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Analysis of Noise in Education Buildings

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ABSTRACT

Main parameters of indoor environmental in terms of noise could influence people health, fettle and ability to work. Therefore proper noise level is strongly important. The research was conducted in a didactic buildings – University of Technology located in Białystok, north-eastern Poland and education buildings the Warsaw University of Life Sciences, Faculty Civil Engineering and Environmental Engineering located in center Poland. Research was devoted to issues related to the noise level in a classrooms of university during the didactic classes. In all rooms of both universities, during working days average noise level was under 40 dB. These values are in accordance with standards. Outside the buildings, the sound level was in the range of 30–35 dB. These values also comply with the guidelines.

Keywords: noise level, sound, indoor environment, education building, university building.

INTRODUCTION

The indoor environment is not only air with its temperature (Li et al., 2019; Rodríguez Vidal et al., 2020) humidity (Kong et al., 2019; Lisik and Cichowicz, 2022) or concentration of carbon dioxide (AlGaithi and Kim, 2021; Fantozzi et al., 2022; Gomez-Carmona et al., 2022) or dust (Akther et al., 2019; Colman Lerner et al., 2018; Tureková et al. 2022). The most frequently analyzed is thermal comfort in various types of rooms (Zhang et al., 2022; Roussel et al., 2022), because it is noticed and precisely defined by most people. The internal environment is also lighting, colors and sound level (Ebenezer et al., 2022; Alam et al., 2020; Gładyszewska-Fiedoruk, 2019).

The noise is loud, confused, or senseless shouting or outcry the noise of the rioters, any sound that is undesired or interferes with one's hearing of something. Noise it causes irritability, fatigue and fatigue of the whole body, especially a hearing (Ayr et al., 2001, 2002). The noise has a negative action on the human condition and the human health. Excessive noise has a negative effect on the human body. People revealed fatigue, difficulty in learning and concentration, impaired orientation, annoyance, increased blood pressure, headaches, dizziness, and in the worst case of temporary or permanent hearing damage, noise causes anxiety, uncertainty, insecurity, children – crying (Collins et al., 2019; Yong Jeon et al., 2011). Most of these symptoms make learning difficult or impossible.

Until 2015 in the USA none study have examined disparate exposures to noise pollution, even though noise impacts children's health and development (Collins et al., 2019). Analyses indicate that children bear the brunt of transportation noise exposures at school, which may unequally impact their academic performance, health, and future potential. To investigate how noise affects children's cognitive processes, laboratory experiments were conducted on children's attention, short-term memory, counting and reading using auditory stimuli such as traffic noise, low-frequency noise and white noise. The noise levels of the sound stimuli ranged from 35 dB(A) to 65 dB(A) to simulate indoor acoustic conditions. It was found that:

- regardless of the type of noise, the noise level had a direct effect on subjective annoyance, not on cognitive performance;
- cognitive performance did not depend on the noise level, but more on the type of noise;
- noise had a greater effect on performing complex cognitive tasks than simple ones (Zhang and Ma, 2022).

The most commonly used measure of noise is the sound level is expressed in dB(A) (Jachimowicz and Gładyszewska-Fiedoruk, 2017). The noise in education buildings in Polish and European standards is 40 dB(A) (PN-87/B-02151/02, PN-B-02151-4:2015-06). Currently, the results of measurements of the internal environment in a teaching room with mechanical ventilation are presented. The research focused on noise measurements, because there is an additional noise source in rooms with mechanical ventilation (Jachimowicz and Gładyszewska-Fiedoruk, 2017).

METHODOLOGY

The research was conducted in a few education buildings the University of Technology, of Faculty Civil Engineering and Environmental Engineering located in north-eastern Poland and education buildings the Warsaw University of Life Sciences, Faculty Civil Engineering and Environmental Engineering located in center Poland and included tests of noise level.

Measurements were made in April, in Poland the average outside air temperature is 8°C. Analyzed buildings has a central hydraulic heating system. The education buildings of the University of Technology is located in city Bialystok. It is inhabited by nearly 300,000 people. The outside air is clean (Bogdan and Chludzinska, 2010). Buildings the Bialystok University of Technology are located on the campus with one part adjoining the city park, which separates them from communication routes. Thus, it reduces the noise level in teaching rooms. The education buildings of the Warsaw University of Life Sciences is located in city Warsaw. It is inhabited by nearly 1,800,000 people. The outside air is not clean, but also not very polluted (Podawca and Karpiński, 2021). The buildings of the Warsaw University of Life Sciences occupy a large campus. There is a lot of greenery here, which affects the sound level. Both cities are down in the temperate zone. Unfortunately, no classrooms with the same windows were found (the same type of windows). This seems to be crucial in comparative measurements, therefore the results of measurements in these two locations will be presented independently. The permissible noise level outside the building is specified in the Regulation of the Minister of the Environment of June 14, 2007 (Regulation of the Minister of the Environment, 2007). The highest permissible noise level is in the case of:

- protection zone A (spa) and hospital areas outside the city – 45 decibels during the day and 40 at night;
- areas of single-family housing development, areas of hospitals in cities, areas of nursing homes and development areas associated with temporary or permanent stay of children and youth – 50 decibels during the day and 40 decibels at night;
- multi-family housing areas, collective residence areas, homestead development areas, residential and service areas and recreational and leisure areas – 55 decibels during the day and 45 decibels at night;
- areas in the downtown area of cities with more than 100,000 inhabitants – 55 decibels during the day and 45 decibels at night.

The Regulation of the Minister of the Environment of 14 June 2007 does not specify the sound intensity at teaching facilities. It seems that the sound level should be the same as for built-up areas associated with temporary or permanent residence of children and youth – 50 decibels during the day and 40 decibels at night. Analyzed (exemplary) object present in Figure 1 – building (A) and classroom (B) in the Bialystok University of Technology, Figure 2 – building (A) and classroom (B) in the Warsaw University of Life Sciences. The research conducted in the classrooms was recorded along with the course of the classes. Classes are usually 45 minutes long. In analyzed classrooms during measurements there were 20 persons. The type of ventilation in the analyzed classrooms while classes were in progress was mechanical ventilation. The research in classrooms were conducted twice on the same group of students. Series 1 – students unfamiliar with measurements

Figure 1. Building (a) (web1) and classroom (b) in the Bialystok University of Technology

Figure 2. Building (a) (web2) and classroom (b) in the Warsaw University of Life Sciences

reacted spontaneously to changes in sound level (lectures with laboratory measurements). Series 2 – students did not reacted (test). The measurements were performed using for the measurement of sound (sound pressure) were using measuring instrument Testo 815 0563 8155. For all measurements located 1.0 m above the floor at five room points and then average values were calculated (Recknagel et al., 2008). Baseline values were measured at the beginning of the measurements. In the later stages of the experiment, the obtained values were compared with the initial values. In addition, sound outside the buildings was measured at the beginning and end of the measurements. The precision a measuring instrument Testo 815 0563 8155 presented Table 1 and instrument presented in Figure 3.

RESULTS AND DISCUSSION

In Figures 4 and 5 presented noise level (sound) in Białystok (Fig. 4) and Warsaw (Fig. 5) in classrooms and outside. Sound measurements in classrooms were very difficult, as students at both universities laughed at the noise level spikes that arose during the teacher's oration, adding to the overestimation of the sound value. In addition, it was surprising for the students that when they put their hand in a jacket pocket or turned on the computer, there was an additional sound. The measurement results can be considered representative at the end of the classes. The students got used to the irregularity of the measurement results and no longer reacted. In analyzed classrooms during working days noise level was

Table 1. Description of measuring equipment

Testo 815 0563 8155			
Measuring items	Measuring range	Resolution	Accuracy
Sound	+32 to +130 dB(A)	0.1 dB(A)	±1.0 dB(A)

usually under 40 dB(A) (PN-87/B-02151/02; PN-B-02151-4:2015-06) and it was from 33 dB(A) to 72 dB(A) – at the moment joy of the students (Figs. 4-5). The average acoustic level during the measurements in classrooms was in Białystok, in series 1 – 48 dB(A), in series 2 – 37 dB(A) and in Warsaw in series 1 – 51 dB(A), in series 2 – 38 dB(A). In the graphs (Fig. 4 and Fig. 5) the curves from the sound intensity measurements with enthusiastic students differ very clearly from the sound intensity curves in classrooms without students, in classrooms with calm students and outside the building. The presented research results are similar to the research presented in the literature (Caviola et al., 2021; Balasbaneh et al., 2020) and meet the requirements specified in the standards (PN-87/B-02151/02; PN-B-02151-4:2015-06).

Fig. 3. Measuring instrument Testo 815 0563 8155

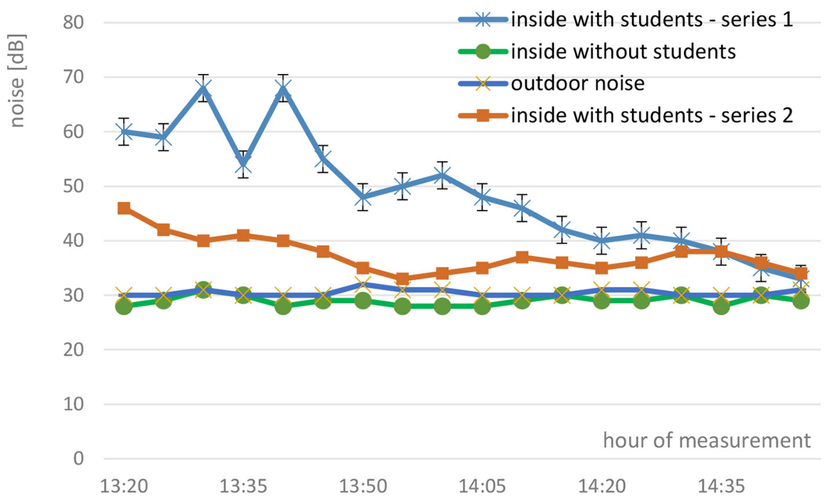

Fig. 4. Noise level in Białystok

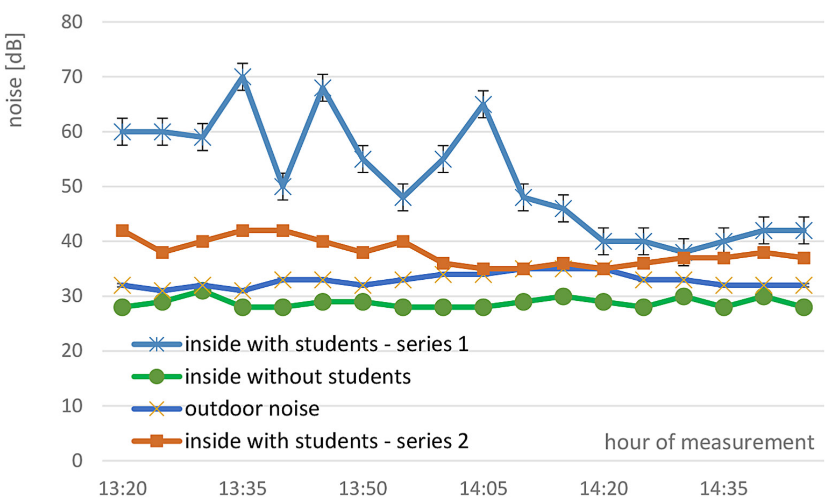

Fig. 5. Noise level in Warsaw

On different days of measurements, the noise varies by a maximum of 0.4% at the same time. The measurement of noise is affected by an error in the range of 0.05% to 8.4% (Teleszewski & Gajewski, 2020 A, B). Initial the noise level (without students) in both researched universities was from 25 dB(A) to 30 dB(A). This acoustic value was influenced by the ventilation and the quality of the windows. The noise level outside the building was from 30 dB(A) to 35 dB(A) (Figs. 4-5) and had an impact on the noise level in the tested rooms. This means that it is quieter inside the classrooms (lower sound level) than outside the building. In Bialystok outside was quieter than Warsaw. Indoor sound levels appear to be less influenced by outside noise than by the quality of windows.

CONCLUSION

The results of measurements and studies allowed to analyze indoor environmental in educational buildings in terms of noise. In the rooms of both universities, the sound level was similar and complied with the applicable standards. Both universities are located in a green area and the noise of the city does not reach them. In Warsaw, the sound level was slightly higher than in Białystok, but the standards were not exceeded. This means that both universities meet the requirements for acoustic comfort. The acoustic environment in both universities is very good for both study and relaxation, as the measured sound level values are below the most stringent guidelines for hospitals. During the tests, no correlation between the sound level in the rooms and the sound level outside the building was noticed in any of the tested rooms, but this issue requires more thorough research.

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