Improving for indoor air quality selective, simple and quick assessment: case study

Žanna Martinsone, Ilona Pavlovska, Linda Paegle, Aneka Kļaviņa, Kristīne Sproģe and Inese Mārtiņsone

Institute of Occupational Safety and Environmental Health/ Riga Stradiņš University

Contact information:

Phone number, +371 26157562
E-mail: zanna.martinsone@rsu.lv

Case study results show that even if carbon dioxide (CO_2) level in all premises was below 1000 ppm, the particulate matter (PM) number concentration was up to background level in older building, where the ventilation system is poorly adapted to offices because of building historical architecture.

Figure 1. Type of new and old building (pictures are informative).

Introduction

One of the best-known indoor air quality (IAQ) indicators is carbon dioxide (CO_2) because of quick, cheap evaluation, simple interpretation of results and well-structured legislation regarding recommended values. However, IAQ can be poor despite low CO_2 levels in premises because of, e.g., PM's higher concentrations.
The aim of study was evaluating indoor air quality of industrial premises (new building with /also local ventilation) and non-industrial premises (old type centralized/mechanical ventilation).
The complex assessment of PM mass and number concentrations, and CO_2 level in the indoor environment could be essential factors for a deeper understanding of ventilation, work processes and other indoors activities impact to IAQ in general.

Methods

The PM0.1-10 (particulate matter, diameter: 0.1 - 10 microns) number concentration and CO_2 level was used to describe selected company indoor air quality in the different buildings and premises. The first building was historic and more than 100 years old in City Centre (assessed premise - office/archive, windows located to street) and the other building was new, about 30 years old, 1 km far from the City Centre (assessed premises: small metal details sorting and packaging; paper-type material sorting and packaging, windows without opening function). The area of premises is from 29 to 492 m^2. Both buildings are located along the same busy street (Figure 1). All measures were provided during the 1st week of October, 2021.

Figure 1. Buildings location near busy street – Krišjāņa Valdemāra iela.

Total PM was collected by gravimetric method (Mettler Toledo XP9) using NIOSH MAM 0500:1994 method, CO_2 level (good air quality - level <1000 ppm) and microclimates' parameters were measured using TESTO 480 according LVS EN ISO 16000-26:2012 and LVS EN ISO 7726:2004, respectively. PM0.1-10 size, mass and number distribution were analyzed by ELPI+, Dekati (Electrical Low Pressure Impactor – Figure 2).

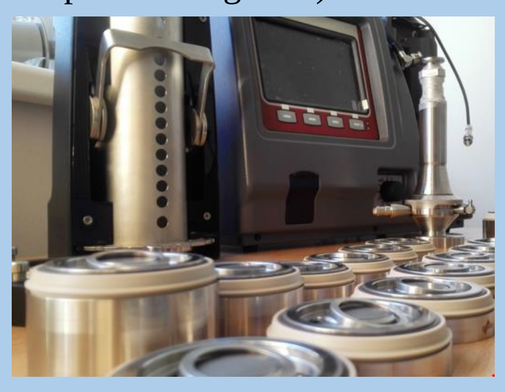

Figure 2. PM0.1-10 size, mass and number distribution detection by ELPI+, Dekati .

Results and Discussion

Results show that even CO_2 level in all premises was below recommended level, the PM number and mass concentration was higher in older building. Air temperature (22 – 23°C) and relative air humidity (32 – 33%) also were detected.
In general, purposive improving of ventilation systems at production premises shows excellent results (close to clean room level (Mendes et al., 2017)) despite PM production during the work process. Furthermore, office/archive premises' results show higher levels of PM even CO_2 level was below recommended value (1000 ppm). Insufficient ventilation leads to higher PM as well as other potential pollutants accumulation in office/archive premises. In addition, the ventilation system is not very well adapted (low air flow motion) because of building historical architecture. Besides industrial premises had lower concentrations of PM despite providing 20 – 90 minutes long potential PM emitting processes (Tables 1-4). Morawska et al. (2017) provides data related to background levels in living rooms, schools and offices (5 – 13×10^3 1/cm^3(or pt/cm^3)), but Finnish study considers "clean room" levels lower than 2600 1/cm^3. In general, the simultaneous monitoring of PM and CO_2 should be provided to improve IAQ evaluation (Mendes, 2017; Luigi&Tambani, 2019).

Table 1. Parameters of chemical pollution in stables.

Table 1. Overview of IAQ parameters' mean values.

Parameters	Metal material premise*	Paper material premise*	Office/archive premise (windows are open)**
Total PM mass conc. (mg/m^3)	0.03 ± 0.01	0.13 ± 0.02	0.15 ± 0.02
PM10 mass conc. (mg/m^3)	0.011	0.06	0.07
PM10 number conc. (1/cm^3)	3.8×10^3	3.8×10^3	15×10^4
PM2.5 mass conc. (mg/m^3)	0.014	0.007	0.013
PM2.5 number conc. (1/cm^3)	3.8×10^3	3.8×10^3	15×10^4
CO_2 conc. (ppm)	586 ± 13	563 ± 12	540 ± 12
Air flow motion (m/s)	0.08	0.09	0.02

Note: * - new building, ** - old building.

Tables 2-4. Data of ELPI+ series mesurements in tested premises – raw data of case study.

Table 2. Old building ELPI data – office premise.

ELPI Stage	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total concentration (stage 1 – 14)	Unit	Median size	Unit
Di – diameter cut-off, µm	*0,01*	*0,021*	*0,04*	*0,07*	*0,12*	*0,20*	*0,31*	*0,48*	*0,76*	*1,25*	*2,02*	*3,02*	*4,45*	*7,31*				
Number conc.	5332	3707	2296	1397	711	233	42	16	0	0	2	1	0	1	**13738**	1/cm^3	0.023	µm
Mass conc.	0	0	0.0001	0.0003	0.0007	0.0010	0.0007	0.0010	0	0	0.0086	0.0003	0	0.0935	**0.1061**	mg/m^3	5.828	µm

Table 3. New building ELPI data – metal material.

ELPI Stage	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total concentration (stage 1 – 14)	Unit	Median size	Unit
Di – diameter cut-off, µm	**0,01**	**0,021**	**0,04**	**0,07**	**0,12**	**0,20**	**0,31**	**0,48**	**0,76**	**1,25**	**2,02**	**3,02**	**4,45**	**7,31**				
Number conc.	1731	1297	152	486	283	140	35	21	0	1	2	0	1	1	**4150**	1/cm^3	0,023	µm
Mass conc.	0	0	0	0.0001	0.0003	0.0006	0.0006	0.0012	0	0.0008	0,0106	0	0.0010	0.0351	**0.0502**	mg/m^3	4.499	µm

Table 4. New building ELPI data – paper material.

ELPI Stage	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total concentration (stage 1 – 14)	Unit	Median size	Unit
Di – diameter cut-off, µm	*0,01*	*0,021*	*0,04*	*0,07*	*0,12*	*0,20*	*0,31*	*0,48*	*0,76*	*1,25*	*2,02*	*3,02*	*4,45*	*7,31*				
Number conc.	**1148**	**797**	**561**	**442**	**191**	**95**	**35**	**16**	**0**	**0**	**2**	**0**	**0**	**1**	**3288**	1/cm^3	0.026	µm
Mass conc.	**0**	**0**	**0**	**0.0001**	**0.0002**	**0.0004**	**0.0006**	**0.0010**	**0**	**0**	**0.0068**	**0**	**0**	**0.0630**	**0.0720**	mg/m^3	5.870	µm

Conclusions

There is necessary a complex approach for better indoor air quality assessment, e.g., additional parameters which could also describe purposeful ventilation installation (taking account usage of certain premises/building), maintenance and efficiency rate in building.
Buildings with historical – architectural value could be poorly suitable to achieve good indoor air quality at premises/workplaces.

References: Morawska L. *et al.* 2017. Airborne particles in the indoor environment of homes, schools, offices and aged care facilities: The main routes of exposure. Environment International: Volume 108, November, Pages 75-83;
Mendes L, Kangas A, Kukko K, *et. al*. 2017. Characterization of Emissions from a Desktop 3D Printer. Jour of Ind Eco, 21:S94-S106. https://doi.org/10.1111/jiec.12569; Schibuola Luigi and Chiara Tambani. 2019. Indoor environmental quality classification of school environments by monitoring PM and CO2 concentration levels. Atmospheric Pollution Research. 11. 10.1016/j.apr.2019.11.006