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AIR QUALITY MEASUREMENTS IN THE CLASSROOM, DURING THE COVID-19 PANDEMIC

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Abstract

This study investigates indoor air quality in a naturally ventilated school classroomlocated in a university from Romania, with a focus on the following parameters: particular matter ($PM_{2.5}$ and PM_{10}), carbon dioxide(CO_2),and air humidity. The purpose was to examine the effects oftwo separateseminars on indoor air quality and then compare the results with existing standards.CO_2 was the only parameter that exceeded the recommended rates after two indoor activities, held in the presence of eighty students that wore protection masks, given the regulations during Covid-19 pandemic.

Keywords:indoor air quality, air pollutants, school, students, health.

Introduction

Air is the fastest supporting environmental factor for transporting pollutants into the environment. Air pollution has numerous adverse effects with significant impact on human health and can cause damage to flora and fauna in general.

Recent studies show that in today’s technology society, people spend 90% of their time in closed spaces (home, office, means of transport, etc.). Therefore, it appears the need for air quality control in enclosed spaces.Poor indoor air quality can be particularly harmful to vulnerable groups such as children, the elderly and those with cardiovascular and chronic diseases such as asthma.

To ensure optimum indoor air quality, all relevant climatic parameters must be monitored. Parameters that have the greatest impact on indoor air quality are air temperature, humidity, CO_2 content, but also particulate matter $PM_{2.5}$ and PM_{10}.

People have a decisive impact on indoor air quality through substances released into the environment, such as carbon dioxide (CO_2). By measuring the carbon dioxide concentration, the air quality in these rooms can be subjectively and reliably evaluated. As a general rule, high concentrations of carbon dioxide have a negative impact on people's ability to concentrate. Excessive concentration of CO_2 causes fatigue and difficulty concentrating and can cause illness. In practice, the concentration of CO_2 at work should not exceed the level of 1000 ppm (according to Pettenkofer). In order to achieve adequate indoor air quality, an air exchange rate of at least 50 m^3/h for each room user must be observed.

The adverse effects on health of particulate matter (PM) are especially well documented. There is no evidence of a safe level of exposure or a threshold below which no adverse healtheffects occur. More than 80% of the population in the WHO European Region (including theEuropean Union, EU) lives in cities with levels of PM exceeding WHO Air Quality Guidelines. Only a slightly decreasing trend in average concentrations has been observed in countries in the EU over the last decade. Pollution from PM creates a substantial burden of disease, reducing life expectancy by almost 9 months on average in Europe. Since even at relatively low concentrations the burden of air pollution on health is significant, effective management of air quality that aims to achieve WHO Air Quality Guidelines levels is necessary to reduce health risks to a minimum (World Health Organization. Regional Office for Europe, 2021).

Since 2005, the evidence for a biological mechanism, derived from both epidemiological andtoxicological studies, has also increased and indicates that exposure to $PM_{2.5}$ is associatedwith systemic inflammation, oxidative stress and alteration of the electrical processes of theheart(Brook et al., 2010). Long-term exposure has also been associated with preclinical markers of atherosclerosis (Künzli et al., 2005) and with progression (Künzli et al., 2010) of this pathology of high relevance to cardiovascular diseases.A more complete review of the likely biological mechanisms, strongly supportive of a causal association between $PM_{2.5}$ and cardiovascular disease and mortality, is provided by (Brook et al., 2010).

Research Methodology

The classroom chosen for this study was not used on the day of the experimentand was naturally ventilated five minutes before access. Before entering the classroom, students (n. 40 for each seminar) were given protective masks, according to the regulation in force during the COVID-19 pandemic, and trained to sit in their usual place. Measurements of thefirst seminar(S1) were carried out from 12:14 p.m. to 13:41 p.m. and the second seminar (S2) measurements from 14:05 p.m. to 15:30 p.m. in one day. The classroom was ventilated for five minutes, before the beginning of each seminar. During both seminars, all windows were closed.The results were compared with the recom*m*ended values from the National Agency for Environmental Protection and the evidence available in the literature.

Procedures

The measuring equipment was placed on a desk about 1 m above the floor level in the centre of the classroom. The indoor $PM_{2.5}$and PM_{10} concentrations, the temperature and the CO_2 were measured by the Nanovator 69 air quality monitor which allowed real-time monitoring of the pollutants, with accurate results. The CO_2 level is detected with an infrared sensor and the PM level is detected with a laser sensor.

Monitor calibration was performed outside in on mode. According to the manufacturer's specifications, after 5 minutes the left button was pressed and held for 3 seconds until the audible signal was heard so that the calibration was complete.

Measurements

$PM_{2.5}$ and PM_{10}

Table 1. Concentration range for particulate matter $PM_{2.5}$ and PM_{10}according to the National Agency for Environmental Protection

PM2.5 (ug/m3)	PM10 (ug/m3)	Specific index	
0-10	0-20	1	Good
10-20	20-40	2	Acceptable

20-25	40-50	3	Moderate
25-50	50-100	4	Bad
50-75	100-150	5	Very bad
75-800	150-1200	6	Extremely bad

The specific air quality index, short for "specific index" (table 1), is a system for coding the concentrations recorded for each of the following monitored pollutants. The general index is established for each of the automatic stations within the National Air Quality Monitoring Network as the highest of the specific indices corresponding to the pollutants monitored. The general index and specific indices are represented by integers between 1 and 6, each number corresponding to a color.

CO_2

Max Joseph von Pettenkofer (1818-1901), a German hygienist, was the first to measure the concentration of CO_2 in the air (Paunović et al., 2005). According to his studies it was established that 1500 ppm is the maximum allowable limit for the concentration of CO_2 in indoor air. Prolonged exposure to high concentrations of CO_2 can diminish concentration, affect metabolism, and can be toxic to the heart (Nazaroff, 2012; Permentier et al., 2017).

Air humidity

Low relative humidity can increase the most common mucosal-related symptoms, such as dry and tired eyes, which can affect work performance(Seppänen& Fisk, 2006). People exposed to relative humidity between 30 and 60% are more likely to reduce work fatigue caused by dry eye and airway mucous than those exposed to a drier environment for extended periods and therefore the recommended indoor relative humidity is between50 and 70% (Wargocki et al., 2010).

Results

Table 2. Readings of all experimental parameters in both seminars

Parameters	S1			S2		
	T1 (12:14 PM)	T2 (13:34 PM)	T3 (13:41 PM)	T1 (14:05 PM)	T2 (15:25 PM)	T3 (15:30 PM)
$PM_{2.5}$ (mg/m^3)	19	16	15	12	9	11
PM_{10} (mg/m^3)	24	21	19	15	11	14
CO_2 (ppm)	852	2312	1555	544	2070	2100
HUM (%)	59	61	53	49	60	60

T1= first measurement at the beggining of the seminar

T2= second measurement at the end of the seminar

T3= last measurement after 5 minutes of natural ventilation

Table2 shows that the average concentrations of $PM_{2.5}$ and PM10in the occupied classroom range from 9 µg/m^3 to 19 µg/m^3 and 11µg/m^3 to 24µg/m^3, respectively.

The concentration of CO_2 in indoor air reached its highest value at the end of the first seminar (2312 ppm) and its lowest value (544 ppm) after five minutes of natural ventilation, after students left the first seminar. Humidity levels range between 49 to 60%.

Discussion

The performance of $PM_{2.5}$ and $PM_{10}$of the selected classroom meet the requirements of the indoor air quality standards. These values stand for „good" and „acceptable" specific indexes proposed by the WHO's and Romania's standards.

Classrooms are usually crowded, overheated, and poorly ventilated.Therefore, carbon dioxide rates can increase causing several problems when its concentrations rise above the value 1500 ppmor even at lower levels (1000 ppm). Some researchers state that the number of students is directly and significantly associated with higher concentrations of carbon dioxide (CO_2) in the classroom and can increaseup to +25%(Coley & Beisteiner, 2002).

The mean levels of carbon dioxide all exceeded the WHO requirements (600 ppm) and alsothe recommended standard of 1000-1500 ppm when the classroom was occupied.This was mainly attributed to the closing of windows and doors to keep the inside environment at reasonable levels of thermal comfort. Also, we need to consider the size of the classroom (70 m^2) and the number of students who attended the seminars (80 altogether).

Nevertheles, we observed a rapid decrease in the concentration of CO_2 in the indoor airafter natural ventilation that lasted five minutes after the first seminar. Furthermore, at the beginning of the second seminar, after around 25 minutes, CO_2 reached an acceptable value of 544 ppm, which means that breaks between indoor activities need to be long enough for the air quality to be restored.

Conclusion

Based on the available evidence and consistently with the WHO and European Commission Guidelines for Indoor Air Quality the following recommendations can be useful to cope with issues related to COVID-19 pandemic:

- Classroom overcrowding should be avoided.
- Propper ventilation of the classrooms before and after courses.
- Implementation of protocols and measures to monitor IAQ.
- School buildings should be surrounded by green spaces and trees wherever possible (Dadvand et al., 2015).
- Monitoring the temperature and humidity rate (optimal rates between 45%-55%) with thermostats. Furthermore, the use of dehumidifiers should also be considered if necessary.
- If schools are situated nearby traffic-intensive roads, ports, railroads, airports or industrial areas and farms, it should be considered the use of high performance filter systems for air conditioners together with air purifiers that neutralize fine dust (McCarthy et al., 2013).

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