

Indoor Carbon Dioxide Air Quality and Thermal Comfort in Primary School Classrooms of Maisan Province, Iraq

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Received: May 16, 2023; Revised: May 24, 2023; Accepted: June 20, 2023

Abstract

The comfort and health of students may be affected by contaminated interior environments. One of the key elements for improving academic performance is ensuring proper ventilation and indoor thermal comfort. This study aimed to assess the effectiveness of ventilation and measure temperature and humidity levels in several primary school classrooms in southern Iraq's Maisan Province. Utilizing a high-precision sensor, the study was conducted in 26 schools (22 public and 4 private) dispersed throughout the province, where thermal conditions and carbon dioxide (CO₂) concentrations were tracked for seven months as an alternative to evaluate ventilation efficiency by Smart air monitoring device. According to the results of CO₂ concentration were around 516 - 3,477 ppm, most classrooms had high CO₂ levels owing to poor ventilation, exceeding the ASHRAE standard of 62.1. During several monthly readings, the temperature was around 15 - 32.3 °C and relative humidity levels were 18.9 - 79.4%, exceeding the ASHRAE standard 55%. This can be ascribed to the considerable number of pupils occupying the space in the room and the effect of classroom and school building characteristics on indoor air quality. As a result, practical, straightforward steps are required to improve ventilation efficiency.

Keywords: Carbon dioxide; Children; Classrooms; Iraq; Schools; Ventilation

1. Introduction

Schools are considered one of the most important types of internal environment because of the impact of their internal conditions on the health and comfort of their occupants (Haddad *et al.*, 2021). Children spend more time at school than in any other place but their home (Bluyssen *et al.*, 2018) in crowded indoor environments such as classrooms, healthy ventilation is an essential strategy for improving indoor air quality (Vassella *et al.*, 2021). Globally, studies have shown that the quality of ventilation in buildings can be assessed by measuring indoor carbon dioxide levels. Indoor CO₂ levels that exceed international standards indicate inefficient ventilation and the possible accumulation of other pollutants that may have significant health impacts on building occupants (Lazovic *et al.*, 2016; Vilcekova *et al.*, 2017; Deng & Lau, 2019; Alshrefy *et al.*, 2020).

High carbon dioxide concentrations can lead to headaches, drowsiness, and the possibility of asthma, dry cough, and wheezing in children. Inadequate school ventilation is associated with higher rates of student absenteeism and lower educational performance (Cai *et al.*, 2021; Choe *et al.*, 2022).

Thermal comfort improves the indoor air quality (Kumar *et al.*, 2016). Inappropriate classroom temperatures are common in many countries (Wargoeki *et al.*, 2007). The degree of thermal comfort varies from person to person and is related to metabolic rate, clothing insulation, indoor air velocity, and relative humidity (Majewski *et al.*, 2020). Maintaining indoor humidity at appropriate levels is critical for ensuring satisfactory indoor environments (Liu *et al.*, 2023). It has been shown that heat discomfort caused by high temperatures in the classroom has