

# NOISE, SOURCES OF NOISE AND ITS INFLUENCE ON THE QUALITY OF WORK AND LIVING ENVIRONMENT

Sanja Lj. Korica<sup>a</sup>, Kristina D. Popović<sup>b</sup>

University Union – Nikola Tesla, Faculty for Ecology and Environmental Protection, Belgrade, Republic of Serbia,

<sup>a</sup> e-mail: koricasanja@gmail.com,

ORCID iD: <http://orcid.org/0000-0002-7915-9430>,

<sup>b</sup> e-mail: kristinapopovic@gmail.com,

ORCID iD: <http://orcid.org/0000-0003-0724-3710>

<http://dx.doi.org/10.5937/vojtehg65-12900>

FIELD: Acoustics, Noise, Environmental Protection

ARTICLE TYPE: Professional Paper

ARTICLE LANGUAGE: English

## Summary

*Fast technological development has made noise an inevitable part of everyday life. The main sources of noise are: machines, factories, traffic and noise from the neighbourhood. As a mixture of sounds of different characteristics, noise can be permanent, nonpermanent and impact with different levels, duration and time distribution. Due to the harmful effects of noise on human health, it is necessary to undertake steps which will contribute to the reduction of noise levels. Noise pollution and activities for the protection against noise have been analysed in this paper.*

*Keywords: acoustics, noise.*

## Introduction

Noise is most often defined as undesirable sound, and in that sense, it obeys all laws of acoustics as a special part of physics which studies generation, propagation and perception of sound.

Sound represents a type of a mechanical wave which can be detected by the sense of hearing (Georgijević, 2005, pp.253-257). It is created by oscillating, in other words, by compression and spreading of air molecules travelling under the influence of an external force. As every mechanical wave, sound is determined by two basic physical parameters - wavelength and frequency. Wavelength is a distance between two neighbouring condensations, as well as two neighbouring attenuations of the medium through which sound travels. Frequency is the number of oscillations produced in one second and is measured in the unit called

Hertz (Hz). A normal human ear can hear frequencies in the range from 20 to 20 000Hz. Every sound below a frequency of 20 Hz is called infrasound and every sound under 20 000 Hz is called ultrasound; they have wide application in medicine and technology. Certain animals (such as dogs, cats, bats, etc.) have a much wider spectrum of hearing sounds (Figure 1).



Figure 1 – Range of audibility in animals  
 (<http://www.znanje.org/i/i25/05iv08/05iv080911fl/zvuk.htm>, 2016)  
 Рус. 1 – Диапазон слышимости животных  
 (<http://www.znanje.org/i/i25/05iv08/05iv080911fl/zvuk.htm>, 2016)  
 Слика 1– Спектар чујности код животиња  
 (<http://www.znanje.org/i/i25/05iv08/05iv080911fl/zvuk.htm>, 2016)

Sounds are, according to their characteristics, divided into two main groups: murmurs and tones. A murmur is a sound which appears by irregular oscillations of a sound source where the frequency is constantly changed. A tone appears by regular oscillations of a sound source where the frequency is constant.

## Intensity of noise

Like every other type of a mechanical wave, a sound is determined also by its intensity, which represents the amount of sound energy passing through the surface area unit (Vučić & Ivanović, 2000, pp.301-303). Also, every sound source possesses certain power which is equal to the energy which in the time unit passes through the surrounding space and is expressed in Watts (W). The ratio of power and intensity of a sound wave is given by the following expression (Sas, 2007, pp.6-7):

$$P = 4\pi r^2 * I [W] \quad (1)$$

where:

$P$  – source power

$I$  – sound intensity on the surface of the imaginary sphere

$r$  – radius of the imaginary sphere

A direct application of the linear scale for measuring sound intensity would lead to very big numbers which are, therefore, very difficult for manipulation. Besides, the human ear does not respond to sound stimulations linearly but logarithmically. For that reason, the concept of subjective sound intensity is introduced in practice as (Sas, 2007, pp.7):

$$L = 10 \frac{\log I}{I_0} (dB) \quad (2)$$

where:

$I$  – objective sound intensity for the given subjective

$I_0$  – objective sound intensity for the referent intensity (threshold of hearing  $-10^{-12} \text{W/m}^2$ )

The unit for this logarithmic ratio is decibel (dB).

A mechanical wave which has an intensity of about  $10 \text{W/m}^2$  is not experienced as a sound, because it produces pain in the ear. This value is called the limit of pain. Subjective intensity of sound at the threshold of hearing is 0 dB, whereas subjective intensity of sound at the limit of pain is 120 dB (Georgijević, 2005, p.283). However, depending on the type of sound, the feelings of pleasantness and unpleasantness are not directly connected to sound intensity. Some examples of sound intensity levels for certain cases are given in Table 1 (Georgijević, 2005, p.283).

*Table 1 – Levels of sound intensity for characteristic cases*  
*Таблица 1 – Уровень громкости звука характерных источников*  
*Табела 1 – Ниво јачине звука карактеристичних извора*

Sound intensity level	Examples from the environment
130	jet engine at a distance of 20m
120	loud rock music
110	compression drill at a distance of 2m
100	motorcycle without silencers
90	car horn at a distance of 5m
80	loud shouting, heavy traffic
70	playing the piano, noisy restaurant
60	conversation, office
50	normal conversation, quiet street
40	quiet conversation, quiet music
30	very quiet surroundings
20	very quiet garden outside the town
10	rustling of leaves in the quietest wind
0	threshold of hearing

## Sources of noise

Noise represents an important, undesirable pollutant of the environment. The level of noise depends on sound source power, soundpath propagation length, i.e. on the distance from the emitter to the surrounding of the recipient (Cvetković & Praščević, 2005, pp.111-117). The main sources of noise in urban areas are traffic noise, noise from the neighbourhood and industrial noise (Belić et al, 2009, p.5), (Damjanović & Mitić, 2015, pp.19-21). Traffic noise is present in most of the cities. It is estimated that, during a rush hour in city streets with heavy traffic, sound intensity varies from 80dB onwards. A special threat to the population from noise represents the proximity of airports where the level of noise in a diameter of 1km is estimated to be 90dB and higher. As for the noise from the neighbourhood, which includes playgrounds, schools, kindergartens, etc., its general estimation is difficult and it mainly depends on a concrete case. A pleasant place for living is considered to be a place in which its intensity does not exceed 60dB at a distance of 25m from the sound source. Industrial plants have different influence depending on working places, but in most cases they represent a source of so-called constant noise which appears in the uniform work regime. Particularly harmful to health are sound sources representing different types of very fast impacts or explosions (less than 1s). They are, by the rule, differently categorised in order to determine their impact on the human health.

## Influence of noise on the human health

Contemporary processes of urbanization and industrialization are constantly increasing the number of noise sources so that today there is almost no working place or settlement not exposed to noise. Noise is among physical agents harmful to health and, besides hearing damage, it has a number of nonauditive effects (Nikolić & Nikolić, 2013, pp.93-96), (<http://www.b92.net/zdravlje/prevencija.php>, 2016).

Disruption of sleep is considered to be the basic and the most important one because it further leads to mood swings, feeling of tiredness, apathy, decrease in working ability, headache and pronounced nervousness. A number of field studies have indicated that sleeping is particularly badly affected by heavy vehicles and trains. For a good night's sleep, it is desirable that noise does not exceed 30dB. It is considered that noise of about 65dB can cause anxiety, irritability or headache in very sensitive persons. Noise of about 90dB can affect hearing and cause neurovegetative problems (hypertension, endocrine and metabolic disorders). When the level of noise exceeds a value of 90dB, permanent damage of hearing occurs as well as serious neurovegetative problems.

## Noise protection measures

Since today noise often disturbs basic human activities such as work, rest and sleep and can also be a cause of permanent hearing damage, different protection measures are introduced in order to reduce noise levels to the permitted values. In order for the problem of noise level reduction to be solved in a proper way, it is necessary to provide reliable noise measurements. Noise measuring represents obtaining a precise sound intensity value which further determines which sound can cause potential damage and which protection measures should be undertaken in order to improve the acoustics of dwellings, industrial plants, music and movie halls, etc.

Nowadays, there are a number of standard methods for measuring the physical parameters of noise which are relatively simple for use; their purpose is to assess the level of damage in accordance with the rules and norms for certain conditions. The basic instrument for noise level determination is a phonometer (soundmeter, measurer of the noise level) (Bruel & Kjaer, 1984, pp.10-15). It is presented at Figure 2.



Figure 2 – Phonometer (<http://www.3me.rs/portfolio-item/db-200-profesionalni-merac-nivoa-buke-sa-pc-interfejsom>, 2016)

Рис. 2 – Фонометр (<http://www.3me.rs/portfolio-item/db-200-profesionalni-merac-nivoa-buke-sa-pc-interfejsom>, 2016)

Слика 2 – Фонометар (<http://www.3me.rs/portfolio-item/db-200-profesionalni-merac-nivoa-buke-sa-pc-interfejsom>, 2016)

A phonometer is often equipped with a filter (octave, one-third octave) which can determine the noise amplitude spectrum as well.

If a place is affected by a number of different noise sources ( $n$ ), then the equivalent noise level can be obtained by the expression (Sas, 2007, pp.21):

$$L = 10 \log \left( 10^{\frac{L_{p1}}{10}} + 10^{\frac{L_{p2}}{10}} + \dots + 10^{\frac{L_{pn}}{10}} \right) \quad (3)$$

Table 2 gives an overview of several annual noise levels at several different locations in the city of Belgrade (Damjanović & Mitić, 2015, pp.73-74):

Table 2 – Overview of the noise level in the city of Belgrade  
 Таблица 2 – Обзор уровня шума в городе Белград  
 Табела 2 – Преглед нивоа буке у граду Београду

Measuring place	Time of day	2003.	2005.	2010.	2013.
Bul. Despota Stefana	day	73	75	82	71
	night	67	70	76	66
Bul. Kralja Aleksandra	day	64	65	69	69
	night	59	61	60	65
KBC	day	55	55	66	49
	night	49	47	54	51
Zeleni Venac	day	68	74	72	72
	night	66	70	61	69
Jurija Gagarina	day	65	59	60	60
	night	63	49	55	55
Kalemegdan	day		64	54	52
	night		51	46	49
Narodnog Fronta	day	67	67	66	68
	night	62	62	64	66
Ustanička	day	65	64	66	65
	night	56	52	57	59
Vojvode Stepe	day	68	62	75	68
	night	62	60	71	64
Zemun, Glavna	day	78	75	73	72
	night	73	68	69	67

The measured values indicate that the levels of communal noise are very high and mostly exceed prescribed values.

The main noise protection measure is the reduction of noise at its very source. New and silent technologies allow that certain machines are quieter than conventional equipment. The noise protection measures are divided in two main groups: individual and group protection measures (Sas, 2007, pp.38-48). Individual protection implies wearing different types of earsets, helmets and earplugs providing protection power in the range from 15 to 30dB, even more. Collective or general protection measures present raising different walls, obstacles and absorption elements (trees, etc.) along sound waves propagation paths in blocks of flats, hospitals, schools and other objects where people dwell. (Cvetković & Praščević,

2005, pp.159-179). It is important to highlight that even small holes in such obstacles reduce their efficiency. In residential areas, problems with noise can be solved by relocating roads out of such areas or by building underground traffic. And finally, if noise is not reduced at its source, the only way left to decrease its influence is on the way from the emitter to the recipient. This protection method is realised through: spatial planning, the layout of the rooms in the building, construction of partitions of certain characteristics, construction of walls and windows in accordance with defined norms and fixing house installations in accordance with the norms for noise protection (JUS U.J6.201, 1990).

Social-legal aspects of noise protection present different types of technical regulations about noise measuring methods, about permitted noise levels, as well as the ways of controlling and sancioning noise polluters. Harmful effects of noise at working places in our country were for the first time defined in the document „Pravilnik o opštim merama i normativima zaštite na radu od buke u radnim prostorijama“ (Službeni list SFRJ, 21/92). The maximum allowed levels of noise in the environment are given in the document “Pravilnik o dozvoljenom nivou buke u životnoj sredini” (Službeni glasnik RS,54/92). The document “Zakon o zaštiti od buke u životnoj sredini”, (Službeni glasnik RS, 36/09, 88/10) defines the most important obligations within the framework of protection against noise and vibrations.

## Conclusion

Noise is an indispensable part of modern living. It is considered to be every undesirable, disturbing sound, which means that not every sound is regarded as noise. In the past few decades in industrially developed countries, noise has become one of the main sources of disturbance of many different human activities but also a cause of complex damage to the human health. In order to monitor harmful effects and undertake certain protection measures in the concrete conditions, it is necessary to determine the noise level by measurements. In practice, it is often the case that the level of noise varies, more or less in time. In order to protect people, in most of the countries, a lot of attention is paid to defining the highest allowable noise level, which, depending on the type of the activity, can be between 35dB and 90dB. This can be mainly achieved by so-called ecological protection measures which imply the use of the best spatial layout in order to decrease noise effects.

## References

- Belić, Č., Biočanin, I. & Papić, H., 2009. *Buka kao fizički zagađivač i poremećaj radne i životne sredine*. In: 1st International Conference Ecological safety in post-modern environment, June, Banja Luka, Republika Srpska, BiH, p.5 (in Serbian).
- Cvetković, D. & Praščević, M., 2005. *Buka i vibracije*, Fakultet zaštite na radu u Nišu (in Serbian).
- Damjanović, D. & Mitić, A., 2015. *Upravljanje bukom u gradu Beogradu*, Stalna konferencija gradova i opština Srbije, Beograd (in Serbian).
- Georgijević, V. & et al., 2005. *Predavanja iz fizike*, Univerzitet u Beogradu - Građevinski fakultet, Beograd, pp.279-293 (in Serbian).
- JUS U.J6.201, 1990. *Akustika u građevinarstvu. Tehnički uslovi za projektovanje i građenje zgrada* (in Serbian).
- Brüel & Kjaer, 1984. *Measuring Sound*, Naerum, Denmark, Brüel & Kjaer, pp.10-15.
- Nikolić, M.D. & Nikolić, D.M., 2013. *Harmful Effects and Monitoring of Noise. (JPMNT) Journal of Process Management – New Technologies 1*, pp.93-96.
- Sas, E., 2007. *Zaštita od komunalne buke*, Univerzitet u Novom Sadu - Prirodno-matematički fakultet, Departman za fiziku (in Serbian).
- Službeni glasnik Republike Srbije, 54/1992. *Pravilnik o dozvoljenom nivou buke u životnoj sredini*, Beograd, JP „Službeni glasnik” (in Serbian).
- Službeni glasnik Republike Srbije, 36/2009. *Zakon o zaštiti od buke u životnoj sredini*, Beograd, JP „Službeni glasnik” (in Serbian).
- Službeni glasnik Republike Srbije, 88/2010. *Zakon o zaštiti od buke u životnoj sredini*, Beograd, JP „Službeni glasnik” (in Serbian).
- Službeni list SFRJ, 21/92. *Pravilnik o merama i normativima zaštite na radu od buke u radnim prostorijama*, Beograd, Novinsko-izdavačka ustanova Službeni list SFRJ (in Serbian).
- Vučić, V. M. & Ivanović, D. M., 2000. *Fizika 1*, IP „Nauka”, Beograd (in Serbian).
- <http://www.znanje.org/i/i25/05iv08/05iv080911fll/zvuk.htm>.  
Accessed: 15.12.2016.
- <http://www.3me.rs/portfolio-item/db-200-profesionalni-merac-nivoa-buke-sa-pc-interfejsom/>. Accessed: 15.12.2016.
- [http://www.b92.net/zdravlje/prevencija.php?nav\\_id=704730](http://www.b92.net/zdravlje/prevencija.php?nav_id=704730).  
Accessed: 15.12.2016.



## ШУМ, ИСТОЧНИКИ ШУМА И ИХ ВОЗДЕЙСТВИЕ НА КАЧЕСТВО РАБОЧЕЙ И ОКРУЖАЮЩЕЙ СРЕДЫ

Саня Л. Корица, Кристина Д. Попович  
Университет «Унион – Никола Тесла», Факультет экологии и охраны  
окружающей среды, г. Белград, Республика Сербия

ОБЛАСТЬ: акустика, шум, защите окружающей среды  
ВИД СТАТЬИ: профессиональная статья  
ЯЗЫК СТАТЬИ: английский

### Резюме:

*Вследствие технологического развития в современном мире, шум стал неотъемлемой частью повседневности. Основными источниками шума являются различные машины, станки, фабрики, заводы, транспорт и прочие звуки из окружения. Как совокупность различных звуков шум может быть стационарным и нестационарным, постоянным и непостоянным, колеблющимся, прерывистым и импульсным, отличаться по уровню и периоду воздействия. Так как шум оказывает негативное воздействие на здоровье человека, необходимо принять все возможные меры по снижению уровня шума. В данной статье представлен анализ негативного воздействия шума и описаны меры и средства по защите от шума.*

*Ключевые слова: акустика, шум.*

## БУКА, ИЗВОРИ БУКЕ И ЊЕН УТИЦАЈ НА КВАЛИТЕТ РАДНЕ И ЖИВОТНЕ СРЕДИНЕ

Сања Л. Корица, Кристина Д. Поповић  
Универзитет Унион – Никола Тесла, Факултет за екологију и заштиту  
животне средине, Београд, Република Србија

ОБЛАСТ: акустика, бука, заштита животне средине  
ВРСТА ЧЛАНКА: стручни чланак  
ЈЕЗИК ЧЛАНКА: енглески

### Сажетак:

*Убрзаним технолошким развојем савременог човечанства бука је постала неизбежан део свакодневног живота. Основни извори буке су машине, фабрике, саобраћај, као и звуци из суседства. Као мешавина звукова различитих карактеристика бука може бити трајна, испрекидана и ударна, промјенљивих нивоа, различитог трајања и временске расподеле. Због њеног штетног утицаја на људско здравље потребно је предузети одређене активности*

*ради редуковања нивоа буке. У овом раду анализирана је загађеност буком и делатности на плану заштите од ње.*

*Кључне речи: акустика, бука.*

---

Paper received on / Дата получения работы / Датум пријема чланка: 11.01.2017.  
Manuscript corrections submitted on / Дата получения исправленной версии работы /  
Датум достављања исправки рукописа: 07.03.2017.  
Paper accepted for publishing on / Дата окончательного согласования работы / Датум  
коначног прихватања чланка за објављивање: 09.03.2017.

© 2017 The Authors. Published by *Vojnotehnički glasnik / Military Technical Courier* ([www.vtg.mod.gov.rs](http://www.vtg.mod.gov.rs), втг.мо.упр.срб). This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/3.0/rs/>).

© 2017 Авторы. Опубликовано в «Военно-технический вестник / *Vojnotehnički glasnik / Military Technical Courier*» ([www.vtg.mod.gov.rs](http://www.vtg.mod.gov.rs), втг.мо.упр.срб). Данная статья в открытом доступе и распространяется в соответствии с лицензией «Creative Commons» (<http://creativecommons.org/licenses/by/3.0/rs/>).

© 2017 Аутори. Објавио Војнотехнички гласник / *Vojnotehnički glasnik / Military Technical Courier* ([www.vtg.mod.gov.rs](http://www.vtg.mod.gov.rs), втг.мо.упр.срб). Ово је чланак отвореног приступа и дистрибуира се у складу са Creative Commons licencom (<http://creativecommons.org/licenses/by/3.0/rs/>).

