COMPARATIVE ANALYSIS BETWEEN THE PEROSONAL NOISE EXPOSURE LEVEL OF INDUSTRY WORKERS AND SCHOOL TEACHERS

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Abstract: The noise is defined as unwanted sound and can be a reason for many different adverse health effects. Occupational exposure to high noise level is a problem almost in all industries but also in the services sector and the exposure level vary depending on the noise sources. According to the investigation done so far, this problem often appears in the industries like transportation, mining, production, and construction. Excessive exposure to high noise levels lead to decreased efficiency, risks of incidents at work, professional diseases and in some cases to hearing loss. The risk of negative health effect depends on the exposure level and the frequency of noise exposure. The negative effects of high noise exposure level often include decreased concentration, risk of accidents, stress, and cardiovascular diseases. In some cases, it may have influence not only on the professional but also on the social life by limited opportunities for employment or promotions. In this paper a comparison between noise exposure level of industry workers and schoolteachers will be presented. To determine the noise exposure level of the schoolteachers and industry workers a noise exposure measurement in real conditions was performed. The A-weighted equivalent-continuous sound pressure levels (LAeq) of each industry worker and schoolteacher were recorded using noise dosimeters during performing the regular daily tasks. The measurements were repeated in 3 series. In total three schoolteachers and three industry workers were involved in the study. Using software tool, the data for the personal noise exposure levels were collected and normalized 8-hours exposure was determinate. The resalts between two different areas of exposure showed that both, schoolteachers, and industry workers are exposed almost to the same noise level. If the machine and equipment are significant noise sources in the industry than the noise of the students in the classrooms during classes, corridors during breaks, sport hall causes the same noise level as in an industrial plant. The results of this research show that there can be a risk factor of adverse effects to the occupational health and safety of both workplaces, the industry, and schools.
Keywords: industry, school, noise exposure

1. INTRODUCTION

Exposure to high noise level is a cause of hearing problems. As much as high is the noise intensity, the risk of damage to the sensory hear cells of the inner ear is increasing and this can lead to permanent hearing problem (Mikulski, Radosz, 2011). The results from the published literature regarding personal noise exposure show that the high exposure level can lead to tinnitus (Nelson et al., 2005).

The noise in the industry mainly is generated by the machines and tooling used in the process of production and maintenance. The worker operating on a specific machine is exposed to noise of the machine, but this affects also the workers operating in the same area or within the whole plant. The various types of equipment used by the industry sector results in high noise level due to many factors as: the type of the used equipment, operational life, and the operational speed of the machines. A large percentage of the labor force employed in the industry is exposed to noise. Improving workplace conditions will have positive effect on humans and their productivity.

The noise generated in the schools is an important factor that has impact on both the schoolteachers and the students, affects the hearing organs and causes problems to the speech reception and comprehension (Bradley, Sato, 2008; Kreisman et al., 2010).

In some cases, it may have influence not only on the professional but also on the social life by limited opportunities for employment or promotions (Alberti, 1998).

The purpose of this paper is to conduct a measurement in an industry sector and schools on the personal noise exposure level and compare the obtained results. The aim is to understand if the results are within the limit values and if there is a risk of adverse effects to the workforce at these two different sectors, industry, and education.

2. MATERIALS AND METHODS

The goal of this study is performing comparison on the personal noise exposure level in an industrial plant and schools. For this purpose, first noise level measurements were performed. The international standard MKS EN ISO 9612: 2010 Acoustics - Determination of noise exposure in the working environment gives the basis of performing noise measurements using the right approach and strategy. The A-weighted equivalent-continuous sound pressure level (LAeq) was obtained during the measurements conducted with 3 schoolteachers and 3 workers in an industrial plant. The unit of measuring the noise level is dB.

For successful measurement an equipment that complies with IEC 61762-1: 2002 instrument class 1 was used (Nesevski et al, 2022). The noise levels were captured with dosimeters and the results were downloaded with a software tool for noise data management. Dosimeters are small device that contain a microphone to capture the level of personal noise exposure. The dosimeters should be placed near the most exposed ear, usually on the shoulder, to capture the real exposure level.

CASELLA Dbadge2 is the manufacturer of the dosimeters used for the measurements of personal noise exposure. The software tool for noise data management used in the research is Noise safe. The participants in the research were trained on how to use the dosimeters during the working day, and what is the purpose of this measurement equipment.

When the measurements were completed an equation according to the ISO 9612-2009 standard was used for calculating the normalized 8-hours exposure (Lex,8 h) level:

$L_{EX,\,8h} = L_{Aeq,\,Te} + 10\log_{10} T_e/T_0$ dB (A),

where:

T_e is daily duration of the workforce exposure,

T_0 is 8 hours reference time, and

$L_{Aeq,\,Te}$ is the equivalent noise level during T_e.

The exposure levels obtained with the research for both schools and industry were compared to determinate the difference of the noise exposure due to the different noise sources in these sectors. The results are presented in following section.

3. RESULTS AND DISCUSSION

Once the measurements were completed, a summary of the results was provided. The Occupational Health and Safety Regulations in North Macedonia outline exposure limit values and action values in relation to the daily noise exposure levels presented in the table below. The peak values of the sound pressure are presented in Table 1 as well. The manufacturing companies must adopt the recommendations and maintain noise exposure level under the limit values in accordance with the Rulebook.

Table 1. Occupational Health and Safety Regulations in North Macedonia

Exposure level	**$L_{EX,8h}$ (dB)**	**$L_{p,\,Cpeak}$ (dB)**	**p_{Cpeak} (Pa)**
Exposure limit values	87	140	200
Upper exposure action values	85	137	140
Lower exposure action values	80	135	112

The results of the schoolteacher's exposure level while performing the usual daily tasks are presented in Table 2. Results in Table 2 clearly indicate that the daily personal noise level exposure in schools is in line with the limit values outlined in the regulations regarding Occupational Health and Safety and exposure to noise in North Macedonia (Hadzi-Nikolova et al, 2013). Considering the fact that the daily 8-hour exposure level have to be maximum 85 dB(A) the exposure levels in table 2 present values near the limit values. The high noise levels in the schools usually are noticed during breaks and sport activities. In these periods of the working day schoolteachers are exposed to noise level above the limit value of 85 dB (Hadzi-Nikolova et al, 2013).

Table 2. Measurements of the personal noise exposure level in the schools

Measurement point	Min [dB(A)]	Max [dB(A)]	Lex,8h [dB(A)]
School MP1	77	85	78.8
School MP2	75	84	78.6
School MP3	74	83	77.5

The data presented in the table strongly recommends immediate adoption of action plan. The high exposure level in the schools requires further investigations on this problem and identifying the sources and periods with the highest impact on the results. If there is no regular monitoring on the exposure level this could lead to serious adverse health effects.

The second round of measurements were performed in an industrial plant. The most significant noise source in the industrial plant are machines and tools used in the production process. In addition, the results obtained for all the departments included in the research will be presented.

Table 3 shows the noise exposure levels in an industrial plant. The measured noise levels do not exceed the limit values presented in the Occupational Health and Safety Regulations in Republic of North Macedonia Anyway, the results indicate that there is a risk of exceeding the limit values. The daily tasks in the industrial plant require exposure to noise generated from the machines and equipment.

Table 3. Measurements of the personal noise exposure level in the industry

Measurement point	Min [dB(A)]	Max [dB(A)]	Lex,8h [dB(A)]
Industry MP1	71	81.3	76.4
Industry MP2	71.9	79.9	74.2
Industry MP3	79.4	83.1	79.6

The percentage of the labour force employed in the industry exposed to noise is very high and according to the literature research, a very huge portion of the industrial plants generate noise that exceeds the limit exposure level, and on average ranges between 70-118 dB. There is much discussion and research how the duration of noise exposure can impact employee performance and perception (Errett et al 2006).

Comparing the results obtained from the measurements for both sectors, industry and education, very similar exposure levels can be noticed. The highest $L_{EX,\ 8h}$ value has been calculated in the industrial plant at measurement point 3. However, in the school constantly high exposure levels can be noticed, almost same at three different measurement points.

Noise can be a serious problem in many workplaces, but whatever the workplace is, there are three key steps that should be followed to prevent the risks due to noise exposure:

1. Detailed risk assessment, identifying the sources and exposed workplaces;
2. Design and implement action plan to prevent or control the risks;
3. Measuring the effectiveness of the action plan.

4. CONCLUSION

Considering the results of the measurements the noise exposure level for both, schoolteachers, and industry workers, is high but still in the limit values. Due to the high exposure level regular control measurements are required as there can be a risk factor for causing adverse effects to the health and safety of the workers.

Health consequences caused by noise exposure at the workplace in an industrial plant or schools can be very serious. The noise has not only health and safety, but socio-economic impact as well. The exposure at high levels will result

in hearing loss, cardiovascular disease, stress, and anxiety, affecting the social life of the teachers and workers in industrial plant.

Implementing hearing conservation programs will mitigate or eliminate the risk for adverse health effects. Performing regular measurements and risk assessment on the personal noise exposure level and tracking the implemented action plans will keep the workplace safe and healthy.

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