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Investigation of Indoor Environment Quality in Classroom - Case Study

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Abstract

The experimental monitoring of indoor air temperature, relative humidity, and carbon dioxide were carried out for the investigation of real state of the indoor environment in selected classrooms during winter and summer semester. Concurrently subjective evaluation by questionnaire was conducted. The average value of indoor air temperature was 23.1°C, relative humidity 41.15 % and CO_2 concentration 1315.88 ppm in winter semester. The average value of indoor air temperature was 24.8°C, relative humidity 36.28% and CO_2 concentration 1094.62 ppm in summer semester. Results of objective and subjective assessment show that it is important to propose optimization measures for reducing the CO_2concentrations and thermal load in summer period.

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Keywords: Classroom; indoor environment; monitoring; physical factors; chemical factors; subjective perception

Nomenclature

CO_2	carbon dioxide
IAQ	indoor air quality
IEQ	indoor environmental quality

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1. Introduction

People spend up to 90–95% of their time inside buildings, and it is estimated that at least 30% of nonindustrial buildings can be considered to exist as problem buildings, many of them due to indoor air pollution [1].Characterization of indoor air quality in school classrooms is crucial to children's health and performance [2]. Classrooms can be contaminated by various indoor pollutants, such as allergens, particles, volatile organic compounds etc. Indoor air pollution can lead to long-term and short-term health problems for students and staff but also can lead to decreasing productivity [3].Good indoor air quality (IAQ) is important to ensure improved performance and productivity of students and teachers [4]. According to study [5] during the week, pupils were spending more time in schools (up to 87%) of their time indoors, where they were exposed to environmental influences. Since children spend quality time in school trying to learn, it is important to study the effects of their classroom environment on their health and performance [6]. The air inside schools can be more polluted than the air outside [5]. Ventilation of indoor spaces with outdoor air is essential. It is currently used because it is expected to play an important role in reducing the burden of disease related to exposures indoors. According to study [7] the role of ventilation for reducing burden of disease has been confirmed on many subsequent occasions, when insufficient ventilation was found to be associated with increased morbidity and even mortality. Since the 19th Century, the indoor carbon dioxide (CO_2) concentration has been used as an indicator of air quality in buildings and of the effective outdoor air supply rate in occupied rooms[8, 9]. Many studies are focused on measurement of CO_2 concentrations in the school buildings. Study [10] is focused on control of CO_2 in a naturally ventilated classroom in United Kingdom. This study recommended that at least one classroom should have a CO_2 sensor for continuous monitoring and recording. There are several suitable units that could allow real-time monitoring or trend history with reporting. A visual, 'traffic light' type sensor could be used which would alert the teacher to provide more ventilation when 1500 ppm is exceeded. Study [11] presents results of measurements of carbon dioxide concentrations conducted in the school buildings located in two different climates: Białystok (Poland) and Belmez/Córdoba (Spain) where CO_2concentration would exceed maximum value (1000ppm) during the first hour. Another study [12] is focused on indoor environmental quality (IEQ) assessment of classrooms with an optimized demand controlled ventilation system. Italian study [13] presents work aimed at evaluation the effect of ventilation on indoor air quality in Italian classrooms. Study [14] is aimed to measure the indoor air quality in classrooms with special emphasis on particulate matter and carbon dioxide and the impact of cleaning and ventilation. Many studies are focused on IEQ in school buildings. Another Italian study [15] is focused on the evaluation of air permeability and ventilation rate in Italian classrooms. Study [16] examines associations between school building characteristics, IEQ, and health responses using questionnaire data from both school principals and students. In a real environment makes it very difficult to evaluate the effect of a single parameter on human productivity, mostly because many of them are present at the same time and act together on each occupant [17].

This study presents results from monitoring of IEQ in classroom during winter and summer semester.

2. Methodology

The measurements of selected physical and chemical factors as well as subjective assessment by questionnaire were performed in university classrooms during the teaching in winter and summer semester. Classrooms are located in the building of Faculty of Civil Engineering in Kosice, in the campus of Technical University of Kosice. This study is part of a research project focused on indoor environmental quality in buildings for education.

2.1. Objective measurements

Indoor air temperature, relative humidity and CO_2concentrations were measured with multifunctional measuring device TESTO 435-4 with carbon dioxide sensor Testo 0632. The device measures the carbon dioxide concentration in the range from 0 ppm to 10,000 ppm. Its sensitivity is 75 ppm for carbon dioxide and the precision is ±3%. The accuracy for temperature is from 0°C to +50°C and the precision is ±0.5%. The accuracy for relative humidity is from 0% to 100% and the precision is 1.8%. Measuring device was placed in the center of the classroom in the height of 1.1 m above the floor.