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

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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 20 000 Hz. 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/i25/05iv08/05iv080911fll/zvuk.htm, 2016)

Рис. 1 – Диапазон слышимости животных
(http://www.znanje.org/i/i25/05iv08/05iv080911fll/zvuk.htm, 2016)
Слика 1– Спектар чујности код животња
(http://www.znanje.org/i/i25/05iv08/05iv080911fll/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 (Šas, 2007, pp.6-7):

$$P = 4\pi r^2 \times I[W]$$  \hspace{1cm} (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):

\[
L = 10 \log \frac{I}{I_0} \text{ (dB)}
\]  

(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 10W/m² 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**

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

A phonometer is often equipped with a filter (octave, one-third octave) which can determine the noise amplitude spectrums 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):

\[ L = 10 \log \left( 10^{\frac{L_{21}}{10}} + 10^{\frac{L_{22}}{10}} + \ldots + 10^{\frac{L_{2n}}{10}} \right) \]

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

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,
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 (JUŠ 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 zašti ne 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.
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ШУМ, ИСТОЧНИКИ ШУМА И ИХ ВОЗДЕЙСТВИЕ НА КАЧЕСТВО РАБОЧЕЙ И ОКРУЖАЮЩЕЙ СРЕДЫ

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ОБЛАСТЬ: акустика, шум, защита 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

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ОБЛАСТ: акустика, бук, защита животне средине
ВРСТА ЧЛАНКА: стручни чланак
ЈЕЗИК ЧЛАНКА: енглески

Сажетак:
Убрзаним технологским развоjem савременог човечанства буке је постала неизбежан део свакодневног живота. Основни извори буке су машине, фабрике, саобраћај, као и звуци из суседства. Као мешавина звукова различитих карактеристика буке може бити трајна, искренина и ударна, променљивих 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 букој и делатности на плану заштите од ње.
Кључне речи: акустика, бука.