measurement principles were developed: determination of noise indicators by means of long-term or short-term measurements. The long-term measurements involve measurements during a time long enough to include variations in source operating and meteorological conditions. The results of long-term measurements are more accurate and can be used with fewer corrections than those of short-term measurements. However it was highlighted that optimal duration of long-term measurement cannot easily be determined. Source operating conditions, e.g. traffic composition and vehicle flow conditions, shall be as representative as possible to minimize later corrections. If propagation conditions or emission conditions vary strongly between the different seasons of the year, e.g. because of winter tires and snow cover, it might be necessary to perform measurement during several different seasons in order to achieve a low measurement uncertainty. For long-term assessments and land use planning, long-term time intervals that represent some significant fraction of a year should be used (e.g. 3 months, 6 months, 1 year).

The short-term measurements involve measurements under specified source operating and meteorological conditions and the use of relevant prediction method in order to determine the noise indicators value. If the noise displays periodicity, the measurement time interval should preferably cover an integer number of several periods. If continuous measurements over such a period cannot be made, measurement time intervals shall be chosen so that each represents a part of the cycle and so that, together, they represent the complete cycle. Representative measurement results can be extended in time to cover the period for which they are representative and combined to provide new results. The minimal time interval shall be 10 minutes; however, 30 minute measurement is recommended in order to average weather induced variations.

For both long and short-term measurements meteorological parameters shall be measured. As a minimum requirement wind speed, wind direction, relative humidity and temperature shall be measured. Furthermore, information about the cloud coverage shall be provided.

The long-term measurements can be realized as permanent noise monitoring or semi-permanent noise monitoring. Permanent monitoring can indicate environmental noise trends and help produce noise maps. Semi-permanent monitoring, typically ranging from a few days up to several weeks or months, is also used for cost-effective monitoring of environmental noise trends, limit compliance, public awareness, the improved knowledge of dose-response relationships and calibration of noise maps.

3. METHODOLOGY OF LONG-TERM MEASUREMENT AND MEASUREMENT EQUIPMENT

Data on environmental noise levels in the city of Nis have been systematically collected and analyzed through the project of monitoring the environmental noise level over several years starting from 1995 [9, 15-17].

The environmental noise level monitoring is organized on a monthly basis, for the reference time intervals: daytime (06:00÷22:00) and nighttime (22:00÷06:00). The procedure of continuous noise level monitoring lasts for 12 months.

The measurement time intervals were chosen in such a way that they encompass the whole cycle of noise level changes during the reference time intervals. One measurement interval lasts for 15 minutes. The daytime measurement interval is divided into 3 or 5 periods, whereas the nighttime measurement interval is divided into 2 periods. At each measurement spot, within one cycle/month, there is one 15 minute measurement in each of the periods.

The value of noise indicators were calculated based on these short-term measurements. The results of calculation are shown in [9].

The procedure of permanent continuous environmental noise measurements at two locations in the city of Niš, according to guidelines given in standards SRPS ISO 1996-1 [18] and SRPS ISO 1996-2 [19] and IMAGINE document [12], has been carried out starting from January 1, 2014. In order to evaluate noise levels produced by the road traffic, the environmental noise monitoring system with two noise monitoring stations located rather close to the main road line have been used. One of the terminals (marked as NMT-1) has been located near the intersection of two roads and other (marked as NMT-2) near a primary school. Location of noise monitoring terminals is shown on Fig. 1 and the coordinates are shown in Table 1.

Table 1 The coordinates of noise monitoring terminals

	NMT-1	NMT-2
Latitude	43° 19’ 12.8”	43° 19’ 13”
Longitude	21° 53’ 27.6”	21° 54’ 13.2”
Altitude	195.3 m	196.8 m
Microphone height	4 m	4 m

Fig. 1 Location of noise monitoring terminals (left: NMT-1, right: NMT-2)

Brüel&Kjær's Environmental Noise Management System (Fig. 2) used to permanent noise monitoring consists of:

- Environmental Noise Management System Software Type 7843
- Two Noise Monitoring Terminals Type 3639B

Both terminals are equipped with GPRS router and GPS receiver. One of the terminals (marked as NMT-1) is equipped with Weather Station Type WXT520 manufactured by Vaisala, which enable measurement of the following meteorological parameters: temperature, humidity, air pressure, wind velocity, wind direction and rainfall.

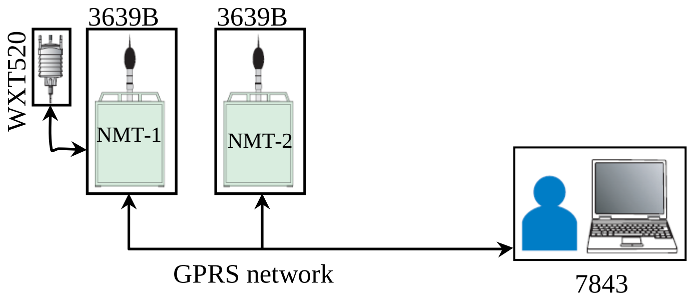

Fig. 2 Environmental Noise Management System

The Environmental Noise Management System (ENM) is built around a server and a set of clients with a professional Microsoft® SQL Server® database as the central server component [20]. The ENM Server provides the basic data storage and business logic for accessing objects in the ENM database. The Server receives data from one or more noise monitoring terminals (NMT). An NMT is a powerful, modular terminal that is optimized for outdoor use in all weather conditions. It provides the Server with noise and weather data and stores data and measurement setups as templates.

Environmental Noise Management System Software Type 7843, the central part of the Brüel & Kjær Environmental Noise Management System makes it a powerful noise data management tool. It offers real-time communication with NMTs ensuring continuous data storage in both the NMTs and the system's central database. The software ensures data retrieval, analysis, reporting and export of noise, weather, and geographic data through its configurable user interface with built-in GIS functionality.

Noise Monitoring Terminal Type 3639-B is a self-calibrating NMT optimized for remote, unattended, environmental noise measurements [21]. It can measure, record, process, store, and transmit noise information as part of a noise monitoring system. The NMT consists of a weatherproof cabinet containing a noise level analyzer and a battery, a GPRS router, GPS receiver and an outdoor microphone, all of which can be mounted on a mast, pole, tripod or wall. Noise monitoring and analysis is performed by the included analyzer Type 2250 protected inside the cabinet which measures data coming from the outdoor microphone and logs it onto its on-board memory, including broadband and 1/3-octave L_{Aeq} or SPL, continuously at half- or one second intervals. The NMT can also be used to identify, record and analyze noise events. Analyses produced include: hourly reports, short reports (from 1 to 30 minutes), calibration check reports, noise events and instrument health reports.

The ENM system enables to view real-time data (Fig. 3) from the NMTs to the server and quickly configure the ENM system or monitor the connection to the NMTs.

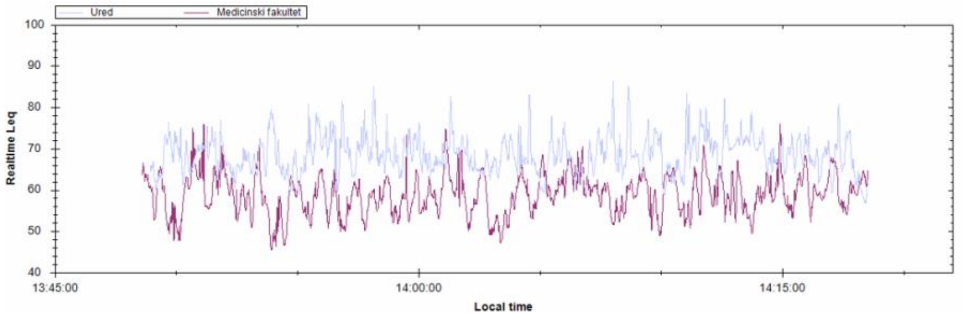

Fig. 3 Real-time data streaming

4. Results of Long-Term Measurements

For the purpose of this paper the results obtained during March, 2014 were analyzed and compared with the semiannual values obtained during the period January-Jun, 2014.The semiannual values of the noise indicators and the monthly March values are shown in Table 2. The daily values of noise indicators during March, 2014 are shown in Fig. 4 and Fig. 5 for NMT-1 and NMT-2, respectively.

Table 2 The semiannual values of the noise indicators compared with the monthly March values

	Semiannual values		Monthly March values	
	NMT-1	NMT-2	NMT-1	NMT-2
L_d[dB(A)]	73.2	70.4	73.3	70.6
L_e [dB(A)]	72.1	69.9	72.1	69.8
L_n [dB(A)]	68.0	66.9	67.9	66.7
L_{den} [dB(A)]	76.0	74.3	76.0	74.2

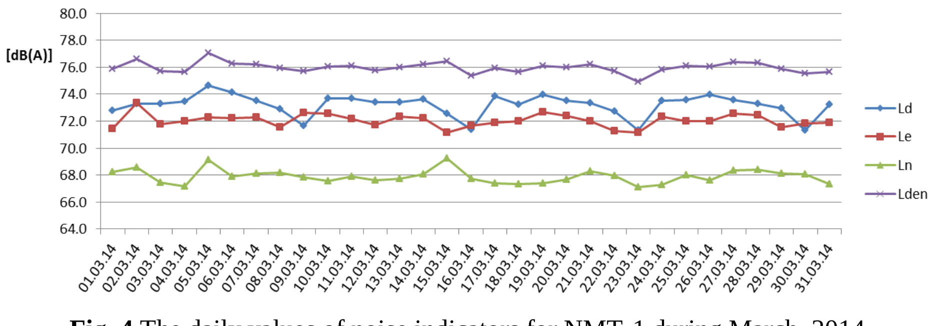

Fig. 4 The daily values of noise indicators for NMT-1 during March, 2014

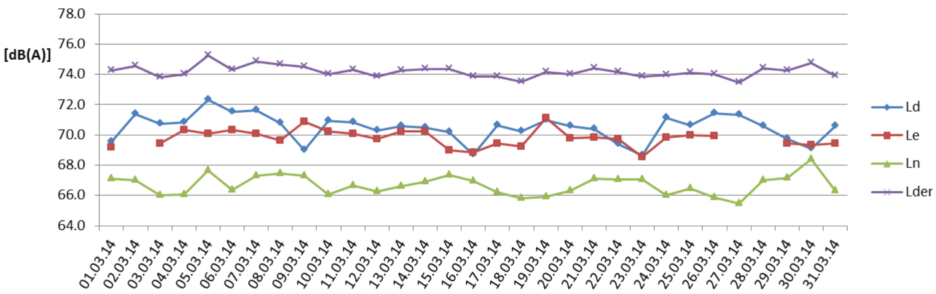

Fig. 5 The daily values of noise indicators for NMT-2 during March, 2014

The monthly value of noise indicator is calculated as a logarithmic average value of the daily values. The daily values of noise indicators are calculated as a logarithmic average value of the hourly L_{eq} values. The hourly L_{eq} values variations point to noise variations during 24 h period. The logarithmic average values of the hourly L_{eq} values during March, 2014 are shown in Fig. 6 and Fig. 7 for NMT-1 and NMt-2, respectively.

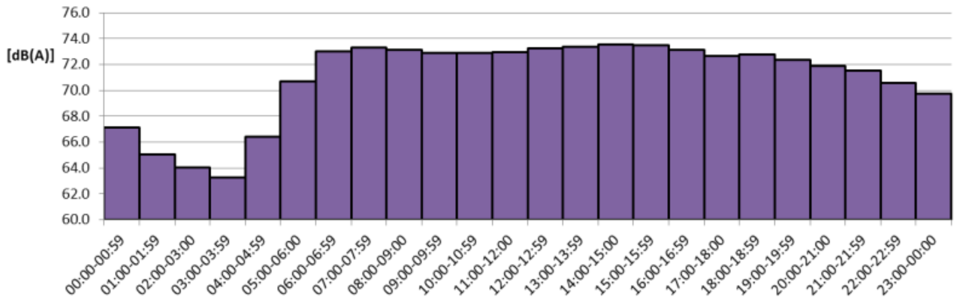

Fig. 6 The average values of hourly L_{eq} values for NMT-1 during March, 2014

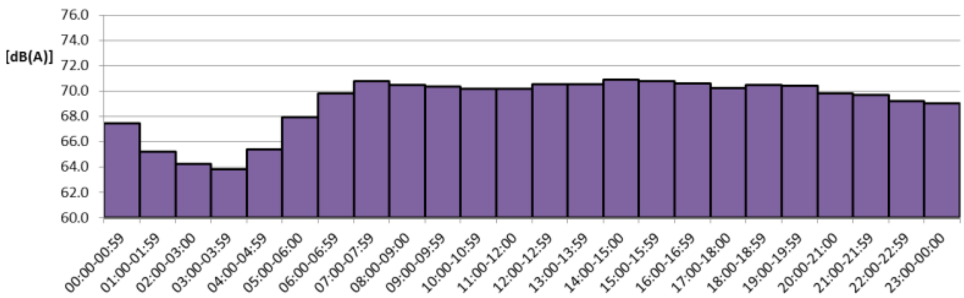

Fig. 7 The average values of hourlyL_{eq} values for NMT-2 during March, 2014

CONCLUSIONS

Based on the results of permanent continuous noise monitoring and the noise indicator determination by long-term measurements which are partly shown in this paper, as a part of the research conducted in order to determine the optimal procedure for noise indicator determination and optimal duration of long-term measurement, the following conclusions can be derived:

- the results of permanent continuous noise monitoring are very accurate and repeatable (see Table 2); the monthly values of noise indicators in observation period are slightly different from semiannual values of noise indicators;
- the variation of daily noise indicators are less then 2 dB; the value of daily and evening noise indicator are very close; maximal difference is smaller then 2 dB; the value of night noise indicator are approximately 4 dB smaller then the value of daily and evening noise indicator;
- the variation of the hourly L_{eq} values in the period from 6 a.m. to 10 p.m. are very small; the daily noise profile for both locations is similar and repeatable in observation period.

Acknowledgement. *This research is part of the project "Improvement of the monitoring system and the assessment of a long-term population exposure to pollutant substances in the environment using neural networks" (No. III-43014). The authors gratefully acknowledge the financial support of the Serbian Ministry of Education, Science and Technological Development .*

REFERENCES

1. E. Murphy, E.A. King, (2010), "Strategic environmental noise mapping: methodological issues concerning the implementation of the EU Environmental Noise Directive and their policy implications", Environment international journal, vol. 36, no. 5, pp. 290-298.
2. B. Berblund, T. Lindvall and D. H. Schwela, (1999), "Guidelines for Community Noise", World Health Organization, Geneva, http://whqlibdoc.who.int/hq/1999/a68672.pdf
3. D. Cvetković, M. Praščević, (2000), "Rating noise level as environmental noise indicator", The scientific journal FACTA UNIVERSITATIS, Series: Working and Living Environmental Protection, Vol. 1, No 5, pp. 39 – 50.
4. M. Praščević, D. Cvetković, D.Mihajlov, (2010), "Methodological approach for strategic environmental noise mapping", in *Proceedings of 22nd Conference with International Conference "Noise and Vibration"*, Niš, Serbia, pp. 11-18, In Serbian.
5. Directive 2002/49/EC of the European Parliament and the Council relating to the assessment and management of environmental noise, Official Journal of the European Communities, L 189, Vol. 45, 2002. [Online]. Available: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32002L0049
6. Law on Environmental Noise Protection, (2010), Official Gazette of the Republic of Serbia, No. 36/09 and No. 88/2010, In Serbian.
7. Regulation on noise indicators, limit values, assessment methods, noise annoyance, noise effects, impact on health, collecting data for noise assessment, (2010), (Official Gazette of the Republic of Serbia, No. 75/10. In Serbian.
8. P. Vos, G. Licitra, G., (2012), *Noise maps in the European Union: An overview*. In G. Licitra (Ed.), Noise mapping in EU: Models and Procedures (pp. 285–310). USA: CRC Press.
9. M. Praščević, D. Cvetković, D. Mihajlov, (2014), "Measurement and evaluation of the environmental noise levels in the urban areas of the city of Nis (Serbia)", Environmental Monitoring and Assessment, Vol. 186, pp. 1157-1165, [Online]. Available: http://dx.doi.org/10.1007/s10661-013-3446-2.
10. M. Pljakić, B. Radičević, J. Tomić, Z. Petrović, (2012), "Analysis of systematic measurements of noise in cities", in *Proceedings of 23rd Conference with International Conference "Noise and Vibration"*, Niš, Serbia, pp. 59-62.

11. S. Milošević, S. Bijelović, E. Živadinović, M. Jevtić, M. Popović, (2010), "Continuous environmental noise measurement in the city of Novi Sad in April 2010", in *Proceedings of 22nd Conference with International Conference "Noise and Vibration"*, Niš, Serbia, pp. 49-52. In Serbian.
12. IMAGINE Project, Deliverable 5, "Determination of L_{den} and L_{night} using measurements", 2011 [Online]. Available: http://www.certificacioacustica.cat/Documents/Articles/D5_IMA32TR-040510-SP08.pdf
13. IMAGINE Project – final report, [Online]. Available: http://cordis.europa.eu/publication/rcn/11878_en.html
14. M. Prašćević, (1995), "Systematic Environmental Noise Measurement of Nis", in *Proceedings of 15th Yugoslav and 3rd International Conference "Noise and Vibration in Living and Working Environment"*, Niš, Serbia, pp. 35–38. In Serbian.
15. D. Cvetković, A. Deljanin, M. Praščević, (1997), "Community noise levels survey of Nis" in *Proceedings of the International Congress on Noise Control Engineering "INTER NOISE"*, Budapest, pp. 815–818.
16. D. Mihajlov, M. Praščević, D. Cvetković, (2008), "Results of the monitoring and assessment of the state of noise level in Nis in 2007, in *Proceedings of 21st Conference with International Participation "Noise and Vibration"*, Tara, ID: 21–23. In Serbian.
17. D. Mihajlov, M. Praščević, D. Cvetković, (2012), "An analysis of the environmental noise levels on the territory of the city of Nis", inProceedings of 23rdNational and 4th International Conference "Noise and Vibration", Niš, pp. 49–58.
18. SRPS ISO 1996-1: 2010, Acoustics - Description, measurement and assessment of environmental noise - Part 1: Basic quantities and assessment procedures.
19. SRPS ISO 1996-2: 2010, Acoustics - Description, measurement and assessment of environmental noise - Part 2: Determination of environmental noise levels.
20. Technical documentation – Environmental Noise Management System Software Type 7843, (2010), version 2.8.1, Bruel&Kjaer, BE 1767-15.
21. Technical documentation – Noise Monitoring terminal Types 3639-A, 3639-B and 3639-C with Hand-held Analyzer Type 2250-N or Hand-held Analyzer Type 2250-N-D00, version 4.1.1, Bruel&Kjaer, BE 1818-17, 2013.

ODREĐIVANJE INDIKATORA BUKE DUGOTRAJNIM MERENJIMA

Direktiva Evropske unije 2002/49/EC o proceni i upravljanju bukom u životnoj sredini i novi propisi Republike Srbije u oblasti buke u životnoj sredini definišu dva osnovna indikatora za procenu buke u životnoj sredini - L_{den} i L_n. Pored njih, preporučuje se i upotreba dodatnih indikatora kao što su L_d i L_e. Za potrebe izrade strateških karata buke i procenu ugroženosti stanovništva bukom potrebno je da se utvrdi godišnja vrednost ovih indikatora. Godišnje vrednosti indikatora buke se mogu odrediti kratkotrajnim i dugotrajnim merenjima, ili njihovom kombinacijom. Kratkotrajna merenja se sprovode za definisani radni režim izvora buke i definisane meteorološke uslova, a godišnje vrednosti indikatora buke se određuju proračunom. Sa druge strane, dugotrajna merenja predstavljaju merenja tokom dovoljno dugog vremenskog intervala koji obuhvata promene režima rada izvora, kao i promene meteoroloških uslova. Rezultati dugotrajnih merenja su precizniji i mogu se koristiti sa mnogo manje korekcija u odnosu na rezultate kratkotrajnih merenja. Radi utvrđivanja godišnjih vrednosti indikatora buke i optimalnih vremenskih intervala za sprovođenje dugotrajnih merenja, u centralnom gradskom području Niša su instalirane dve monitoring stanice za kontinuirano merenje buke. U radu su predstavljene osnovne karakteristike i mogućnosti korišćenih stanica za monitoring buke, kao i prvi rezultati utvrđivanja indikatora buke za period od januara do juna 2014. godine.

Ključne reči: *indikatori buke, merenje buke, stanica za monitoring buke*