EVALUATION AND ASSURANCE OF EDUCATIONAL HABITAT HEALTH BY MONITORING INORGANIC POLLUTANTS CONCENTRATIONS

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ABSTRACT

The educational habitat is one of the critical social infrastructures in a society, the first place for social activity and the most important indoor environment for children, besides their home. The increasing interest in indoor environmental quality of the educational habitat has been emphasized by the rising incidence of respiratory infections and allergic diseases among children, who spend a substantial part of their lives on the school premises. Scientific knowledge on the monitoring of indoor pollutants for their quantitative and qualitative identification, on the sources identification of them, and associated health risks among children are essential to the evaluation and assurance of the educational habitat health, through the adequacy and cost effectiveness of the measures for mitigating the indoor environment issues.

Keywords: *educational habitat; health; monitoring; inorganic pollutants*

REZUMAT

Habitatul educațional este una dintre infrastructurile sociale critice într-o societate, primul loc pentru activitatea socială și cel mai important mediu interior pentru copii, pe lângă locuință. Interesul crescând manifestat pentru calitatea mediului interior specific habitatului educațional a fost susținut de creșterea incidenței infecțiilor respiratorii și a bolilor alergice la copii, care își petrec o parte substanțială din viața lor în spațiile școlare. Cunoștințele științifice privind monitorizarea poluanților din mediul interior pentru identificarea lor cantitativă și calitativă, identificarea surselor și a riscurilor asociate pentru sănătate în rândul copiilor sunt esențiale pentru evaluarea și asigurarea sănătății habitatelor educaționale, prin adecvarea și rentabilitatea măsurilor pentru atenuarea problemelor privind calitatea aerului interior.

Cuvinte cheie: *habitat educațional; sănătate; monitorizare; poluanți anorganici*

1. INTRODUCTION

The educational habitat is one of the critical social infrastructures in a society, the first place for social activity and the most important indoor environment for children besides their home (Chithra and Shiva Nagendra, 2018; Hou et al., 2015). The exposure to air pollutants threatens the health of people of all ages, from any part of the world, both in urban and rural areas, but has a devastating impact on the most vulnerable among us - children (WHO, 2018). The increasing interest in indoor environmental quality of the educational habitat has been emphasized by the rising incidence of respiratory infections and allergic diseases among children, who spend a substantial part of their lives in the school premises (Chatzidiakou et al., 2012; Hou et al., 2015; Kalimeri et al., 2016; Majd et al., 2019). Particularly important for allergies, it is important to avoid the exposure to an allergen,

as when the sensitization to a compound occur, later in life this could enhance the sensibility of the exposed person by cross-sensitization, a phenomenon in which sensitization to a stimulus is generalized to a related stimulus, resulting in the amplification of a particular response to both the original stimulus and the related stimulus. Poor air quality in classrooms can increase the absenteeism due to short and long-term health problems for children and teachers (Kalimeri et al., 2016; Chithra and Shiva Nagendra, 2018; Johnson et al., 2018) problems caused by the exposure to various types of pollutants (Majd et al., 2019), organic or inorganic, or caused by adverse chemical reactions in the educational environment.

The more common manifestation of poor IAQ is by nonspecific symptoms such as headache, eye or nasal irritation, skin rash or itch, malaise, or difficulty concentrating (Johnson et al., 2018). The indoor air pollutants have been associated with several negative health effects such as increased risk for cardiovascular diseases and cardiopulmonary mortality and is a cause of asthma (Cleary et al., 2017).

In this context, the present study aimed to investigate on the indoor air pollutants to which children are exposed by identifying and monitoring of the main inorganic pollutants, i.e. carbon monoxide (CO), nitric oxide (NO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2) and ozone (O_3) in various spaces from educational habitat, located in urban area of Bucharest, Romania.

2. MATERIALS AND METHODS

The analyzed school spaces consisted of two kindergartens (KA, KB), three gymnasium schools (GSA, GSB, GSC) and a high school (HS), with two monitored spaces in each building, naturally ventilated. In order to provide comparable data, the sampling of the inorganic pollutants was realized for all spaces maintaining the same height for sensors positioning, duration and sampling interval. The principle of the monitoring method consists in the qualitative and quantitative identification of the inorganic compounds and the real-time recording of their concentrations by the electrochemical method for 1 hour at 1 minute sampling interval.

The equipment used for the pollutants monitoring in the experimental study and their measuring principles are presented in Table 1. The Gray Wolf equipment has been used in previous studies (Doll et al., 2016; Johnson et al., 2018; Majd et al., 2019).

Table 1. *Information about monitored pollutants, used equipment and their measuring principles*

Pollutant	Equipment	Measuring principle	Range	Accuracy
Carbon monoxide (CO)	Gray Wolf Direct Sense IQ-610	Electrochemical	0 to 500ppm	± 2 ppm, < 50 ppm ± 3% rdg, >50 ppm
Nitric oxide (NO)	Gray Wolf Direct Sense TG-501	Electrochemical	0.0 – 250.0ppm	0.2ppm
Nitrogen dioxide (NO_2)			0.00 - 30.00ppm	0.02ppm
Sulfur dioxide (SO_2)			0.0 – 30.0ppm	<0.1ppm
Ozone (O_3)			0.00 – 1.00ppm	0.02ppm

3. RESULTS AND DISCUSSIONS

In this monitoring study were recorded the concentrations of five inorganic pollutants, respectively carbon monoxide, nitric monoxide, nitrogen dioxide, sulfur dioxide and ozone. The values obtained are summarized in Tables 2 and 3.

Table 2. *Summary of obtained results in kindergartens*

	Minimum/Average/Maximum/Standard Deviation/Median Values			
	Kindergarten A – Space 1	**Kindergarten A – Space 2**	**Kindergarten B – Space 1**	**Kindergarten B – Space 2**
CO, ppm	0,70/2,56/3,40/0,79/2,60	1,40/2,52/3,50/0,57/2,60	0,60/1,25/1,70/0,38/1,40	1,40/1,62/1,70/0,07/1,60
NO, µg/m^3	74,8/90,9/105,3/6,8/91,4	2,2/9,8/52,8/7,8/7,3	-	0,1/0,3/0,9/0,3/0,2
NO_2, µg/m^3	-	-	-	-
SO_2, µg/m^3	-	-	555,9/1973,1/2608,9/218,4/2006,3	-
O_3, µg/m^3	-	-	-	-

Table 3. *Summary of obtained results in gymnasium and high schools*

Minimum/Average/Maximum/Standard deviation/Median Values							
	Gymnasium School A	**Gymnasium School B – space 1**	**Gymnasium School B – space 2**	**Gymnasium School C – space 1**	**Gymnasium School C – space 2**	**High School – Space 1**	**High School – Space 2**
CO, ppm	1,30/1,60/1,80/ 0,10/1,60	1,10/1,10/1,20/ 0,02/1,10	0,30/0,92/1,30/ 0,26/0,90	2,40/3,37/3,90/ 0,44/3,40	1,50/1,59/1,7/ 0,04/1,60	0,90/1,27/1,50/ 0,12/1,30	1,50/1,78/2,2/0,13/1,80
NO, µg/m^3	0,1/1,1/3,7/ 0,8/0,9	0,1/0,2/0,4/ 0,1/0,2	0,1/3,0/10,5/ 2,4/2,6	-	0,1/0,3/0,7/ 0,2/0,3	-	-
NO_2, µg/m^3	-	-	-	-	-	-	-
SO_2, µg/m^3	-	-	0,3/2103,7/ 2378,1/442,4/ 2270,3	-	-	-	-
O_3, µg/m^3	-	-	-	0,04/0,1/0,09/ 0,02/0,06	0,0/0,2/0,6/ 0,2/0,2	0,02/0,13/0,93/ 0,25/0,06	-

Carbon monoxide is extremely toxic; it can combine with hemoglobin in the blood, thus reducing the amount of oxygen in the body. Symptoms characteristic of carbon monoxide exposure are associated with headache, fatigue, nausea, breathing accelerating, chest pain. Epidemiological studies confirmed that exposure to 0.3-2 ppm of CO is associated with asthma (Cleary et al., 2017). The degree of occurrence of these symptoms depends on the state of health and sensitivity of each individual so that the specific response to a given concentration will vary between the occupants. The values recorded in the spaces for kindergartens/gymnasium and high school, between 0.92 ppm and 3.37 ppm, represented in fig.1, are within the permissible limit set by Occupational Safety & Health Administration (OSHA) - PEL (50 ppm) for this compound. However, these values are higher than those recorded in a previous study conducted in three office spaces - 0.9 ppm – from urban area of Bucharest (Vasile et al., 2017).

Nitrogen oxides in indoor air are caused by indoor or outdoor sources. Internal sources of nitrogen oxides include: gas heaters (stoves, furnaces), non-ventilated gas heaters, wood-burning stoves and cigarette smoke.

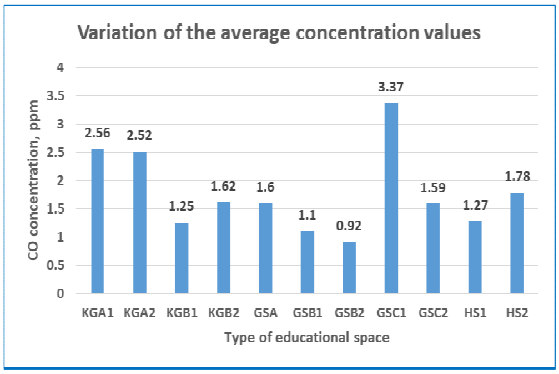

Fig. 1. The variation of the average concentration value of CO in analyzed spaces

Nitrogen dioxide was not present in the indoor air of the analyzed areas. Significant concentrations of nitrogen monoxide (90.9 µg/m^3 and 9.8 µg/m^3), presented in Fig. 2, were recorded in the kindergartens spaces. The comparison with the recorded values for the office spaces – 70.2 µg/m^3 - (Vasile et al., 2017) also highlighted the fact that there are higher values in the spaces of the educational habitat.

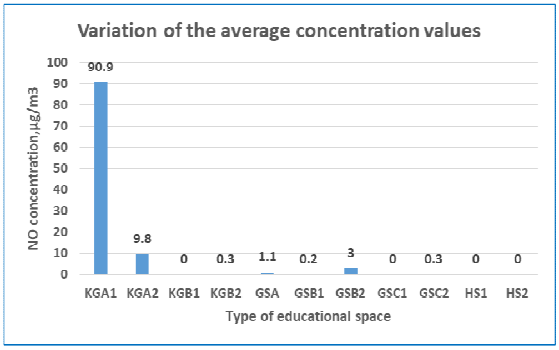

Fig. 2. The variation of the average concentration value of NO in analyzed spaces

The primary psychological response to exposure to SO_2 is bronchial constriction leading to decreased pulmonary function. On the other hand, it was observed that at concentrations of 5 ppm (13150 µg/m^3), antibody production decreases significantly (Brauer et al., 2002). In this case, the concentrations of sulphur dioxide recorded in the premises of the educational spaces, represented in Fig. 3, are below the value recorded in office spaces (2728,5 µg/m^3).

What needs to be emphasized is that these values have been recorded without identifying a clear emission source of this compound as opposed to the office space where the source was located.

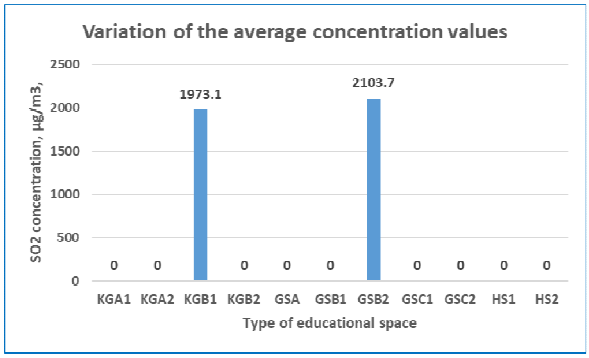

Fig. 3 The average concentration of sulphur dioxide present in indoor air of analyzed spaces

With regard to ozone, it may exist in the ambient air as traces (typically 10 to 100 ppb), the major component being nitrogen (78.084%) followed by oxygen (20.947%). Ozone is a product resulting from a photochemical reaction involving nitrogen dioxide and volatile organic compounds. Even in very small quantities, ozone is potentially harmful to human health (US EPA, 1996). The concentration of ozone in indoor air depends on a number of factors, including the concentration from the outside, the frequency of air shifts, the percentage of indoor emissions, the reactions between ozone and other chemicals in the air. In the indoor air of the analysed areas, ozone concentrations were recorded in only three schools, represented in Fig. 4, and the obtained values were in line with those mentioned in other similar studies (Kalimeri et al., 2016), the rest of the analysed areas being devoid of the presence of this compound.

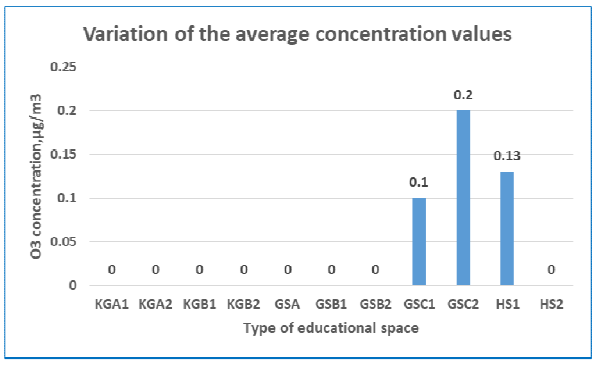

Fig. 4 The concentration of ozone present in indoor air

4. CONCLUSIONS

This study gives an insight to the indoor air quality of the educational habitat represented by two kindergartens, three gymnasium schools and a high school from urban area of Bucharest, Romania, by identification of main inorganic pollutants such as carbon monoxide, nitric oxide, sulfur dioxide and ozone. The monitoring campaign found concentration values of the mentioned pollutants in permissible exposure limits, in line with similar studies conducted internationally, but in several cases, higher than those recorded in our previous studies conducted in office spaces.

Scientific knowledge on the monitoring of indoor pollutants for their quantitative and qualitative identification, on the sources identification of them, and associated health risks among children are essential to the evaluation and assurance of the educational habitat health, through the adequacy and cost effectiveness of the measures for mitigating the indoor environment issues.

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