NATIONAL INDOOR AIR QUALITY ACTION PLAN

SLOVENIA

Version 1

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1. Introduction

National Indoor Air Quality Action plan is based on the vulnerability assessment, SWOT analysis and the field campaign. It is devided into two parts:

1. Specific action plans: for 12 chosen schools, based on the monitoring campaign.
2. General action plans: national strategy for IAQ action plans.

2. Major components of the strategy

The major components of the strategy are the vulnerability assessment, SWOT analysis and the field campaign.

2.1. Vulnerability assessment

2.1.1. Primary schools in Slovenia and in Municipality of Ljubljana

In Slovenia there are 447 primary schools, 375 schools are recognized as healthy schools. The research on the types of school buildings and the state of the school buildings was done among 51 primary schools (50 school buildings) in the Municipality of Ljubljana (these are Healthy and Unhealthy schools). This document provides a general overview about the types of school buildings in the Municipality of Ljubljana: the information on the age of school buildings and the extension of renovation of the buildings.

Number of primary schools in Slovenia and Ljubljana health region[1]

Number of primary schools in Slovenia: **452**

Number of primary schools in Ljubljana health region: **116**

2.1.2. General overview about the types and the state of school buildings in our region: in the Municipality of Ljubljana (MOL)

The partial renovation of buildings was made almost on all 50 school buildings in MOL. Only for two of them (OŠ Livada, built in 1993, and OŠ Dragomelj, built in 2006) no information for building renovation were found.

As main structure material on many older buildings the brick was used (13 buildings), and on newer buildings prevails reinforced concrete.

On the most of school buildings the roof was renovated (39 buildings) and windows were replaced (35 buildings). Some schools decided for plumbing and/or electrical installations (20 schools) and renovation of facade with improved thermal insulation (18 schools).

For the source of energy performance of building the Energy building label ("Energetska izkaznica stavb") was used, the document which exist for app. 30 school buildings in Ljubljana. From this document we took *Initial energy input*, intended for conversion into heat per unit of building area and annual electricity

[1] *Sources: Ministry of Education, Science and Sport. Links: https://krka1.mss.edus.si/registriweb/Seznam1.aspx?Seznam=2010 and https://krka1.mss.edus.si/registriweb/Seznam1.aspx?Seznam=2020*

consumption for building. Based on these documents we prepared two comparison tables with minimal and maximal total energy (in kW/m2a) used for building heating in one year.

2.1.3. The year of School Construction in MOL Ljubljana

Build from 1889-1913 = 8 schools

Build from 1913-1950 = 1 school

Build from 1951-1960 = 8 schools

Build from 1961-1970 = 10 schools

Build from 1971-1980 = 17 schools

Build from 1981-1990 = 4 schools

Build from 1991-2000 = 1 school

Build from 2000-2017 = 1 school

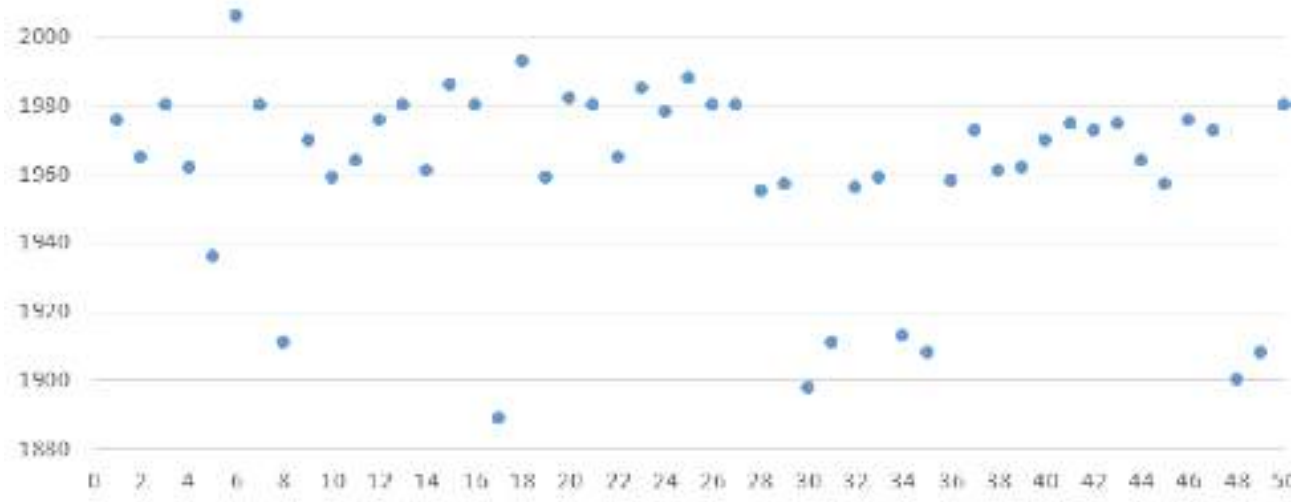


Figure 1: ***The built year of school buildings***

2.1.4. Summary

Due to the reduction of heat loss the following actions are proposed:

- In buildings with high energy consumption the installation of additional thermal insulation of appropriate thickness for the entire building envelope is proposed.
- In buildings with very poorly insulated attic the installation of additional soft thermal insulation is proposed.
- Replacement of windows with low heat losses.
- Installation of ventilation systems with heat recovery for the entire building. The ventilation system should be carried out by several local ventilation devices which are placed in specific locations on each floor of the building.
- The establishment of automatic control system of the heating system by installing thermostatic valves on radiators.
- Replacing older lighting lamps with newer less conception technologies (LED Panels).

- The introduction of organizational actions for regularly switching off lights, switching off electrical and electronic devices that are not in use. These are basic measures to reduce energy consumption in a building, while not causing additional costs.

To conclude there is poor data on indoor air quality in schools in the Municipality of Ljubljana. Moreover, we noticed the lack of laws for designing school buildings in Slovenia. There are also no special guidelines or rules on monitoring indoor air quality in schools.

2.2. SWOT Analysis

The SWOT analysis is based on the review of following topics: education policy, legislations, financial environment, stakeholders' involvement, current state of the appliedd technology, possibility of modern technology development and innovation, dissemination of knowledge and increase of awareness of schools management regarding to ensure the good IAQ, trends in public health that may affect the IAQ and location.

2.2.1. Education policy

In general, there are between 16 (minimum) and 28 (maximum) pupils in one class (if there is a kid with special needs, the maximum number is reduced). Based on the research[2] there are usually 23 kids in one class[3].

The theme indoor air quality is not included in the learning content of basic education system. Moreover, teachers open windows based on their self-assessment (there is no general rule how often they should open windows). The task of headmaster is to draw attention to the poor air quality in classrooms.

Figure 2: Primary school Karl Destovnik Kajuh (Sources: Personal archive).

[2] The interview with headmistress of the Primary school Karl Destovnik Kajuh.

[3] Law on Primary School (Ur. l. RS, no. 81/06 - official consolidated text, 102/07 , 107/10 , 87/11 , 40/12 - ZUJF, 63/13 and 46/16 - ZOFVI-K) , Rules on norms and standards for the implementation of the primary school programme (Ur. l. RS, no. 57/07 , 65/08 , 99/10 , 51/14 and 64/15).

2.2.2. Legislations

There is no independent legal act on the hygienic and technical requirements for primary schools. The individual factors that influence the indoor air quality are considered separately.

Rules on the ventilation and air-conditioning of buildings (Ur. l. RS, no. 42/02, 105/02 in 110/02 – ZGO-1) provides for requirements in terms of temperature, ventilation, and the values of certain pollutants in the indoor air (CO_2, Rn, NH_3, H_2CO, VOC, CO, O_3, PM_{10}). However, there is lack of control over the requirements and knowledge of the requirements by the management of schools.

Communicable Diseases Act (Ur. L. RS, no. 33/06 - UPB) for natural and legal persons and institutions responsible for health commits to the implementation of general measures which, in accordance with special regulations provide an adequate indoor air quality area. The disadvantage of the law is a bad control of the implementation of a general measure and that the relevant air quality is not precisely defined. We propose a precise definition of the term indicator of air quality pollutants and their thresholds.

Regulation on energy efficiency in buildings (Ur. l. RS, no. 52/10) allows the implementation of a hybrid or mechanical ventilation when natural ventilation is not possible. Built-in mechanical or hybrid ventilation systems of buildings must ensure effective heat recovery air.

2.2.3. Financial environment

The Ministry for education usually finance only technology or other equipment, they don't invest in the building. The owner of the school building is usually municipality and it depends on them, how much money they will invest in renovation or reconstruction of the building. There is lack of money for school renovation, usually the renovations are partial (for example roof, façade etc., rarely they add mechanical ventilation in the whole building).

2.2.4. Stakeholders' (including authorities) involvement

In the design, maintenance and use of school building are involved different people, from government to profession and public (Table 1).

GOVERNMENT	PROFESSION	PUBLIC (=users)
AUTHORITIES: - Ministry for education, science and sport - Ministry of health - Ministry of the Environment and Spatial Planning **NATIONAL INSTITUTIONS:** - National institute of Public Health - Slovenian Environment Agency - Universities (Medical faculty, Faculty of health science, Faculty of Civil and Geodetic Engineering, Faculty of Architecture) **MUNICIPALITIES:** - Municipality of Ljubljana	**EMPLOYEES:** - management - teaching staff - technical/ support staff (janitor, cleaners) **DESIGNERS:** - architects - civil and geodetic engineers - mechanical engineers - urban planners - contractors **HEALTH CARE WORKERS** (part of Healthy school iniciative) **PUBLIC HEALTH PROFESIONALS**	**PARENTS** (indirect impact) **PUPILS** (direct impact) **COMMUNITY**

	- public health experts - pediatrics - environmental health engineers	

Cleaners: they have their rules, all cleaning materials are set; when they clean the classroom, they open the window; they need to attend the trainings about cleaning materials, elements.

Designers: they have a big influence in the planning stage when they can educate investors and future users about the importance of indoor air quality.

Parents: they can donate some equipment or furniture; they are the bond between pupils and teachers; they can raise awareness on indoor air quality among their pupils.

Community: In general, the community is bigger and more involved in the school in smaller towns.

Table 1: Different people from government to profession and public involve in the design maintenance and use of school building include in the SWOT analysis.

2.2.5. Current state of the applied technology

Construction materials: the most common building material are concrete and brick.

Boards: usually there are chalkboards.

HVAC systems: always in kitchen (12/12), sometimes in the gym (3/12), offices (3/12), computer room (1/12), school dining room (1/12), school hall (2/12), some classrooms (2/12), the whole building (1/12)[4].

Air conditioning: usually there is AC only in some rooms (e.g. kitchen) and not in all classrooms.

Kitchen usually doesn't have windows, there is usually only mechanical ventilation – consequence is outdour around the school.

Building finishing and furnishing: furniture is bought through tenders, and it doesn't involve hazard materials.

2.2.6. Possibility of modern technology development and innovation

Boards: classical chalk boards should be replaced with modern technology, smart boards.

HVAC systems should be implemented in all room in the school building (not only kitchen, also in the classrooms).

Air conditioning should be implemented in all classrooms (in the whole building).

Kitchen should be located away from other rooms, where pupils spend the most time.

2.2.7. Dissemination of knowledge and increase of awareness of schools' management regarding to ensure the good IAQ

Dissemination and awareness of teachers currently does not take place. So far there are no trainings on indoor air quality by Healthy Schools Network or by any other institution (National institute of Public Health, Ministry of Health).

We suggest dissemination and awareness raising of educational staff and the general public (maybe through a network of Healthy Schools led by National institute of Public Health - the network includes 70% of elementary schools in Slovenia). Good opportunity present document prepared by working group in National institute of Public Health with title Indoor air quality – Guidelines for general public (available on National Institute website:

[4] The results are based on the research among 12 chosen schools in Slovenia.

http://www.nijz.si/sites/www.nijz.si/files/uploaded/notranji_zrak_priporocila_za_prebivalce_zadnja_11012017.pdf).

2.2.8. Trends in public health that may affect the IAQ

In the field of studying the impact of outdoor air pollutants on health there have been carried out several national and worldwide epidemiological studies and international projects. On the other hand, the scientists and experts are realizing that people spend more time indoors where are present numerus harmful substances Field of the exposure to the indoor air pollutants is poorly studied. From the methodological point of view based on the evidence-based public health activities at this suggest several challenges. Challenges are associated with the possibility to obtain data about the type and concentration of pollutants in the indoor air and other risk factors biased on of which we will be able to define health effects. For preparation of these kind of assessments is required active participation of all partners, survey participants and participating organizations / institutions, health and environmental experts, as well as support of local, regional and national authorities is needed (implemented of health impact approach from different point of view).

In Europe in the field of IAQ, so far, have been carried out three major projects (SINPHONIE, TAB and HEIMTSA), whose purpose was to assess the impact of the indoor air quality on the health of children in educational institutions. Research results have been obtained with the purpose of setting up the recommendations and legal bases for improving air quality in indoor environment. In Slovenia, have been, so far carried out two surveys on measuring the carbon dioxide concentration in kindergarten indoor environment. The public health possibility to obtain the information about air quality in the school environment, about the definition of the potential effects on health of children and other important risk factors associated with building, social and physical environment and family history, represents Slovenia's participation in the European Interreg project InAirQ (Transnational Adaption Actions for Integrated Indoor Air Quality Management).

2.2.9. Location

Primary schools are usually placed near the main road, there is usually also car park. Moreover, as Slovenia is agriculture country, fields and farmers are usually near schools (agricultural contamination, e.g. problem of fertilizers).

However, as Slovenia is green country, there is usually a lot of greenery around schools (parks, forest, trees etc.).

2.2.10. Summary SWOT

SWOT analysis tool	Internal analysis	
	STRENGTHS ***What has a positive impact on the school environment regarding IAQ?*** **1.** Teachers open the windows during breaks (lack of measurable data). 2. Use of cleaning products that do not affect the air quality. 3. Central or district heating.	WEAKNESSES ***What has a negative impact on the school environment regarding IAQ?*** 1. Most schools do not have mechanical ventilation systems in classrooms. **2. Air conditioning system only in some parts of school building (usually not in classrooms).** 3. Low awareness of indoor air quality and no dissemination of knowledge

		4. Smoking is not allowed in the building. 5. Mostly no asbestos in the school buildings in Slovenia and mostly not designated as a radon-affected area (school building areas). 6. Cleaning: in the afternoon/evening after school time (deep clean mostly every six months or every year). 7. Legislations: on mechanical ventilation and on school design (Regulations on ventilation and air conditioning of buildings, Regulations on energy efficiency in buildings and Instructions for the construction of primary schools in Slovenia). 8. Brochures on IAQ from National Institute of Public Health. 9. The partial renovation of buildings was made almost on all 50 schools in Municipality of Ljubljana: on the most of school buildings the roof was renovated (39 buildings) and windows were replaced (35 buildings). Some schools decided for plumbing and/or electrical installations (20 schools) and renovation of façade with improved thermal insulation (18 schools). 10. All schools have Energy building label.	among teachers on indoor air quality: no training for teachers on the indoor air quality, thy don't talk about it; IAQ is not included in the learning content of basic education 4. Age of school buildings (majority were built between 1961 – 1980 (44/50 buildings were built before 1980). Mostly only partially restored (for example replacing windows, new ventilation only in 40% of school buildings in the Municipality of Ljubljana) 5. Lack of the proper equipment to check the airflow value in the ventilation ducts / in classrooms. 6. No special guidelines or rules on monitoring indoor air quality in schools. 7. Furnishing: lack of attention to the choice of materials, dominated by price. 8. The lack of law for designing school buildings in Slovenia, with special focus on hygienic and technical requirements for primary school. 9. Using chemicals for floor and desk cleaning. 10. No interdisciplinary collaboration between different actors / stakeholders.
External analysis	OPPORTUNITIES ***What are the opportunities to improve the IAQ in the school environment?*** 1. Recommendations of responsible authorities (eg. National Institute of Public Health, Ministry of health). 2. Guidance and recommendations developed in the frame of projects aimed at improving the indoor air quality in schools. 3. Ongoing process of thermo-modernization of schools. **4.** Common access to the publication of the air quality, results of measurements of the quality of outdoor and indoor air, the impact of air pollution on human health, including children, and methods to reduce the levels of airborne pollution.	**Opportunity-Strength (OS) Strategies** *How can we use Strengths to take advantage of Opportunities?* 1. Dissemination of brochures from National Institute of Public Health between schools. 2. Proper selection of materials and technological processes used in the thermo-modernization of the school. 3. Use of guidance and recommendations developed in projects aimed at improving the indoor air quality in schools. 4. Repair / clean the ventilation ducts during the thermo-modernization process.	**Opportunity-Weakness (OW) Strategies** *How can we overcome Weaknesses by taking advantage of Opportunities?* 1. Regulations on IAQ in schools. 2. Preparation of guidelines for the construction and alteration in cooperation with the competent ministries. 3. Proposal to integrate the topics of air quality in learning content in primary schools. 4. Interdisciplinary meetings / conferences/trainings on healthy building design, healthy environment, potential impact on health.

		5. The possibility of regulating the activity of pupils depending on outdoor air quality. 6. Observation of the incidence of respiratory diseases listed in the literature as associated with air pollution among pupils and undertaking of activities in case of increased morbidity among school children (eg. in selected classes). 7. Need for extended renovation (no mechanical ventilation, only partial renovations so far).	5. Dissemination of knowledge and increase of awareness of school management regarding to ensure the good IAQ. 6. Frequent ventilation of classes (opening of the windows). 7. Conducting of the literature review and disseminate selected publications among school personnel to raise awareness of air quality. 8. Installation of ventilation systems with heat recovery for the entire building.
	THREATS ***What are the threats that can negatively influence the IAQ in the school environment?*** **1.** Surroundings of schools (industry).[5] 2. Heavy traffic (among 12 schools 9 times very heavy, heavy or medium traffic). 3. Infiltration of the large amounts of dust into the inside school environment from the outside. 4. Legal regulations in force – lack of detailed requirements for ensuring proper air parameters in school classes. 5. Lack of funds for necessary repairs. 6. Lack of funds for the installation of modern HVAC systems. 7. Low awareness of indoor air quality among parents participating in the cost of purchase interior and furniture materials.	**Threat-Strength (TS) Strategies** *How can we use Strengths to avoid Threats?* 1. Selection of the right time for cleaning / minor repairs. 2. Frequent cleaning and exact removal of layer of dust. 3. Slow down the traffic at schools (eg. to apply to the local authorities about the installation of speed bumps on the road in the school surrounding). 4. Applying for the additional funds to the local self-government on the basis of the post-inspection recommendations 5. Conducting of the literature review and disseminate selected publications among parents to raise awareness of air quality.	**Threat-Weakness (TW) Strategies** *How can we minimize weaknesses and avoid Threats?* 1. Raising awareness of the indoor air quality among the school staff and parents of pupils. 2. Improvement of the involvement of school staff and parents to take actions towards the improvement of the quality of the indoor environment in schools. 3. Create an authority responsible for ensuring adequate indoor air quality (IAQ) in schools. 4. Agriculture nearby.

Table 2: SWOT analysis

2.3. The field campaign

The field campaign was done in 12 chosen schools.

[5] Please see detail analyses of 12 chosen schools.

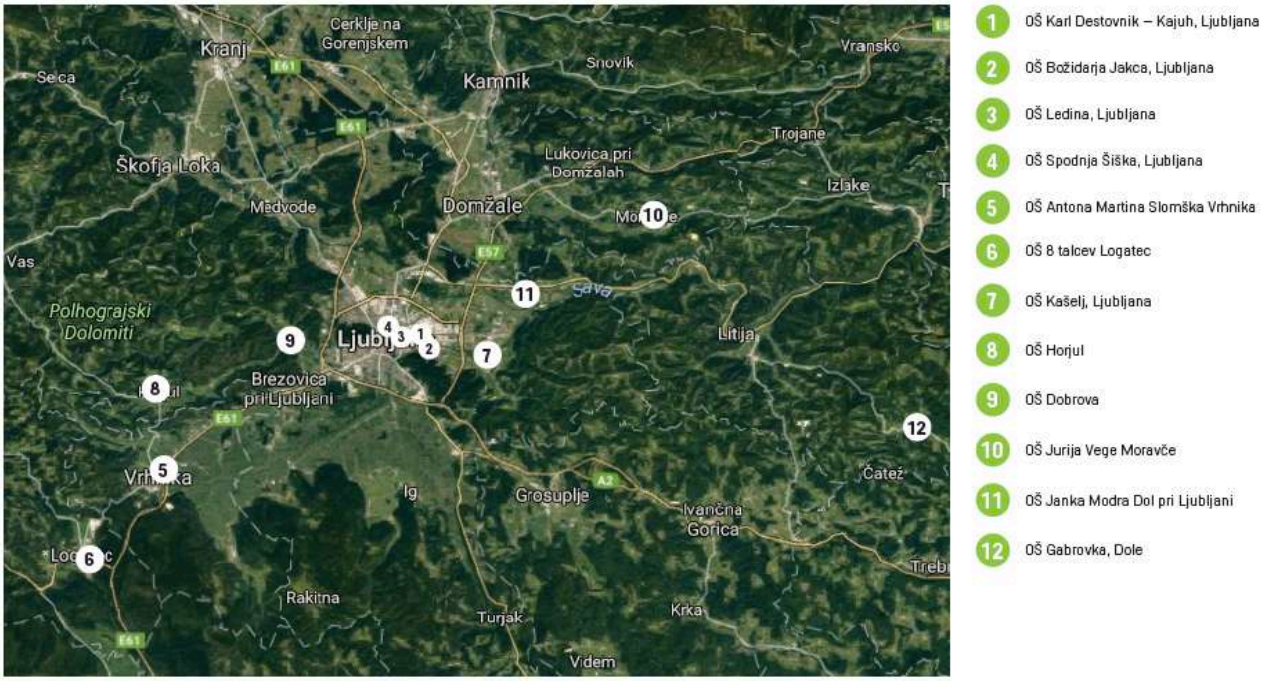


Figure 3: Field campaign in Slovenia

When choosing schools, the following criteria were taken into consideration:

- Location: Rural / urban area (EU nomenclature), Green areas / areas with high traffic / industry

  *About half of schools are expected to be in rural areas (large green areas), and half of schools in the urban area (in a large area of transport / industry).

- Ventilation: Natural, Mechanical, Combination of both
- Age of building: <1946, 1946-1960, 1961-1970, 1971-1989, > 1990

Figure 4: Field campaign in Slovenia

2.3.1. Health and wellbeing assessment of children[6]

Data acquisition:

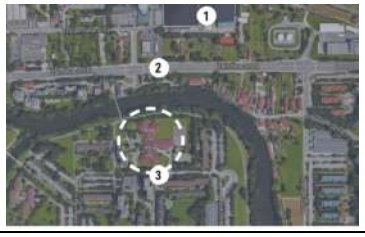
- Survey questionnaire on the frequency of illness symptoms, pupils of third grades of elementary schools, 12 schools that were involved in the project.
- The questionnaire was filled in by parents of children.

Response rate: 203/162 (83.74%)

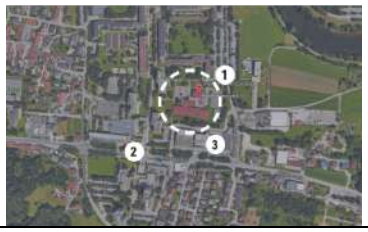
Contents of the questionnaire:

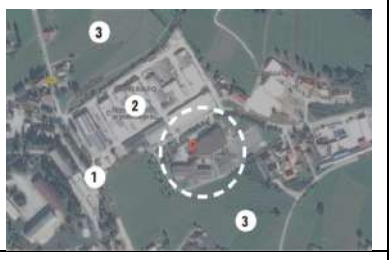
- General information about the child
- Data on pregnancy, childbirth and early childhood
- Information on respiratory and childhood allergies
- Information about the living environment
- Demographic issues
- A child's perception of the school environment

2.3.2. Characterization of a school building by checklists

School	School		Classroom		Other
	Characteristics: location of the school, age, building materials, traffic density nearby	**Problems (high concentrations)**	**Photos of classrooms**	**Problems that can originate from classrooms**	**Potential sources of air pollution**
01	-Ljubljana, residential -1976 -brick, concrete -light traffic	Benzene **Formaldehyde** $PM_{2,5}$ CO_2		Curtains, linoleum, chalk, car park next to the classroom, old furniture, decoration (arts, glues), plants	Car park, heating plant, chemicals for cleaning  *Outdoor sources: 1 heating plant, 2 busy road, 3 car park* 
02	-Ljubljana, residential -1981 -concrete -heavy traffic	Benzene $PM_{2,5}$ **CO_2** RH			Car park, busy road, industry, heating plant, dusty places (basement), water damage

[6] *The results are presented in another document.

					 *Outdoor sources: 1 car park, 2 busy road, 3 market facilities, 4 heating plant, 5 agriculture* 
03	-Ljubljana, city center -1884 (extension 1950) - restoration of some parts (electric cables, classrooms) -brick - heavy traffic	Benzene $PM_{2,5}$ CO_2 RH		Curtains, **decoration** (arts), linoleum, chalk, furniture is not so old Outside parking next to the classrooms, classroom above the parking lot, plastic window	Car park, busy road, moisture damage, chemicals for cleaning  *Outdoor sources: 1 busy road* 
04	-Ljubljana, city center -1908 (extension 1976) -brick, wood -medium traffic	Benzene $PM_{2,5}$ RH		**Decoration (arts),** wooden floor, chalk and pens, plant (a few small), mid old furniture, wooden windows	Car park, **busy road**, **railway nearby**, dusty places (shelter), water damage (basement), chemicals for cleaning,  *Outdoor sources: 1 busy road, 2 railway* 
05	-Vrhnika, suburban -2000 -brick, concrete - medium traffic	Formaldehyde		Linoleum, decoration (medium), bag-armchairs, not old furniture, plastic windows	Car park, joiner, dusty places (gymnasium, classroom for technical courses), water and moisture damage (kitchen, boiler room, classrooms), cleaning with chemicals *Outdoor sources: 1 main road, 2 production, market, light industry facilities, 3 agriculture*

					
06	-Logatec, city centre -1883 (extension 1976) - restoration (1996, insulation) -brick, concrete, stone - medium traffic	Benzene $PM_{2,5}$ RH		Very little decoration, wooden floor, pens and chalks, mid old furniture, plastic windows	Car park, busy road, waste storage site, cleaning device, boiler room, dusty places (classroom for technical courses, library), moisture damage (kitchen), chemicals for cleaning *Outdoor sources: 1 industry (Obrtna cona Logatec), 2 main road, 3 agriculture, 4 waste storage site, 5 individual heating device* 
07	-Ljubljana, suburban -1995 (extension 2010) - restoration (2010) -concrete **-very heavy traffic**	Benzene RH		Very little decoration, linoleum, chalk, plants (little), mid old furniture, plastic window.	Busy road, railway, dusty places (gymnasium, classroom for technical courses), water and moisture damage (classrooms, corridors), chemicals for cleaning  *Outdoor sources: 1 industry, 2 main railway node, 3 individual heating device, 4 agriculture, 5 main road* 
08	-Horjul, village -1975 - restoration (2013, windows, insulation) -brick, concrete, iron - light traffic	Benzene **Formaldehyde** $PM_{2,5}$ CO_2 RH		Little decoration, wooden floor, plastic windows, green space around the school	Dusty places (boiler room), water and moisture damage (kitchen, toilet), chemicals for cleaning, medium industry *Outdoor sources: 1 main road, 2 agriculture, 3 medium industry – METREL mechanica etc. (far away)* 

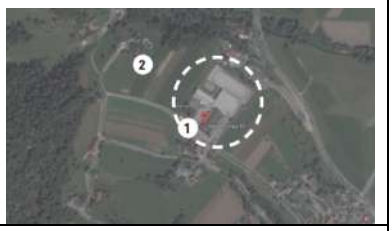
09	-Dobrova, town -1974 (extension 2006) - restoration (2006) -brick, concrete - light traffic	Benzene RH		Wooden floor, chalk, car park, decoration, plastic windows, mid old furniture	Car park, chemicals for cleaning *Outdoor sources: 1 main road, 2 agriculture* 
10	-Moravče, town -1967 - restoration (electric cables, water-system -brick, concrete - **Very heavy traffic**	**Benzene** **$PM_{2,5}$** CO_2 RH		**Tiles on the floor,** decoration (little), chalk, plastic windows, new furniture	**Big Car park**, busy road, heating plant, dusty places (classrooms for technical courses), moisture damage (classrooms), asbestos (flocculate), chemicals for cleaning *Outdoor sources: 1 main road, 2 agriculture (fields), 3 medium industry: IMP PROMONT – electric industry* 
11	-Dol pri Ljubljani, town -1972 - restoration (2016, electric cables, lightening, water-system) -brick, concrete -heavy traffic	Benzene Formaldehyde $PM_{2,}$ CO_2		Plastic windows, decoration, wooden floor,chalk, pens	Car park, busy road, chemicals for cleaning, chemical industry *Outdoor sources: 1 car park, 2 busy road, 3 industry – JUB, chemical industry, 4 agriculture* 
12	-Gabrovka, village -1978 (extension 2006) -concrete - medium traffic	Benzene Formaldehyde $PM_{2,5}$ RH		Decoration (little), linoleum, chalk, pens, curtain, plastic windows, individual heating Construction site	Car park, dusty places (boiler room, classrooms for technical courses), water damage (classrooms), chemicals for cleaning *Outdoor sources: 1 road nearby, car park, 2 individual heating devices, 3 agriculture: fields, farmers, 4 light industry (fruit industry – Presad)* 
All schools: Cleaning in the afternoon					

Table 3: Characterization of school buildings

2.3.3. Assessment of indoor air quality: monitoring campaign

The monitoring campaign took place from 13.11.2017 to 16.3.2018.

School	Date
	13. – 17.11.2017
	20. – 24.11.2017
	27.11. – 1.12.2017
	4. – 8.12.2017
	11. – 15.12.2017
	8. – 12.1.2018
	15. – 19.1.2018
	22. – 26.1.2018
	29.1. – 2.2.2018
	26.2. – 2.3.2018
	5. – 9.3.2018
	12. – 16.3.2018

Table 4: Monitoring campaign

We made measurements of the following parameters:

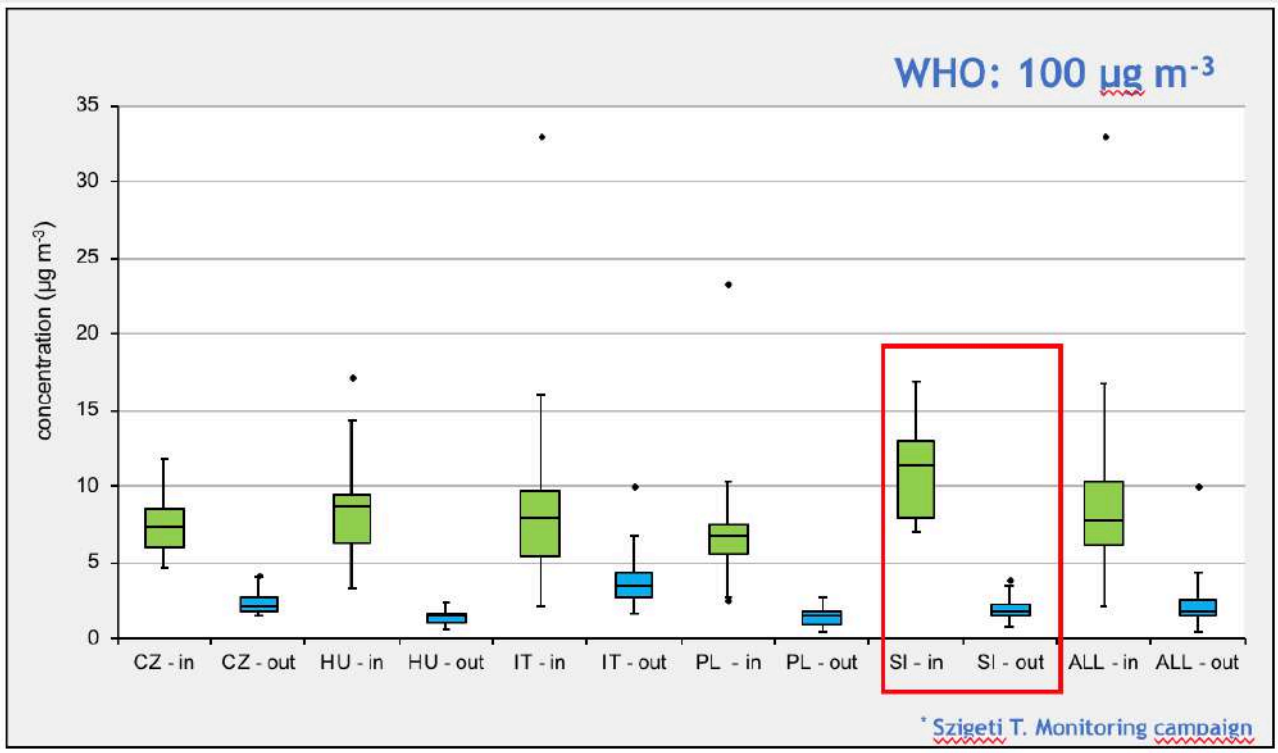
- air temperature and relative humidity
- particles ($PM_{2.5}$)
- CO_2
- aldehydes (formaldehyde)
- VOC (volatile organic compounds) (benzene)
- NO_2
- Radon

Figure 5: Internal measuring station

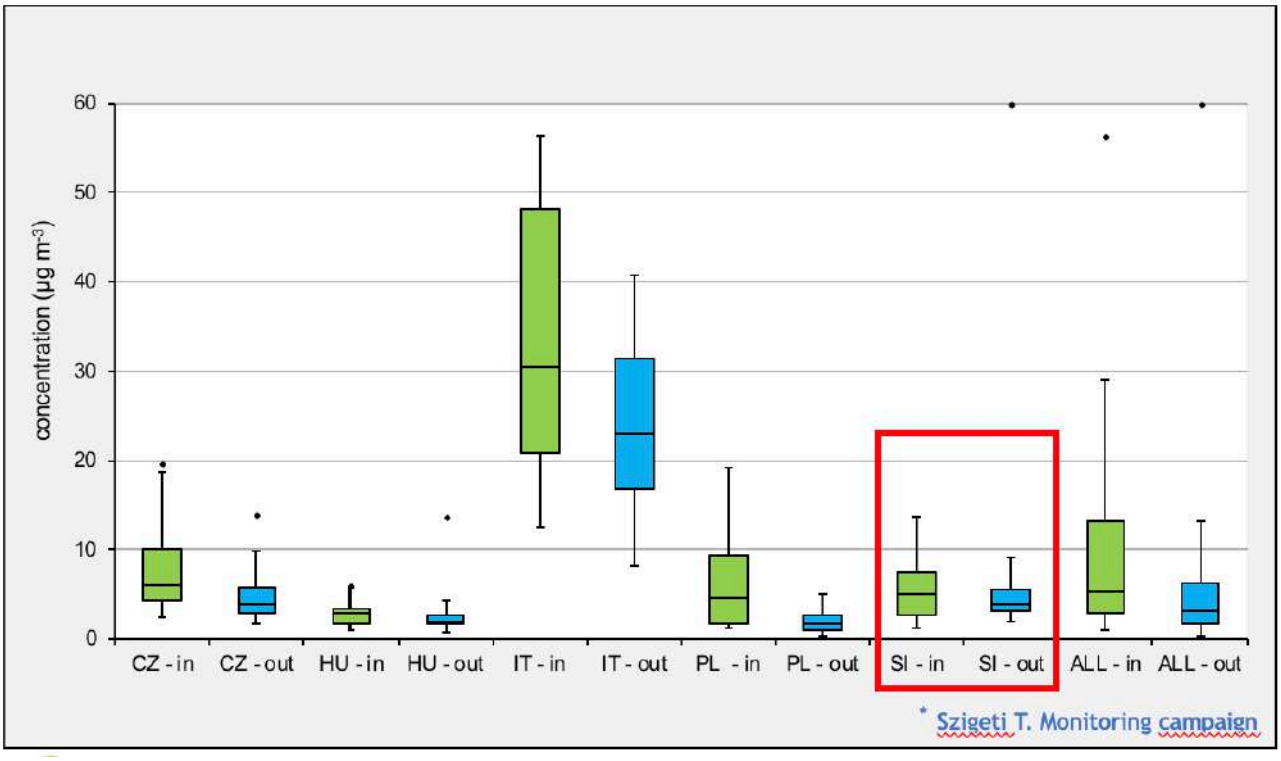
Figure 6: External measuring station

2.4. Results of the field campaign

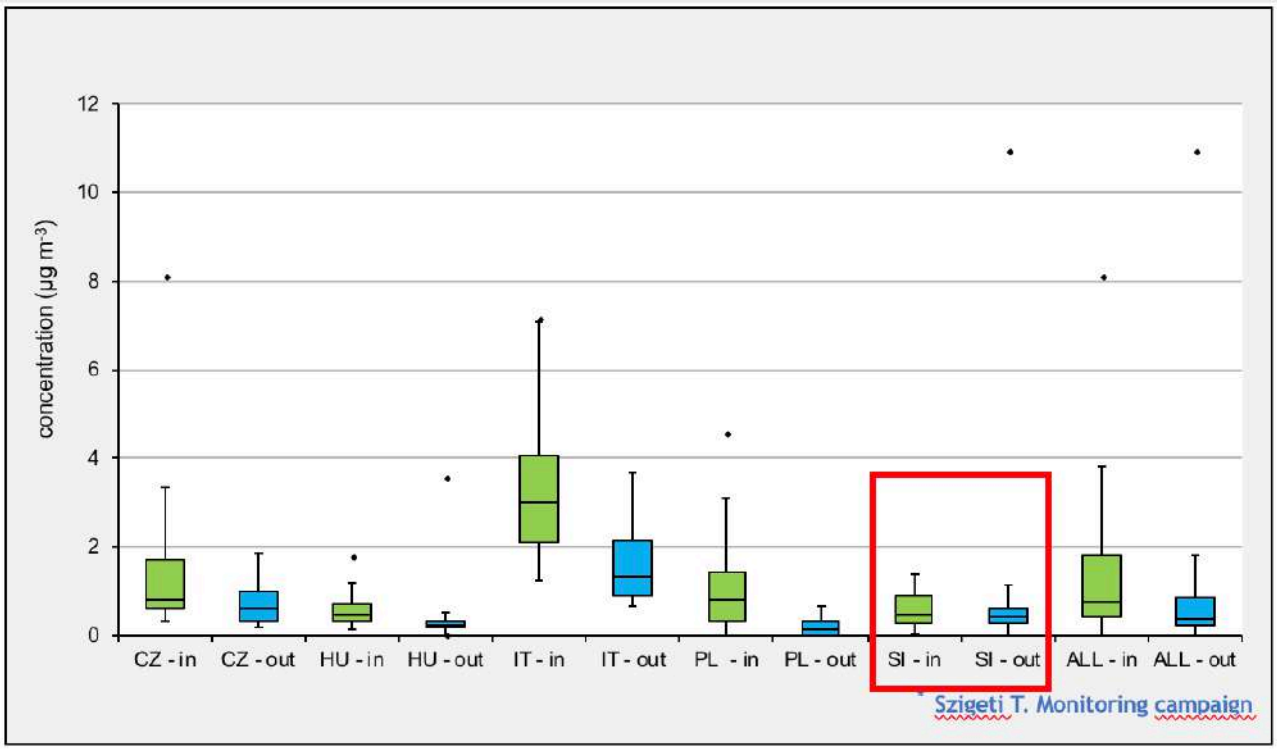
2.4.1. Formaldehyde



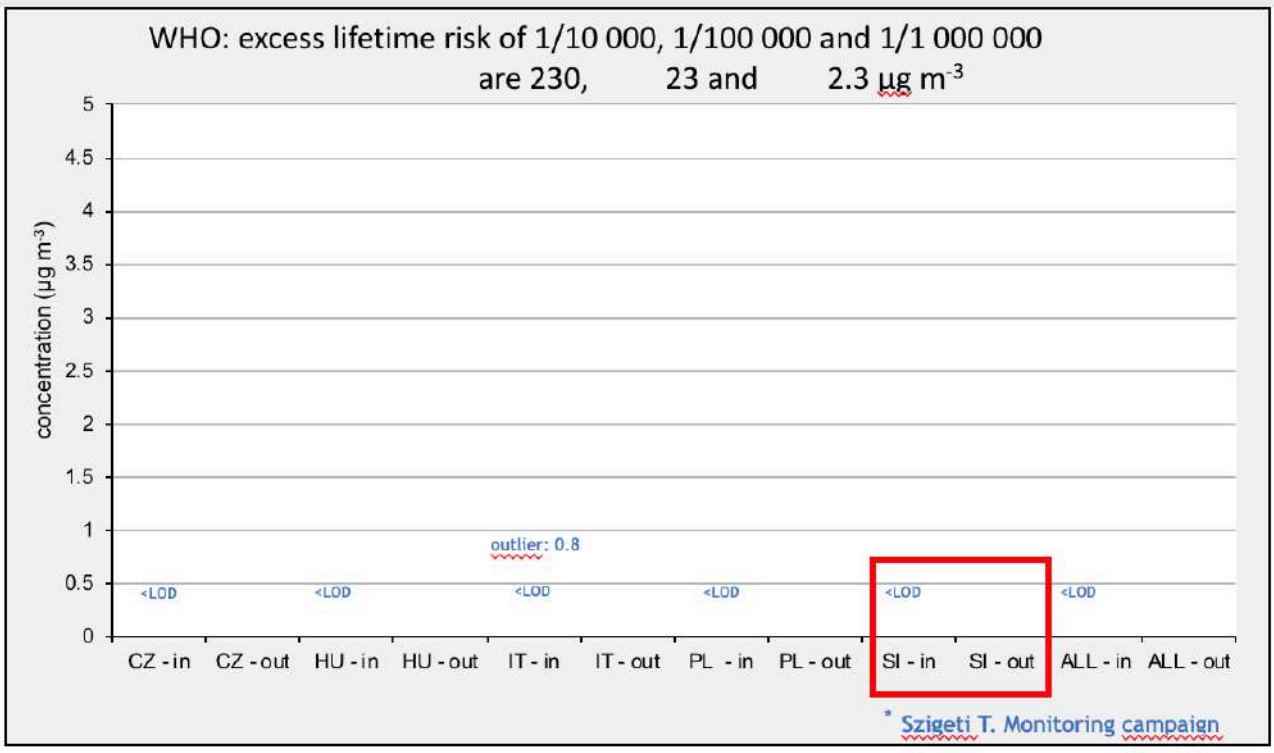
2.4.2. Toluene



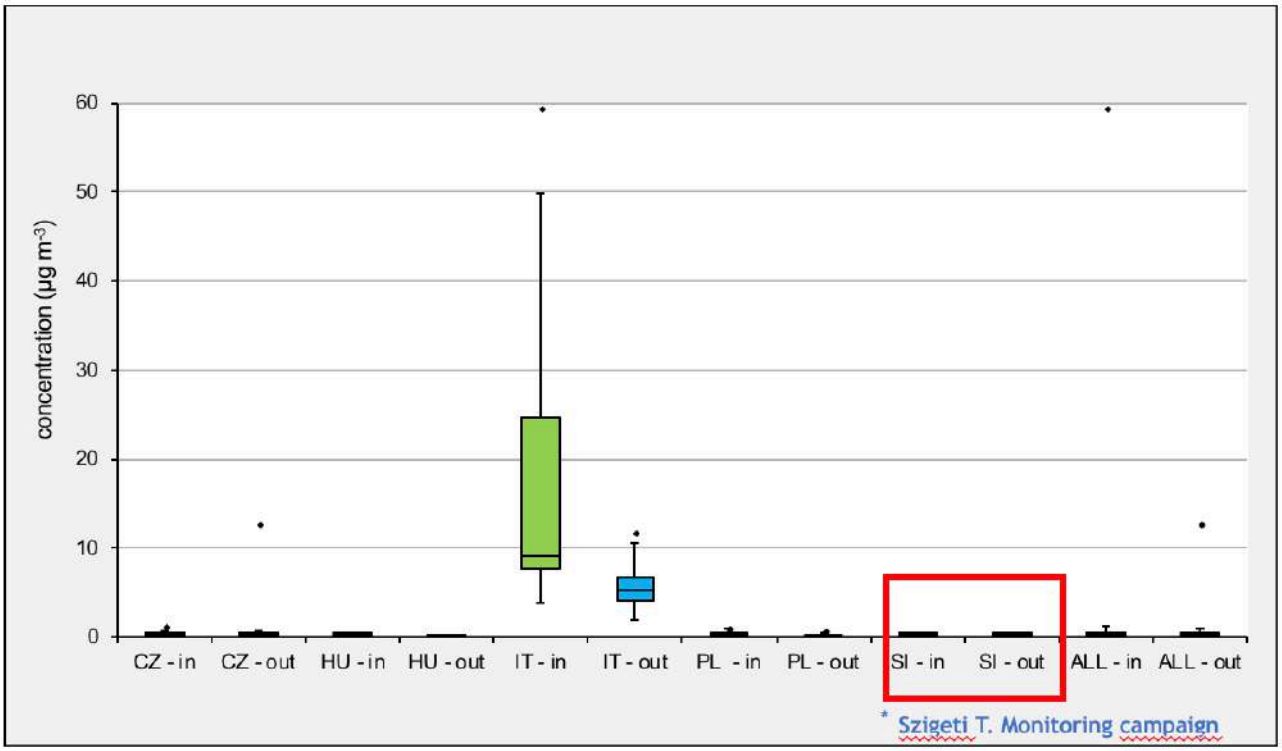
2.4.3. Ethylbenzene



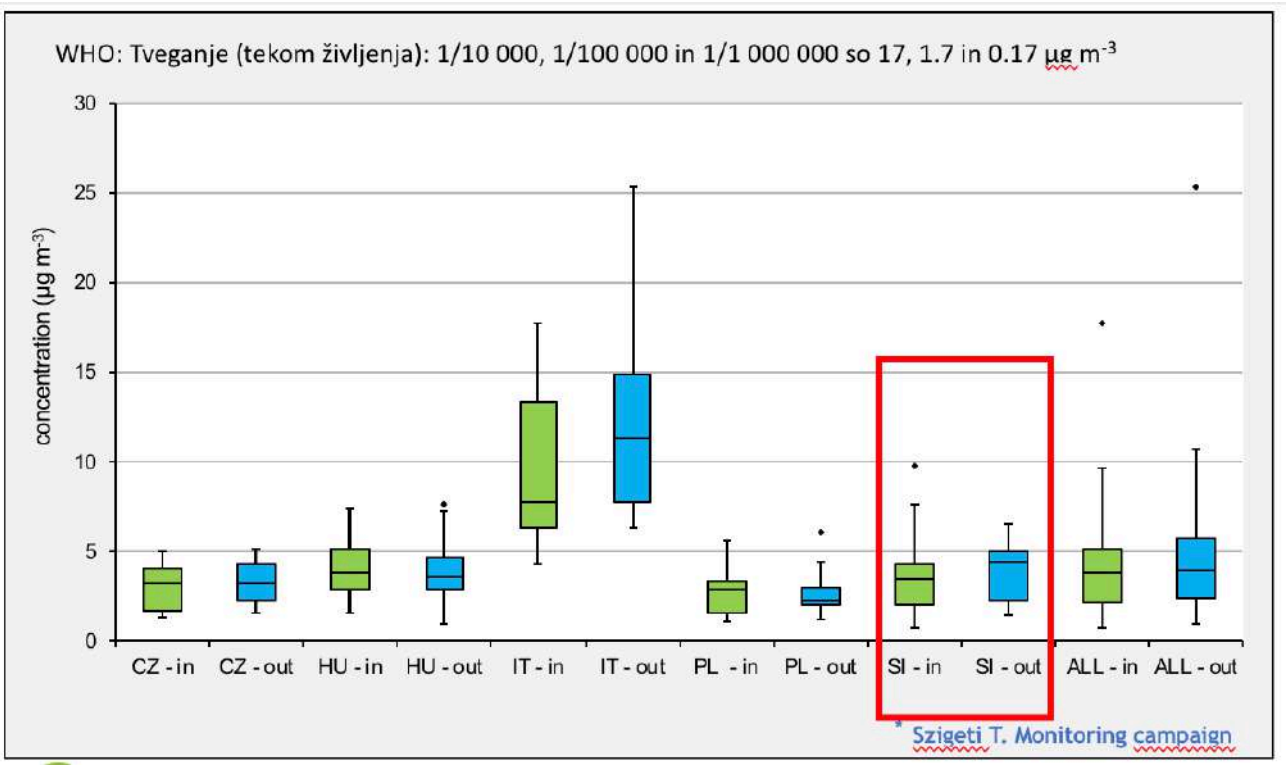
2.4.4. Trichlorethylene



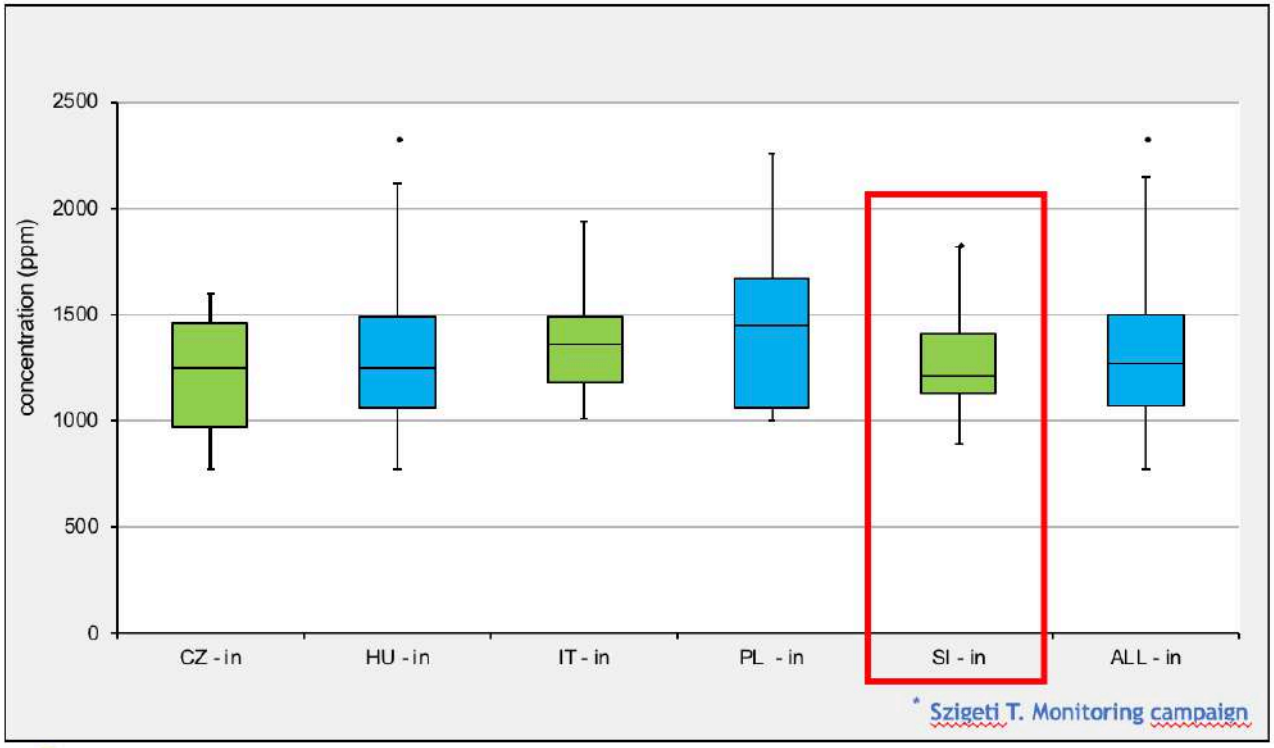
2.4.5. Tetrachlorethylene



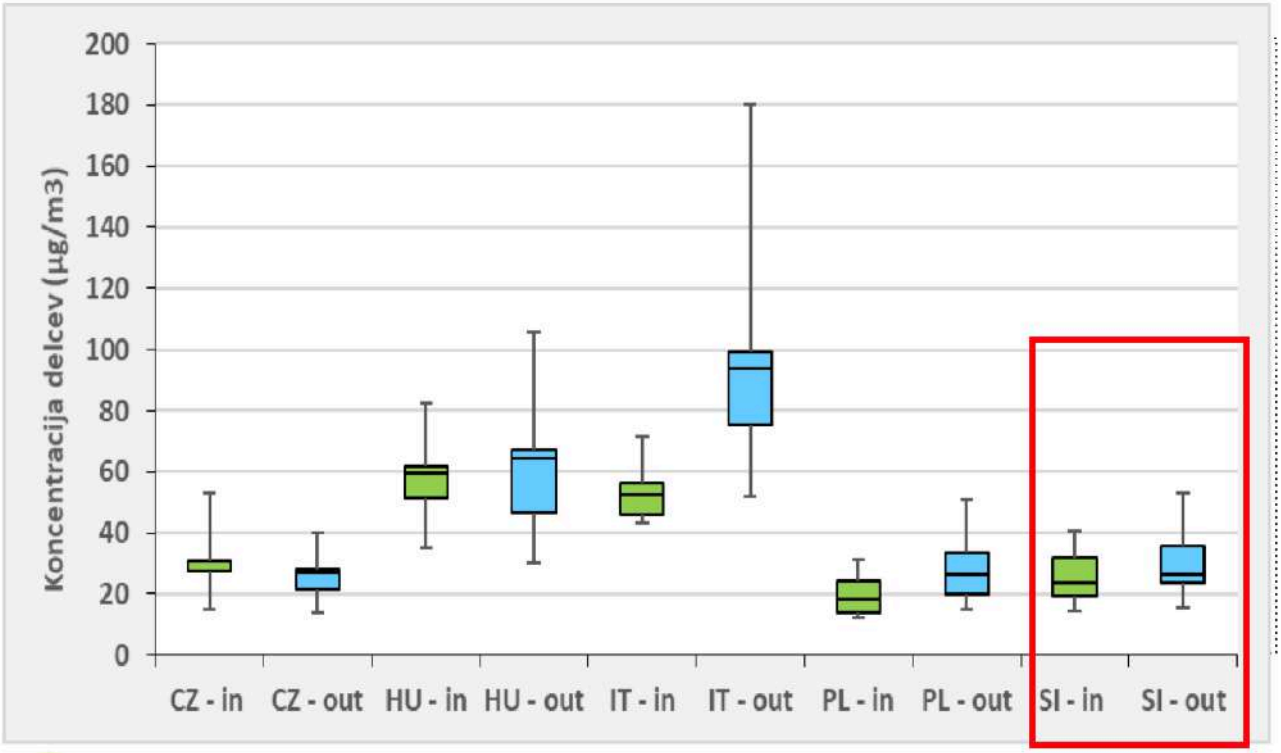
2.4.6. Benzene



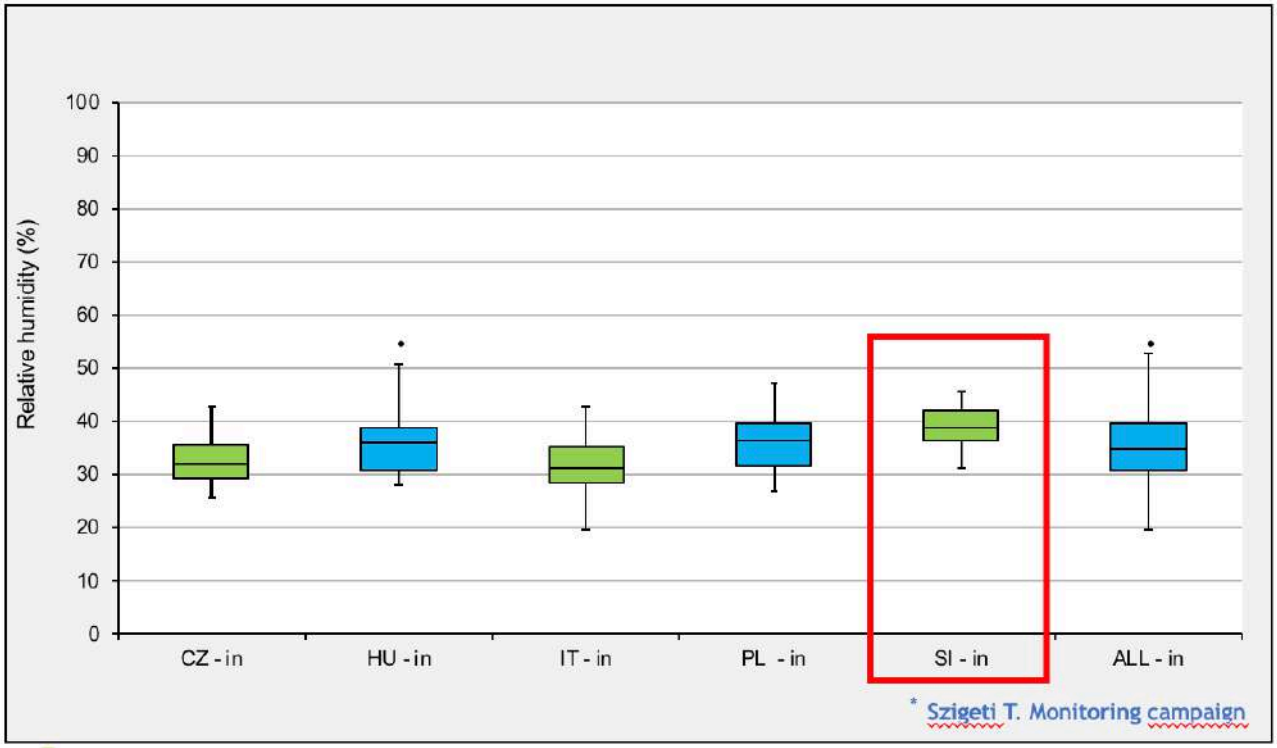
2.4.7. CO_2



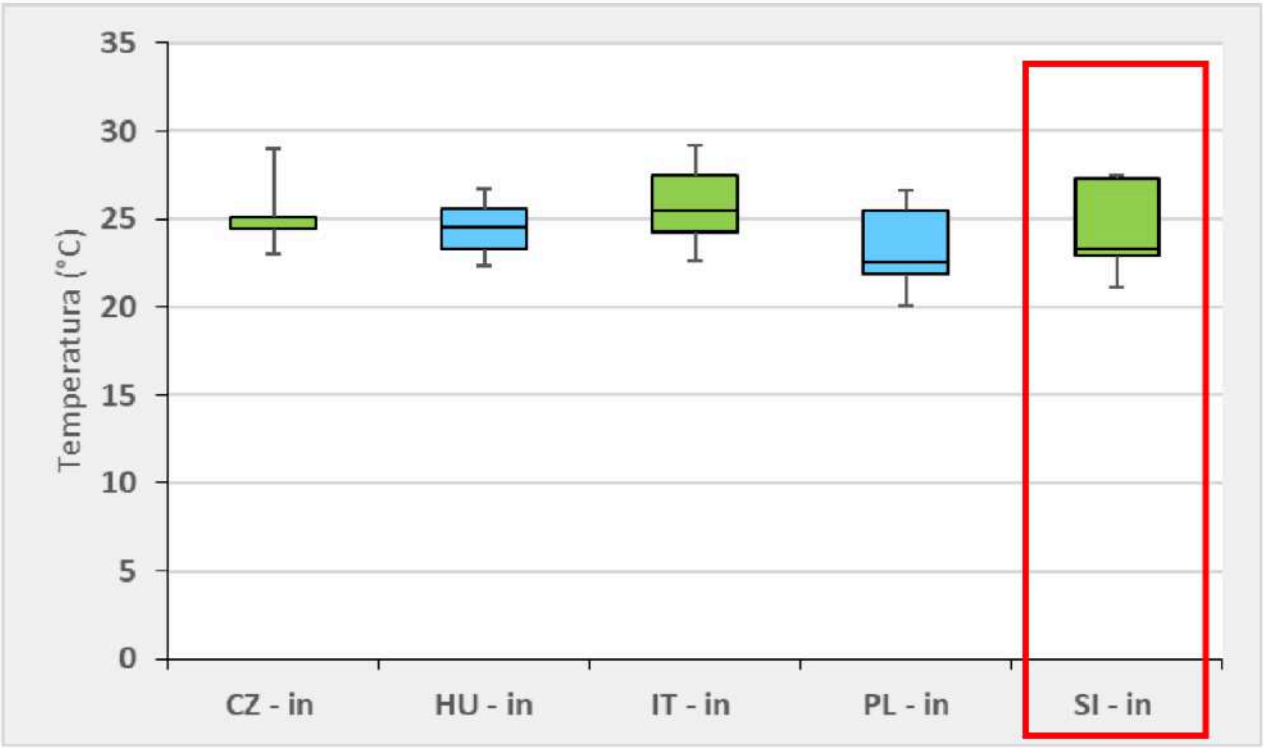
2.4.8. PM2,5



2.4.9. Relative humidity



2.4.10. Temperature



2.4.11. Health risk evaluation: Indoor Health Index

Following table presents the results of the monitoring campaign (winter 2017/2018) in 12 school buildings in Slovenia.

SI01-in	3,11	15,74	12	1396	22,4	44,1	moderate
SI02-in	3,92	9,56	15	1826	21,9	32,6	unhealthy
SI03-in	4,08	11,26	11	1353	20,5	40,0	moderate
SI04-in	5,07	8,15	11	909	22,7	31,2	unhealthy
SI05-in	0,81	12,38	6	1163	23,0	45,4	moderate
SI06-in	2,46	11,47	-	1154	22,8	37,0	moderate
SI07-in	1,94	7,22	6	1075	22,9	41,4	moderate
SI08-in	4,04	16,86	10	1247	23,00	37,4	moderate
SI09-in	1,99	7,07	-	887	22,6	34,8	unhealthy
SI10-in	9,79	7,37	19	1439	23,1	37,6	very unhealthy
SI11-in	4,86	13,64	15	1503	22,6	43,7	moderate
SI12-in	2,03	12,89	11	1182	20,9	40,8	moderate
	benzene	formaldehyde	$PM_{2.5}$	CO2	T	RH	
Health (IHI)	1,7	10	10	1200	18.5-25.5	43-67	

Figure 7: Results of field campaign

Of the 12 schools, indoor air pollution was estimated as:

- Very high: 2 schools (increased concentration of benzene and CO_2)
- High: 5 schools (elevated CO_2 concentrations, low humidity levels in air and one school elevated benzene concentration)
- Moderate: 5 schools (mostly concentrations of benzene and formaldehyde (7 schools), 4 schools have elevated CO_2 concentrations in the air and 3 schools have elevated concentrations of particles in the air).

Indoor health index

Category	Benzene [µg/m3]	Formaldehyde [µg/m3]	$PM_{2.5}$ [µg/m3]
Healthy	<1.7	<10	<10
Moderate	1.7 - 4.99	10 - 19.9	10-24.9
Unhealthy	5 - 7.5	20 - 50	25-49.9
Very unhalthy	7.51 - 10	51 - 100	50-75
Dangerous	>10	>100	>75

Comfort index

catergory	RH[%]	T [°C]	CO_2 [ppm]
healthy	43 < RH < 67	18.5 < T < 25.5	<1200
moderate	37 < RH < 43 67 < RH < 73	17.5 < T < 18.5	1200-1800
unhealthy	RH<37 RH>73	T<17.5 T >25.5	>1800

Figure 8: Legende for indoor health index and comfort index

Category	Number of schools
Healthy	/
Moderate	5
Unhealthy	5 (CO_2 - 4x benzene - 1x)
Very unhealthy	2 (CO_2 - 1x benzene - 1x)
Dangerous	/

Table 5: Indoor health index in Slovenia

Category	Number of schools
Healthy	3
Moderate	6
Unhealthy	3 (RH)

Table 6: Comfort index in Slovenia

3. Action plans for 12 chosen schools based on parameters

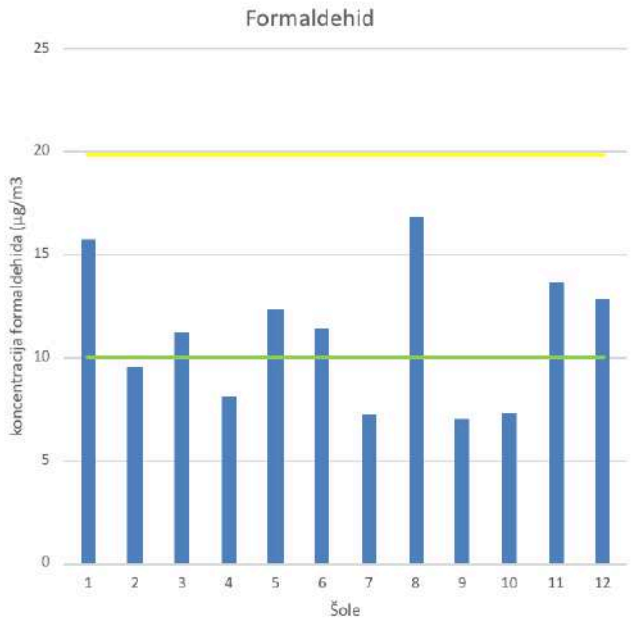
First we prepared action plans based on different parameters.

3.1. Formaldehyde

3.1.1. Results

According to the project, the classes set in Slovenia are:

- Of the 12 schools, there are 7 schools of elevated concentration of formaldehyde in the air. The elevated values range from 11.26 µg/m3 to 16.86 µg/m3.
- Except for one, all schools, in addition to formaldehyde, have other parameters (eg benzene concentrations in the air) increased.
- In addition to 7 Slovenian schools, two more schools have higher formaldehyde concentrations (Poland - 23.25 µg / m3 and Italy - 13.33 µg / m3)



	BENZEN	FORMALDEHID	$PM_{2,5}$	CO_2	RV
šola		16			
šola		10			
šola		11			
šola		8			
šola		12			
šola		11			
šola		7			
šola		17			
šola		7			
šola		7			
šola		14			
šola		13			

Figure 9: Formaldehyde

3.1.2. Possible source

Outdoor sources

Formaldehyde is an intermediate in the oxidation of methane and other carbons - for example, in forest fires, exhaust gases of automobile engines and tobacco smoke. It's an integral part of smog.

Sources inside the building

Equipment:

- Furniture from chipboard.
- Floor linings containing formaldehyde (some laminates).

Other products that can be a source of formaldehyde: nourishing cosmetics, clothing.

3.1.3. Action plans

Proposed action plans to lower the concentration of formaldehyde:

- "Prevention" of the entry of formaldehyde from the outside air.
- We select suitable, dedicated furniture and linings - we equip the rooms with interior equipment that does not contain formaldehyde or as little as possible.
- The rooms are ventilated, in particular new, refurbished or equipped with new furniture.
- During and after the use of products that are source of formaldehyde, the school environments are well ventilated.
- Maintain the temperature and relative humidity of the school environments at the lowest comfort levels (formaldehyde concentrations increase with increasing temperature and humidity).
- We spend as much time in fresh, clean air in the outdoor space.

- We are spreading knowledge about preventing exposure to formaldehyde (for example, when buying articles, always check the composition information, always wash all new clothes, do not use air fresheners).

3.2. Benzene

3.2.1. Results

Of the 12 schools, 9 schools (75%) have increased level of benzene:

- The elevated values range from 1.94 µg/m3 to 9.79 µg/m3.
- One school has elevated only concentrations of benzene (all other parameters do not exceed the limit value).
- In addition to Slovenian (9) schools, other countries also have higher concentrations of benzene (Czech Republic: 1 school, Poland: 2 schools, Hungary: 4 schools and Italy: 11 schools) ranging from 2.07 µg/m3 to 17.79 µg/m)

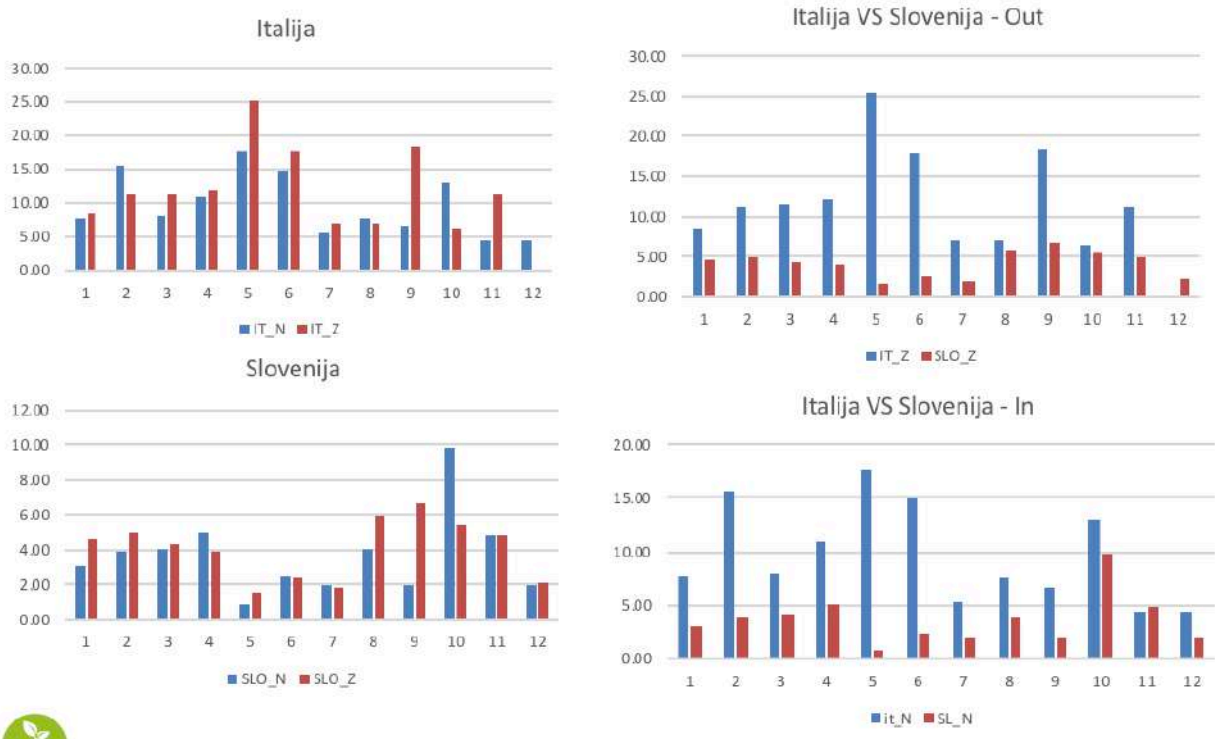
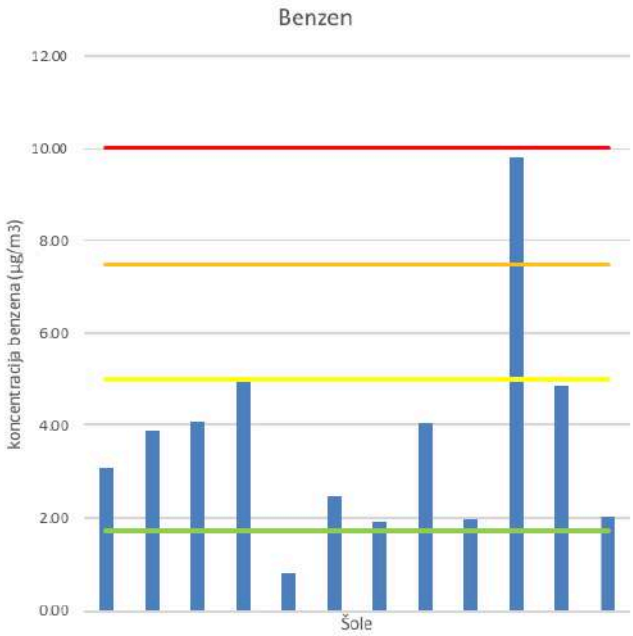


Figure 10: Results for benzene concentration in Slovenia and Italy



	BENZEN	FORMALDEHID	PM 2,5	CO_2	RV
šola	3,11				
šola	3,92				
šola	4,08				
šola	5,07				
šola	0,81				
šola	2,46				
šola	1,94				
šola	4,04				
šola	1,99				
šola	9,79				
šola	4,86				
šola	2,03				

Figure 11: Benzene (results)

3.2.2. Possible source

Outdoor sources

Traces of benzene can arise from incomplete combustion of each substance rich in carbon. Benzene is formed between fire eruptions, forest fires, smoke, traffic, incomplete combustion of polyvinyl chloride (PVC), gasoline evaporation at gas stations, exhaust gases of motor vehicles and industrial gases, etc.

Sources inside the building

Products that may contain benzene: adhesives, color coatings, waxes for furniture polishing, detergents, etc.

3.2.3. Action plans

Proposed action plans to lower the concentration of benzene:

- "Prevention" of the entry of benzene from the outside air (location of parking lots, cigarette smoke, etc.).
- Prohibit smoking indoors.
- The work that must be done with products containing benzene is done outside, in the open space.
- During and after using products that are the source of benzene, the living areas are well ventilated (eg during painting/ use of colors).
- We discard supplies of colors and fuels that we will not use immediately (we follow the instructions for separating waste).

3.3. VOC

3.3.1. Possible source

VOC is a group of organic compounds containing carbon, hydrogen and other elements - at ambient temperature have a high vapor pressure, so they easily evaporate.

Outdoor sources

- The main source: traffic - volatile organic compounds are formed when burning fossil fuels (eg in petrol).
- Diesel fuel emissions
- Wood burning
- Extraction and processing of petroleum and gas
- Industrial emissions

Sources inside the building

- Colors, paint strippers
- Varnishes and coatings
- Balls and sealants
- Adhesives
- Floor coverings, carpets, products made of pressed wood
- Art and craft products: permanent markers, etc.
- Office printers and copiers

Sources inside the building - the most common sources in the home environment:

- Cleaners and disinfectants
- Air fresheners
- Personal care products (cosmetics and deodorants)
- Fuel oil, gasoline

The problem of VOCs: their diversity. Measurements that give us the same results do not necessarily tell us what the air quality is if we do not know the main VOC in the vicinity.

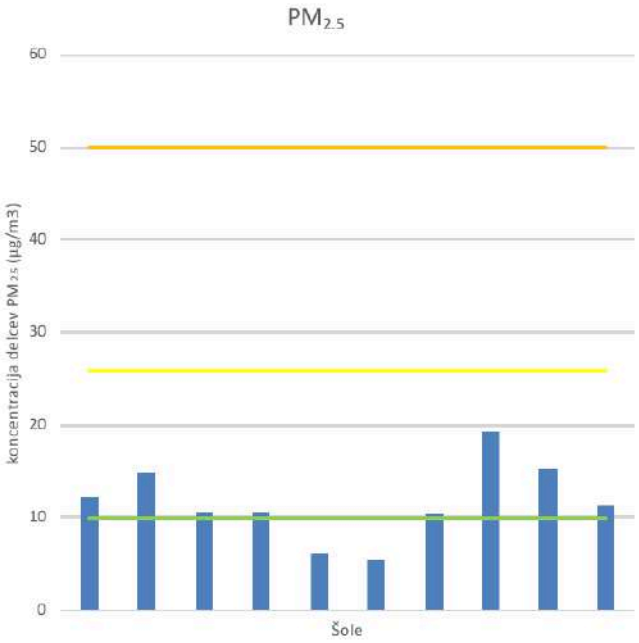
3.3.2. Action plans

Proposed action plans to lower the concentration of VOC:

- Preventing entry of VOC from the outside air (eg parking lots).
- Choose products that do not contain VOCs
- We do not store products that are a source of VOC in rooms where children stay.
- If we use products that are a source of VOC (various cleaners, paints, varnishes ...), use them according to the manufacturer's instructions.
- For the use of products that are the source of VOC, ensure sufficient amounts of fresh air.
- Buy and stock the products that are the source of VOCs in the quantities that we will spend. Discard the excess storage in unopened or open containers (note the instructions for separating waste).
- Never mix products that are the source of organic volatile compounds, unless stated in the manufacturer's instructions.
- Reduce exposure to formaldehyde, benzene and perchlorethylene in a living environment at school and at home.

3.4. Particulate Matters $PM_{2,5}$

3.4.1. Results



	BENZEN	FORMALDEHID	PM 2,5	CO_2	RV
šola			12		
šola			15		
šola			11		
šola			11		
šola			6		
šola			-		
šola			6		
šola			10		
šola			-		
šola			19		
šola			15		
šola			11		

Figure 12: Particulate Matters $PM_{2,5}$

3.4.2. Possible source

Outdoor sources

- traffic, burning, industrial discharges, weather conditions and unfavorable geographical location

Sources inside the building

- people and their activities
- equipment, premises - house dust, activities in the kitchen, heating

3.4.3. Action plans

Proposed action plans to lower the concentration of $PM_{2,5}$:

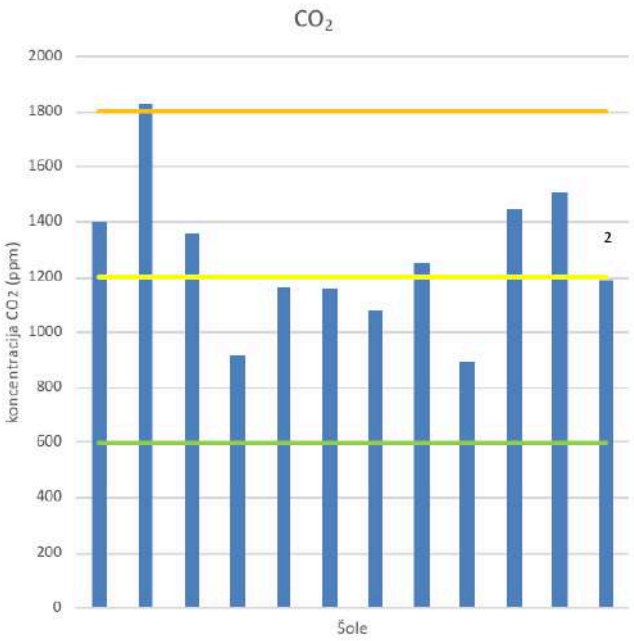
- We regularly monitor the notifications and forecasts of the ARSO on outdoor air quality.
- For increased particulate pollution, we have implemented these measures to reduce exposure: http://www.arso.gov.si/zrak/kakovost%20zraka/podatki/PM10_napoved.html;
- Instructions for educational institutions is further defined in letter No.354-177 / 16-1 / 354 of December 2016
- Instructions for kindergartens and schools: RECOMMENDATIONS FOR VICTIMS AND SCHOOLS FOR HANDBOOKING IN DAYS WITH INCREASED VALUES OF PM 10 IN OUTDOOR AIR
    - "Preventing" the entry of particles from the outside air
    - The rooms are effectively ventilated when the air pollution is the lowest in the day (usually in the early morning hours, before the traffic jams).

- Especially during limited ventilation due to elevated concentrations of particles in ambient air, avoid activities that cause dust in enclosed spaces.
- Ensure proper ventilation of other rooms (corridors, cabinets ...), mechanical ventilation of the kitchen and sanitary facilities.

- General instructions on cleaning and maintaining the indoor environments:
  - For vacuuming dust, we use vacuum cleaners with HEPA filters. If the HEPA filter is too clogged, it stops and no longer performs its role. It is important to clean them frequently (washing HEPA filters) or replace them.
- General instructions on fire:
  - Replace solid fuels with cleaner fuels and energies (eg solar energy, electricity, natural gas, liquefied petroleum gas, heating oil ...).
  - Use combustion plants that are energy efficient.
  - Regular cleaning and maintenance of heating, smoke and ventilation devices. For furnaces for liquid and gaseous fuels, before the start of the heating season, ensure that the burners are correctly adjusted.

3.5. CO_2

3.5.1. Results



	BENZEN	FORMALDEHID	PM 2,5	CO_2	RV
šola				1396	
šola				1826	
šola				1353	
šola				909	
šola				1163	
šola				1154	
šola				1075	
šola				1247	
šola				887	
šola				1439	
šola				1503	
šola				1182	

Figure 13: CO_2

3.5.2. Possible source

Outdoor sources

- individual heating
- traffic

Sources inside the building

- Human

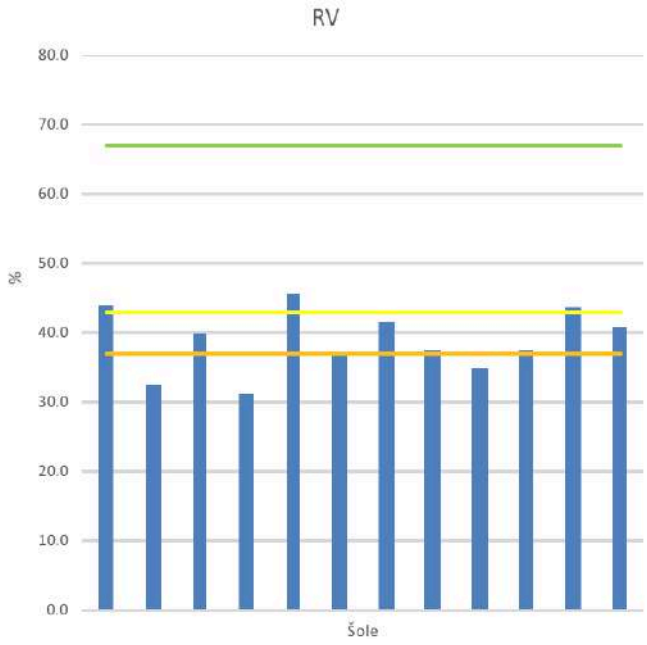
3.5.3. Action plans

Proposed action plans to lower the concentration of CO_2:

- "Preventing" the entry of CO_2 from the outside air (eg the location of parking lots).
- Observing norms regarding the volume of air/ person in the premises and consistent provision of air exchange.
- Regularly effective ventilation!

3.6. Relative humidity

3.6.1. Results



	BENZEN	FORMALDEHID	PM 2,5	CO_2	RV
šola					44
šola					33
šola					40
šola					31
šola					45
šola					37
šola					41
šola					37
šola					35
šola					38
šola					44
šola					41

Figure 14: Relative humidity

4. Other IAQ action plans

We divided IAQ action plans in three main groups: (1) process improvements; (2) technical improvements; (3) other improvements. Based on this we prepared examples of action plans for 12 chosen primary schools, where monitoring campaign took place.

4.1. Process improvements

Operational improvements:

- modifying the mode of some activities that can affect the quality of the indoor environment (e.g., increasing air exchange rate, limiting the number of people in the room, changing the cleaning period).

Systemic improvements:

- Regular measures that will lead to the removal of the source (e.g., replacement of floor coverings, prohibition of using some detergents).

Cleanliness of the rooms:

- Select cleaning methods that are effective for the given need.
- Buy products with the least adverse impact on human health.
- It is important that the housekeeping staff are trained on how your housekeeping procedures and products may affect IAQ.
- Have written procedures, know what equipment and products are used in your building and purchasing safer products.
- The use of more natural cleaners, avoid using colours, paints

Maintenance (cleanliness, quality) of the roof, gutters, drainage:

- Regular inspection of the rooms and quick action and remediation in case of leakage of water and accumulation of moisture in the premises

Art classes/ use of specific materials for lectures:

- After activities using adhesives, glues, paints, etc. (art lessons) ventilate the classroom well

4.2. Technical improvements

Natural ventilation:

- Extraction of air (air outlet) from the kitchen (the smell of food).

Mechanical ventilation:

- Plan for maintenance of HVAC system. The plan should include monitoring, inspecting and cleaning HVAC components such as outside air intakes, outside air dampers, air filters, drain pans, heating and cooling coils, the interior of air handling units, fan motors and belts, air humidification, controls and cooling towers.

Flooring:

- Change of flooring with healthy building materials

4.3. Other improvements

Legislations:

- Establishing the law regulations - monitoring parameters (CO2, T, RH), regulations for schools (number of pupils in classroom).

Awareness raising:

- Improve knowledge about the importance of indoor air pollution (ventilation, materials, behavioural, etc) – different actions for different groups of people.

5. Examples of IAQ action plans

Based on the field campaign (results of monitoring campaign) and action plans (chapter 3) we prepared action plans for 12 schools in Slovenia.

For each action we evaluated its feasibility (last column), based on its investment (cost and time consuming). We defined three groups:

- 1 - really feasible: cheap, fast
- 2 – feasible: in the middle between 1 and 3, needed some time and some money
- 3 - hardly feasible: expensive, slow (a lot of time needed)

School	What do we want to improve	Improvements			Who can do it?		Feasibility*
		Technical improvements	Process improvements	Other (law, etc.)	School personnel	External experts	
01	Lower the concentrations of Benzene **Formaldehyde** $PM_{2,5}$ CO_2		Reducing use of paints, varnishes, adhesives, artificial floor coverings (art decoration) (formaldehyde).		Teachers, all employees, Headmaster of the school		1, 2
		mechanical ventilation (PM, benzene, CO_2)				Experts	3
			Use of natural cleaners (formaldehyde)		Cleaning lady Headmaster of the school		1
			Opening the windows after cleaning (formaldehyde)		Cleaning lady		1
			More frequent ventilation (CO2, formaldehyde)		Teachers (All employees of the school)		1
				Concentrations of CO_2 based on legislations Regular measurements		Government	2, 3
			Do not open the windows (ventilation) during the hours when traffic is increased (heavy) (PM, benzene)		Teachers (All employees of the school)		1
02	Lowering the concentrations of: Benzene $PM_{2,5}$ **CO_2** RH	Mechanical ventilation (benzene, PM, RH, CO2)				Experts	3
			Reconstruction of damaged area (water damage)		Headmaster of the school	Experts	2
			More frequent ventilation (CO2, RH*)		Teachers (All employees of the school)		1
				Concentrations of CO_2 based on legislations Regular measurements		Government	2, 3
			Do not open the windows (ventilation) during the hours when traffic is increased (heavy) (PM, benzene)		Teachers (All employees of the school)		1
			Frequent, thorough wet cleaning (especially critical – dusty places) (PM)		Cleaning lady responsible person for school hygiene		1
03		Mechanical ventilation				Experts	3

	Lower the concentrations of: Benzene $PM_{2,5}$ CO_2 RH	(benzene, PM, RH, CO2)					
			More frequent ventilation (CO2, RH)		Teachers (All employees of the school)		1
				Concentrations of CO_2 based on legislations Regular measurements		Government	2, 3
		Changing plastic windows (RH)			Headmaster of the school	Experts	3
			Do not open the windows (ventilation) during the hours when traffic is increased (heavy) (PM, benzene)		Teachers (All employees of the school)		1
04	Lower the concentrations of: Benzene PM2,5 RH	Mechanical ventilation (benzene, PM, RH)				Experts	3
			More frequent ventilation (CO_2, RH)		Teachers (All employees of the school)		1
			Do not open the windows (ventilation) during the hours when traffic is increased (heavy) (PM, benzene)		Teachers (All employees of the school)		1
			Frequent, thorough wet cleaning (especially critical – dusty places) (PM)		Cleaning lady responsible person for school hygiene		1
05	Lower the concentrations of: Formaldehyde		More frequent ventilation. Use of natural cleaners. Opening the windows after cleaning. Reducing use of paints, varnishes, adhesives, artificial floor coverings (art decoration).		Teachers (All employees of the school), Cleaning lady responsible person for school hygiene		1, 2
06	Lower the concentrations of: Benzene $PM_{2,5}$ RH	Mechanical ventilation (benzene, PM, RH)				Experts	3
			Do not open the windows (ventilation) during the hours when traffic is increased (heavy) (PM, benzene)		Teachers (All employees of the school)		1
			Frequent, thorough wet cleaning (especially critical – dusty places) (PM)		Cleaning lady responsible person for school hygiene		1

07	Lower the concentrations of: Benzene RH	Mechanical ventilation (benzene, RH)				Experts	3
			Reconstruction of damaged area (water and moisture damage) (RH)		Headmaster of the school	Experts	2
			Do not open the windows (ventilation) during the hours when traffic is increased (heavy) (PM, benzene)		Teachers (All employees of the school)		1
08	Lower the concentrations of: Benzene **Formaldehyde** $PM_{2,5}$ CO_2 RH	Mechanical ventilation (benzene, RH, formaldehyde, PM, CO_2, RH)				Experts	3
			Reconstruction of damaged area (water and moisture damage) (RH)		Headmaster of the school	Experts	2
			More frequent ventilation (CO_2, RH)		Teachers (All employees of the school)		1
				Concentrations of CO_2 based on legislations Regular measurements		Government	2, 3
			Use of natural cleaners. Opening the windows after cleaning (formaldehyde)		Cleaning lady responsible person for school hygiene		1
			Reducing use of paints, varnishes, adhesives, artificial floor coverings (formaldehyde).		Teachers (All employees of the school), Headmaster of the school		1, 2
			Do not open the windows (ventilation) during the hours when traffic is increased (heavy) (PM, benzene)		Teachers (All employees of the school)		1
			Frequent, thorough wet cleaning (especially critical – dusty places) (PM)		Cleaning lady responsible person for school hygiene		1
09	Lower the concentrations of: Benzene RH	Mechanical ventilation (benzene, RH)				Experts	3
			More frequent ventilation and temperature regulation (RH)		Teachers (All employees of the school)		1
			Do not open the windows (ventilation) during the hours		Teachers (All employees of the school),		1

			when traffic is increased (heavy) (benzene)				
10	Lower the concentrations of: **Benzene** **$PM_{2,5}$** CO_2 RH	Mechanical ventilation (benzene, RH, CO_2, PM)				Experts	3
			More frequent, proper (correct) ventilation and temperature regulation (RH, CO_2)		Teachers (All employees of the school)		1
				Concentrations of CO_2 based on legislations Regular measurements		Government	2, 3
			Reconstruction of damaged area (water and moisture damage) (RH)		Headmaster of the school	Experts	2
			Frequent, thorough wet cleaning (especially critical – dusty places) (PM)		Cleaning lady responsible person for school hygiene		1
			Do not open the windows (ventilation) during the hours when traffic is increased (heavy) (PM, benzene)		Teachers (All employees of the school)		1
11	Lower the concentrations of: Benzene Formaldehyde $PM_{2,}$ CO_2	Mechanical ventilation (benzene, RH, CO_2, PM)				Experts	3
			More frequent, proper (correct) ventilation and temperature regulation (formaldehyde, CO_2)		Teachers (All employees of the school)		1
				Concentrations of CO_2 based on legislations Regular measurements		Government	2, 3
			Do not open the windows (ventilation) during the hours when traffic is increased (heavy) (PM, benzene)		Teachers (All employees of the school)		1
			Use of natural cleaners. Opening the windows after cleaning (formaldehyde)		Cleaning lady responsible person for school hygiene		1
			Reducing use of paints, varnishes, adhesives,				

			artificial floor coverings (art decoration) (formaldehyde).				
12	Lower the concentrations of: Benzene Formaldehyde $PM_{2,5}$ RH	Mechanical ventilation (benzene, RH,formaldehyde , PM)				Experts	3
			Frequent, thorough wet cleaning (especially critical – dusty places) (PM)		Cleaning lady responsible person for school hygiene		1
			Reducing use of paints, varnishes, adhesives, artificial floor coverings (art decoration). Use of natural cleaners. Opening the windows after cleaning (formaldehyde)		Teachers (All employees of the school), Cleaning lady responsible person for school hygiene		1,2
			Reconstruction of damaged area (water and moisture damage) (RH)		Headmaster of the school	Experts	2
			Do not open the windows (ventilation) during the hours when traffic is increased (heavy) (PM, benzene)		Teachers (All employees of the school)		1
	*RH: depends what are the weather conditions when we ventilate the room.						

Table 7: Action plans for 12 schools

6. National IAQ action plan

The main topics of national strategy for IAQ are

- Stakeholders
- General process plan for improvement of IAQ in the school buildings
- Capacity building

Additionally, other main objectives of national strategy are:

- Monitoring
- Awareness raising
- Legislations

National IAQ action plan has three time frames: in one year, in 5 years, in 10 years (table 8).

Time	Main aims	Main actions
In 2019	Awareness raising about IAQ	Preparation of guidelines for different stakeholders. Process improvements Capacity building trainings
In 5 years	Small changes in primary schools (municipality level)	Monitoring of IAQ Technical improvements
In 10 years	Legislations (national level)	New regulations for renovations and new buildings (school building)

Table 8: Time frame of action plans

6.1. Stakeholders

In the design, maintenance and use of school building are involved different people, from government to profession and public (chapter 2.2.4). The responsibilities and roles regarding IAQ management must be described at different levels (i.e. stakeholder, municipality, school management). The representatives of all affected sectors should be included in the development process.

In this chapter we are proposing different actions that could be done by different stakeholders.

6.1.1. School staff

	what	improvement
MANAGEMENT BOARD	Establishment of IAQ team	The feeling of belonging of school staff, regular checking of school building, improvements preparation
	Awareness raising actions about IAQ in schools	General awareness about IAQ
	Efficient ventilation of offices with photocopier machine	↓ **O3**
	Classroom distribution Appropriate number of pupils in each classroom (avoid overcrowding)	↓ **CO2, benzene**
	Adequate ventilation of sanitary facilities and kitchen	↓ **mould and moisture**
	Rare use of basement for learning process	↓ **PM, benzene, toluene, Na, Cl, ethanol**

Table 9: Action plans for management board

	what	improvement
TEACHERS	Organized food distribution in Mensa, not in the classrooms	↓ **unpleasant odour and appearance of pests**
	Natural ventilation every 45 minutes (opening windows and doors)	↓ **CO2**
	Prohibited smoking near the school building	↓ **NO, CO**
	Avoiding hanging different elements near windows	↑ **level of air condition and frequency of fresh air supply**
	Plants in the classrooms	↓ **formaldehyde, benzene, trichlorethylene, carbon monoxide, carbon dioxide**
	Using tables with markers	↑ **PO4** ↓ **benzene**
	Using tables with caulk	↑ **Cl, benzene** ↓ **F**

Table 10: Action plans for teachers

	what	improvement
MAINTAINANCE STAFF	Periodic checking/inspection of the school building	A quick solution, removing moulds and moisture odours
	Installation of air dehumidifier in basement	↓ **relative humidity and preventing the appearance of moulds**
	Installation of doormats on the school entrance	↓ amount of outdoor pollutants
	Natural ventilation in the morning	↑ **fresh air supply and control of pollutants that accumulate in the room at night**
	Pests control	Knowledge of lures, marked places for placing lures, education of pupils in school about the danger of handling lures
	Adequate temperature (20 - 22 °C) and relative humidity (30-50%) in the room	↓ **the appearance of mould and moisture - the installation of measuring devices (involving kids in measurement procedures)**
	Regular control/inspection of filters in mechanical ventilation systems	↓ **particulate matters**

Table 11: Action plans for maintenance staff

	what	improvement
CLEANING STAFF	Regular removal of waste from the classrooms	↓ **unpleasant odour and appearance of pests**
	Inspection of all technical data of all chemicals (appropriate concentration, use of materials)	↓ **VOC, Cl2, NH3**
	Frequency of cleaning	↓**Na, Cl, NO3, benzene**
	Education about the importance of effective cleaning	Improvement of cleaning process
	No fragrances in the sanitary facilities	↓ **phthalates, VOC**
	Use of safe cleaning products	↓ **ammonia, chlorine, VOC**

Table 12: Action plans for cleaning staff

6.1.2. Professionals

	what	improvement
PROFESSIONALS	Good construction management (time plans etc.)	
	Insulation of external wall and pipes	
	Use of wood Use of plastic building materials	↓ **PM, K, toluene** ↑ Mg, VOC. NO3. K , Mg
	Use of safe colours, interior furnishing	↓ **VOC**

Table 13: Action plans for professionals

6.1.3. Government

Public buildings that were built 30-50 years ago are mostly in poor condition due to irregular internal and external maintenance.

Government should ensure regular reconstruction of public buildings from the municipal budget and European budget (schools, health centres, kindergartens etc.).

	what	improvement
GOVERNMENT	Time plan of building renovation	↑ **organization according to needs of reconstruction and project budget**
	Providing parking spots for employees (not near classrooms)	↓ **CO**
	Roof replacement, thermal insulation, replacing windows	↓ **energy consumption**

Table 14: Action plans for government

6.1.4. Parents

Some action plans for parents:

- Surveillance of health status of children (asthma, severe breathing, problems with eyes)
- health status of children survey (questionnaires)
- in case of health problem identification informing the employees of the school

6.2. General process plan for improvement of IAQ in the school buildings

Proposed national protocol for primary schools in Slovenia:

School building: _____ (name, location)

Stage 1. Identify IAQ team members for a school building _____, define an IAQ manager: _____

Stage 2. Vulnerability assessment and SWOT analysis

- School building (surroundings, technical characteristics, maintenance, number of users, their distribution);
- Identification of different actions for improving indoor air quality (what/how)
- Identification of children and employees wellbeing (self-assessment)
- Identification of children and employees' health status (questioner)

Stage 3. Monitoring campaign (measuring process of some pollutants) and check list (professionals assessment of the building status)

Stage 4. Action plans for improvement of indoor air quality (priority list based on school management)

The process of implementation and evaluation of each action:

- Defining the aim of action
- Method of implementation of action
- Time plan
- Stakeholders involvement plan
- Check list of action
- Evaluation of action
- Quality control of action

Stage 5. Defining the periodical monitoring of IAQ in school buildings (frequency, methods, control and action) and defining exceptions.

6.3. Capacity building trainings

The capacity-building is an important part of the national strategy, thus there is a need for education and special handbooks for the target groups. Capacity building trainings will be organized for different target groups:

- School employees
- Building sector
- Government

6.4. Monitoring

Preventive measures regarding indoor air pollution are important. In the long term the priority is to reduce the sources of emissions.

6.5. Awareness raising

Education and training for key groups such as architects, local authorities and owner occupiers should be improved. The authorities' supervisory responsibility with respect to inadequate indoor environments needs to be extended.

Some awareness raising actions should be:

- Informing wider population about the importance of IAQ in primary schools.
- Presentation of monitoring campaign & results.
- Presentation of best practices from other countries based on benchmark visits.

6.6. Legislations

The policy requires that all material should be carefully selected and adequate ventilation provided. Only materials that have been tested and for which toxicological profiles have been issued can be used. IAQ standards should also be used in addition to emission standards of building materials and linings to account for the possible impacts of interaction between the various materials. [7]

Most of the legislation concerning IAQ still needs to be prepared. The exception is the legislation on occupational environment and smoking in public places.

7. Conclusion

Following table presents connections between different building elements and possible pollutants that could have effect on IAQ.

In the next stage **GUIDELINES FOR DESIGNING NEW SCHOOL BUILDINGS** should be prepared by the government and they should be put in legislations.

	Indicator	What it refers to (more in detail)	Possible pollutants
Location (external environment)	Type of location	Residential, city centre, suburban, town, village	Particles
	Building area / Land / external environment	Away from sources of pollution (neighbourhood, traffic, heating, industry).	Particles, NO_2, NO_x, CO, benzene, benzoapiren, etc…
Building characteristics	Building design	Floorplan analysis, separation of the clean and unclean paths, organization of the building premises (spaces)	unpleasant odours
	Type of the building		
	Construction year		

[7] http://apps.who.int/iris/bitstream/handle/10665/108169/E65523.pdf;jsessionid=3F5225F60FC07329B7D24C2DAB62DD80?sequence=1

	State of the building	Renovated (windows, insulation, heating, ventilation, etc.)	Pollutants due to new material (), energy use
	History or current visible signs of water damage, leakage …		Microbiological pollutants
	Visual moulds		Allergens
Building construction	Thermal insulation	materials, planning and implementation	Microbiological pollutants, energy use
	Waterproofing (insulation)	materials, planning and implementation	Dampness (microorganisms)
	Construction	Front, roof, building construction, insulation, windows -Thermal bridges, condensation. Design and implementation of structural parts of buildings (front, roof, building construction, insulation, windows; Thermal bridges, condensation).	Microorganisms
	Materials	Building materials used for construction, isolation, roof covering, etc.	Formaldehyde
MEP (Mechanical, Electrical, and Plumbing)	Ventilation	Proper planning, regular maintenance, toilet facilities adequate ventilation Type, speed, frequency, if ventilation is mechanical: respect of manufacturer's instructions	CO_2, other pollutant (from activity and materials in the classroom) (↑ may increase pollutant from the traffic)
	Heating	Heating method (biomass)	Particles, CO, VOC, PAH, benzopyrene, POPs (persistent organic pollutants)
Equipment 1 (built-in equipment)	Flooring		Formaldehyde
	Paints, varnishes, protective coating		Formaldehyde
	Lightening		
Equipment 2	Furniture		Formaldehyde
	Products made by pupils, decorations	Drawings, paintings, art products - paint, adhesives, varnishes	Formaldehyde
	Things children bring to school		
	Pot plants (soil)		↑ microorganisms (moulds), ↓ formaldehyde, CO, benzene, trichloroethylene, CO_2
	Possible pets in the class		Microorganisms
Equipment 3 (technical stuff)	Computer equipment		O_3, phenol, toluene, 2-ethylhexanol, formaldehyde, *increase SBS symptoms, dissatisfaction with the perceived air quality*
	Air conditioning		
Processes	Ventilation	Mechanical / natural ventilation, frequency	CO_2, other pollutant in indoor air (from activity and materials in the classroom)

			(↑ may increase pollutant from the traffic)
	Humidity control		Microorganisms (general satisfaction with indoor environment)
	Temperature control		Thermal comfort
	Use of air refreshers, purifiers		Phthalates, VOC (TVOC, Total Volatile Organic Compounds), benzene, formaldehyde. Secondary pollutants (Biogenic Volatile Organic Compounds, BVOCs)
	Use of colours (learning activities, arts)		VOC
	Activities in the classroom (eating, "active" games)	Eating in the classroom / in the dining room Activities - Rising dust, increased metabolic rate (CO2)	unpleasant odours, Particles, dust, CO_2,
	Writing on boards (pens, chalk)		Pens: ↑ PO4 ↓ benzene Chalks: ↑ Cl, benzene ↓ F
	Number of pupils in the classroom		CO_2, microorganisms
	Children attending classes even when they are ill		Microorganisms
Maintenance	Cleaning (process and cleaning products)	When? How often? What chemicals are used for cleaning?	Particles, microorganisms
	Use of natural cleaners		VOC, phthalates, formaldehyde, benzene, Cl2, NH3
	Maintenance of school furniture (broken, worn out)		
Other	Awareness raising Capacity building trainings	Education, awareness about the importance of indoor air quality	General (also specifically applied to problems each school is facing)
	Monitoring IAQ		

Table 15: Connections between building elements and possible pollutants

8. Annex

SI01

VULNARIBILITY ASSESSMENT/ SWOT

School is located near city center of Ljubljana, close to a busy road. The main industrial point source is heating plant. The school building was built from brick and concrete at the

end of the 18th century (1976). It was renovated in 2006 (windows) and 2008 (roof renovation). Air conditioning and mechanical ventilation is only in some parts of the building: kitchen.

MONITORING CAMPAING

The indoor air quality was in the moderate category based on the indoor health index. The main air pollutants were benzene, formaldehyde, CO_2 and particulate matter ($PM_{2.5}$). The concentration of formaldehyde was 15,74 µg/m3 and CO2 1396 ppm. It should be noted that the outdoor value for the $PM_{2.5}$ and benzene mass concentrations were also high (benzene indoor 3,11 µg/m3; outdoor 4,61 µg/m3; $PM_{2.5}$ indoor 12 µg/m3; outdoor 19 µg/m3), thus the inappropriate indoor air quality was mainly caused by the outdoor air pollution.

Furthermore, all the comfort parameters were in the healthy range.

CLASSROOM ASSESSMENT

Curtains, linoleum, chalk, parking lot next to the classroom, old furniture, decoration (arts, glues), some plants

PROPOSED ACTION PLANS

Benzene:

- "Prevention" of the entry of benzene from the outside air (location of parking lots, cigarette smoke, etc.).
- During and after using products that are the source of benzene, the living areas are well ventilated (eg during painting/ use of colors).

Formaldehyde:

- "Prevention" of the entry of formaldehyde from the outside air.
- We select suitable, dedicated furniture and linings - we equip the rooms with interior equipment that does not contain formaldehyde or as little as possible.
- The rooms are ventilated, in particular new, refurbished or equipped with new furniture.
- During and after the use of products that are source of formaldehyde, the school environments are well ventilated.
- Maintain the temperature and relative humidity of the school environments at the lowest comfort levels (formaldehyde concentrations increase with increasing temperature and humidity).

CO2:

- specific frequency and type of natural ventilation (change of protocol)
- reduce the number of children in the class
- add air quality sensors (CO2, T, RH)

PM2,5:

- limit the ventilation of the rooms during the increased traffic, and during the temperature inversion
- reduce biomass heating
- change filters regularly in mechanical ventilation

SI02

VULNARIBILITY ASSESSMENT/ SWOT

School is located near the city center of Ljubljana in residential area, close to busy road, parking lot and agriculture fields. The main industrial point source is heating plant. The school building was built from concrete at the end of the 18th century (1981). It has not

been renovated yet. Air conditioning and mechanical ventilation is only in some parts of the building: kitchen.

MONITORING CAMPAING

The indoor air quality was in the unhealthy category based on the indoor health index.

The main air pollutants were benzene, CO_2 and particulate matter ($PM_{2.5}$). The concentration of CO_2 indoor is 1826 ppm. It should be noted that the outdoor value for the $PM_{2.5}$ and benzene mass concentrations were also high (benzene indoor 3,92 µg/m3; outdoor 4,97 µg/m3; $PM_{2.5}$ indoor 15 µg/m3; outdoor 23 µg/m3), thus the inappropriate indoor air quality was mainly caused by the outdoor air pollution.

Furthermore, one of the comfort parameters was in the unhealthy range; the relative humidity was really low in the classroom (32,6%).

CLASSROOM ASSESSMENT

PROPOSED ACTION PLANS

Benzene:

- "Prevention" of the entry of benzene from the outside air (location of parking lots, cigarette smoke, etc.).
- During and after using products that are the source of benzene, the living areas are well ventilated (eg during painting/ use of colors).

CO2:

- specific frequency and type of natural ventilation (change of protocol)
- reduce the number of children in the class
- add air quality sensors (CO2, T, RH)

PM2,5:

- limit the ventilation of the rooms during the increased traffic, and during the temperature inversion
- reduce biomass heating
- change filters regularly in mechanical ventilation

SI03

VULNARIBILITY ASSESSMENT/ SWOT

School is located in the city center of Ljubljana, close to busy road. The school building was built from brick at the end of the 19th century (1884) and extended in 20th century (1950). It was renovated in 1963 (roof renovation and some other partial renovations like electrical cables, classrooms). Mechanical ventilation is only in some parts of the building: kitchen, gym, and offices.

MONITORING CAMPAING

The indoor air quality was in the moderate category based on the indoor health index. The main air pollutants are benzene, formaldehyde, CO_2 and particulate matter ($PM_{2.5}$). The concentration of formaldehyde was 11,26 µg/m3 and CO_2 1353 ppm. It should be

noted that the outdoor value for the benzene and $PM_{2.5}$ mass concentration was also high (benzene indoor 4,08 µg/m3; outdoor 4,36 µg/m3; $PM_{2.5}$ indoor 11 µg/m3; outdoor 14 µg/m3), thus the inappropriate indoor air quality was mainly caused by the outdoor air pollution.

Furthermore, one of the comfort parameters was in the moderate range; the relative humidity was low in the classroom (40%).

CLASSROOM ASSESSMENT

Curtains, decoration (arts), linoleum, chalkboards, Some classrooms are located near parking lot

PROPOSED ACTION PLANS

Benzene:

- "Prevention" of the entry of benzene from the outside air (location of parking lots, cigarette smoke, etc.).
- During and after using products that are the source of benzene, the living areas are well ventilated (eg during painting/ use of colors).

Formaldehyde:

- "Prevention" of the entry of formaldehyde from the outside air.
- We select suitable, dedicated furniture and linings - we equip the rooms with interior equipment that does not contain formaldehyde or as little as possible.
- The rooms are ventilated, in particular new, refurbished or equipped with new furniture.
- During and after the use of products that are source of formaldehyde, the school environments are well ventilated.
- Maintain the temperature and relative humidity of the school environments at the lowest comfort levels (formaldehyde concentrations increase with increasing temperature and humidity).

CO2:

- specific frequency and type of natural ventilation (change of protocol)
- reduce the number of children in the class
- add air quality sensors (CO2, T, RH)

PM2,5:

- limit the ventilation of the rooms during the increased traffic, and during the temperature inversion
- reduce biomass heating
- change filters regularly in mechanical ventilation

SI04

VULNARIBILITY ASSESSMENT/ SWOT

School is located in the city center of Ljubljana, close to busy road and railway. The school building was built from brick and wood at the beginning of the 20th century (1908) and extended at the end of the 20th century (1976). It was renovated in 1988 (roof) and in 1992 (façade). Mechanical ventilation is only in some parts of the building: kitchen, and computer room.

MONITORING CAMPAING

The indoor air quality was in the unhealthy category based on the indoor health index. The main air pollutant is benzene and particulate matter ($PM_{2.5}$). It should be noted that the outdoor value for the benzene and $PM_{2.5}$ mass concentration was lower than indoor

(indoor 5,07 µg/m3; outdoor 3,93 µg/m3; $PM_{2.5}$ indoor 11 µg/m3; outdoor 13 µg/m3), thus the inappropriate indoor air quality was mainly caused by the indoor air pollution.

Furthermore, one of the comfort parameters was in the unhealthy range; the relative humidity was low in the classroom (31,2%).

CLASSROOM ASSESSMENT

Decoration (arts), wooden floor, chalk and pens, a few small plants

PROPOSED ACTION PLANS

Benzene:

- "Prevention" of the entry of benzene from the outside air (location of parking lots, cigarette smoke, etc.).
- During and after using products that are the source of benzene, the living areas are well ventilated (eg during painting/ use of colors).

PM2,5:

- limit the ventilation of the rooms during the increased traffic, and during the temperature inversion
- reduce biomass heating
- change filters regularly in mechanical ventilation

SI05

VULNARIBILITY ASSESSMENT/ SWOT

School is located in the suburban area, close to the main road, light industry and agriculture fields. The school building was built from brick and concrete at the beginning of the 21st century (2000). It has not been renovated yet. Mechanical ventilation is only in some parts of the building: kitchen.

MONITORING CAMPAING

The indoor air quality was in the moderate category based on the indoor health index. The main air pollutant is formaldehyde (12,38 µg/m3).

Furthermore, all comfort parameters were in the healthy range.

CLASSROOM ASSESSMENT

Linoleum, decoration (medium), jabooz, quite new furniture

PROPOSED ACTION PLANS

Formaldehyde:

- "Prevention" of the entry of formaldehyde from the outside air.
- We select suitable, dedicated furniture and linings - we equip the rooms with interior equipment that does not contain formaldehyde or as little as possible.
- The rooms are ventilated, in particular new, refurbished or equipped with new furniture.
- During and after the use of products that are source of formaldehyde, the school environments are well ventilated.
- Maintain the temperature and relative humidity of the school environments at the lowest comfort levels (formaldehyde concentrations increase with increasing temperature and humidity).

SI06

VULNARIBILITY ASSESSMENT/ SWOT

School is located in the city center of Logatec, close to the main road, light industry, agriculture fields and waste storage site. Nearby were noted also a lot of individual heating devices. The school building was built from brick, concrete and stone at the end of the 19th century (1883) and extended at the end of the 20th century (1976). It was renovated in 1994 (roof) and in 1996 (façade). Mechanical ventilation is only in some parts of the building: kitchen, dining room, and school hall.

MONITORING CAMPAING

The indoor air quality was in the moderate category based on the indoor health index. The main air pollutants are benzene, and formaldehyde. The concentration of formaldehyde was 11,47 µg/m3. It should be noted that the outdoor value for the benzene mass concentration was quite similar to the indoor (indoor 2,46 µg/m3; outdoor 2,43µg/m3), thus the inappropriate indoor air quality was probably mainly caused by the indoor air pollution.

Furthermore, one of the comfort parameters was in the moderate range; the relative humidity was low in the classroom (37%).

CLASSROOM ASSESSMENT

Very little decoration, wooden floor, pens and chalks

PROPOSED ACTION PLANS

Benzene:

- "Prevention" of the entry of benzene from the outside air (location of parking lots, cigarette smoke, etc.).
- During and after using products that are the source of benzene, the living areas are well ventilated (eg during painting/ use of colors).

Formaldehyde:

- "Prevention" of the entry of formaldehyde from the outside air.
- We select suitable, dedicated furniture and linings - we equip the rooms with interior equipment that does not contain formaldehyde or as little as possible.
- The rooms are ventilated, in particular new, refurbished or equipped with new furniture.
- During and after the use of products that are source of formaldehyde, the school environments are well ventilated.
- Maintain the temperature and relative humidity of the school environments at the lowest comfort levels (formaldehyde concentrations increase with increasing temperature and humidity).

SI07

VULNARIBILITY ASSESSMENT/ SWOT

School is located in the suburban area, close to the main road and main railway node, light industry, and agriculture fields. Nearby were noted also a lot of individual heating devices. The school building was built from concrete at the end of the 20th century (1995) and extended at the beginning of the 21st century (2010). It was renovated in 2010 (roof and façade). Mechanical ventilation is only in some parts of the building: kitchen, office, and in four classrooms.

MONITORING CAMPAING

The indoor air quality was in the moderate category based on the indoor health index. The main air pollutant is benzene. It should be noted that the outdoor value for the benzene mass concentration was lower than indoor (indoor 1,94 µg/m3; outdoor 1,86 µg/m3), thus the inappropriate indoor air quality was probably mainly caused by the indoor air pollution.

Furthermore, one of the comfort parameters was in the moderate range; the relative humidity was low in the classroom (41,4%).

CLASSROOM ASSESSMENT

Very little decoration, linoleum, chalk, little plants

PROPOSED ACTION PLANS

Benzene:

- "Prevention" of the entry of benzene from the outside air (location of parking lots, cigarette smoke, etc.).
- During and after using products that are the source of benzene, the living areas are well ventilated (eg during painting/ use of colors).

SI08

VULNARIBILITY ASSESSMENT/ SWOT

School is located in the village, close to the main road, medium industry, and agriculture fields. The school building was built from brick, concrete and iron at the end of the 20th century (1975). It was renovated in 2013 (partial renovation: windows, insulation – façade, new mechanical ventilation). Mechanical ventilation is in the whole building.

MONITORING CAMPAING

The indoor air quality was in the moderate category based on the indoor health index. The main air pollutants are benzene, formaldehyde and $C0_2$. The concentration of formaldehyde was 16,86 µg/m3 and CO2 1247 ppm. It should be noted that the outdoor value for the benzene mass concentration was higher than indoor (indoor 4,04 µg/m3; outdoor 5,96 µg/m3), thus the inappropriate indoor air quality was probably mainly caused by the indoor air pollution.

Furthermore, one of the comfort parameters was in the moderate range; the relative humidity was low in the classroom (37,4%).

CLASSROOM ASSESSMENT

Little decoration, wooden floor, green space around the school

PROPOSED ACTION PLANS

Benzene:

- "Prevention" of the entry of benzene from the outside air (location of parking lots, cigarette smoke, etc.).
- During and after using products that are the source of benzene, the living areas are well ventilated (eg during painting/ use of colors).

Formaldehyde:

- "Prevention" of the entry of formaldehyde from the outside air.
- We select suitable, dedicated furniture and linings - we equip the rooms with interior equipment that does not contain formaldehyde or as little as possible.
- The rooms are ventilated, in particular new, refurbished or equipped with new furniture.
- During and after the use of products that are source of formaldehyde, the school environments are well ventilated.
- Maintain the temperature and relative humidity of the school environments at the lowest comfort levels (formaldehyde concentrations increase with increasing temperature and humidity).

CO2:

- specific frequency and type of natural ventilation (change of protocol)
- reduce the number of children in the class
- add air quality sensors (CO2, T, RH)

SI09

VULNARIBILITY ASSESSMENT/ SWOT

School is located in the town, close to the main road, and agriculture fields. The school building was built from brick, and concrete at the end of the 20th century (1974) and extended at the beginning of the 21st century (2006). It was renovated in 2006 (partial renovation: roof and façade). Mechanical ventilation is only in some parts of the building: kitchen, and school hall.

MONITORING CAMPAING

The indoor air quality was in the unhealthy category based on the indoor health index. The main air pollutant is benzene. It should be noted that the outdoor value for the benzene mass concentration was higher than indoor (indoor 1,99 µg/m3; outdoor 6,64 µg/m3), thus the inappropriate indoor air quality was probably mainly caused by the indoor air pollution.

Furthermore, one of the comfort parameters was in the unhealthy range; the relative humidity was low in the classroom (34,8%).

CLASSROOM ASSESSMENT

Wooden floor, chalk, car park, decoration

PROPOSED ACTION PLANS

Benzene:

- "Prevention" of the entry of benzene from the outside air (location of parking lots, cigarette smoke, etc.).
- During and after using products that are the source of benzene, the living areas are well ventilated (eg during painting/ use of colors).

SI10

VULNARIBILITY ASSESSMENT/ SWOT

School is located in the town, close to the main road, medium industry and agriculture fields. The school building was built from brick, and concrete at the end of the 20th century (1967). It was partial renovated: electric cables, water system, and flooring in the classrooms. Mechanical ventilation is only in some parts of the building: kitchen, and office.

MONITORING CAMPAING

The indoor air quality was in the very unhealthy category based on the indoor health index. The main air pollutant is benzene, CO_2 and particulate matter ($PM_{2.5}$). The concentration of CO_2 was 1439 ppm. It should be noted that the outdoor value for the benzene and $PM_{2.5}$ mass concentration was different than indoor (benzene: indoor 9,79 µg/m3; outdoor 5,43 µg/m3; $PM_{2.5}$ indoor 19 µg/m3; outdoor 24 µg/m3), thus the inappropriate indoor air quality was probably caused by the indoor/outdoor air pollution.

Furthermore, one of the comfort parameters was in the moderate range; the relative humidity was low in the classroom (37,6%).

CLASSROOM ASSESSMENT

Tiles on the floor, decoration (little), chalk, new furniture

PROPOSED ACTION PLANS

Benzene:

- "Prevention" of the entry of benzene from the outside air (location of parking lots, cigarette smoke, etc.).
- During and after using products that are the source of benzene, the living areas are well ventilated (eg during painting/ use of colors).

CO2:

- specific frequency and type of natural ventilation (change of protocol)
- reduce the number of children in the class
- add air quality sensors (CO2, T, RH)

PM2,5:

- limit the ventilation of the rooms during the increased traffic, and during the temperature inversion
- reduce biomass heating
- change filters regularly in mechanical ventilation

SI11

VULNARIBILITY ASSESSMENT/ SWOT

School is located in the town, close to the busy road, parking lot, medium industry and agriculture fields. The school building was built from brick, and concrete at the end of the 20th century (1972). It was partial renovated in 2016: electric cables, lighting, water system, classrooms, windows and insulation. Mechanical ventilation is only in some parts of the building: kitchen.

MONITORING CAMPAING

The indoor air quality was in the moderate category based on the indoor health index. The main air pollutants are benzene, formaldehyde, particulate matter ($PM_{2.5}$), and CO_2.

The concentration of formaldehyde was 13,64 µg/m3, and CO_2 1503 ppm. It should be noted that the outdoor value for the benzene and $PM_{2.5}$ mass concentration was similar to the indoor (benzene: indoor 4,86µg/m3; outdoor 4,84 µg/m3; $PM_{2.5}$: indoor 15µg/m3; outdoor 14 µg/m3), thus the inappropriate indoor air quality was probably caused by the indoor and outdoor air pollution.

Furthermore, all comfort parameters were in the healthy range.

CLASSROOM ASSESSMENT

Decoration, wooden floor, chalk, pens

PROPOSED ACTION PLANS

Benzene:

- "Prevention" of the entry of benzene from the outside air (location of parking lots, cigarette smoke, etc.).
- During and after using products that are the source of benzene, the living areas are well ventilated (eg during painting/ use of colors).

Formaldehyde:

- "Prevention" of the entry of formaldehyde from the outside air.
- We select suitable, dedicated furniture and linings - we equip the rooms with interior equipment that does not contain formaldehyde or as little as possible.
- The rooms are ventilated, in particular new, refurbished or equipped with new furniture.
- During and after the use of products that are source of formaldehyde, the school environments are well ventilated.
- Maintain the temperature and relative humidity of the school environments at the lowest comfort levels (formaldehyde concentrations increase with increasing temperature and humidity).

CO2:

- specific frequency and type of natural ventilation (change of protocol)
- reduce the number of children in the class
- add air quality sensors (CO2, T, RH)

PM2,5:

- limit the ventilation of the rooms during the increased traffic, and during the temperature inversion
- reduce biomass heating
- change filters regularly in mechanical ventilation

SI12

VULNARIBILITY ASSESSMENT/ SWOT

School is located in the village, close to the road, parking lot, medium industry and agriculture fields. Nearby were noted also a lot of individual heating devices. The school building was built from concrete at the end of the 20th century (1978) and extended at the beginning of the 21st century (2006). It has not been renovated yet. Mechanical ventilation is only in some parts of the building: kitchen and two classrooms.

MONITORING CAMPAING

The indoor air quality was in the moderate category based on the indoor health index. The main air pollutants are benzene, formaldehyde, and particulate matter ($PM_{2.5}$). The concentration of formaldehyde was 12,89 µg/m3. It should be noted that the outdoor value for the benzene and $PM_{2.5}$ mass concentration was higher than indoor (benzene:

indoor 2,03 µg/m3; outdoor 2,17 µg/m3; $PM_{2.5}$: indoor 11µg/m3; outdoor 12 µg/m3), thus the inappropriate indoor air quality was probably caused by the outdoor air pollution.

Furthermore, one of the comfort parameters was in the moderate range; the relative humidity was low in the classroom (40,8%).

CLASSROOM ASSESSMENT (based on check list)

Decoration (little), linoleum, chalk, pens, a lot of curtains

PROPOSED ACTION PLANS

Benzene:

- "Prevention" of the entry of benzene from the outside air (location of parking lots, cigarette smoke, etc.).
- During and after using products that are the source of benzene, the living areas are well ventilated (eg during painting/ use of colors).

Formaldehyde:

- "Prevention" of the entry of formaldehyde from the outside air.
- We select suitable, dedicated furniture and linings - we equip the rooms with interior equipment that does not contain formaldehyde or as little as possible.
- The rooms are ventilated, in particular new, refurbished or equipped with new furniture.
- During and after the use of products that are source of formaldehyde, the school environments are well ventilated.
- Maintain the temperature and relative humidity of the school environments at the lowest comfort levels (formaldehyde concentrations increase with increasing temperature and humidity).

PM2,5:

- limit the ventilation of the rooms during the increased traffic, and during the temperature inversion
- reduce biomass heating
- change filters regularly in mechanical ventilation