NATIONAL INDOOR AIR QUALITY ACTION PLAN

Hungary

Version 1
2018

Indice

A. Introduction

Indoor air quality (IAQ) in primary school buildings is of great importance as children spend approximately 6-8 h daily in the school enviroment. IAQ measurements have already been performed in the frame of international projects (i.e. SEARCH and SINPHONIE) in Hungary. In total, 16 school buildings were investigated before 2012. Some questions have already been answered regarding the indoor (school) environment; however, there are still several unanswered questions. In order to solve IAQ-related problems related to primary school buildings, a national IAQ action plan has to be elaborated. It helps to integrate activities that affect the IAQ into the system's normal use, management and maintenance. The aim is to create a healthier indoor environment by improving IAQ through reducing or eliminating the sources of air pollutants and setting rules or preventive measures.

The preparation of the national action plan is based on the Joint Transnational Strategy for Indoor Air Quality Action Plans developed within the InAirQ project. Integral parts of the strategy are the vulnerability assessment, the SWOT analysis and the environmental and health surveillance methods. Based on the methods applied for baselining and the results of the IAQ monitoring campaigns, recommendations are suggested.

The extent of air pollution in the building of a school depends on the interaction between the building and its external environment, as well as the way the building was built, what kind of building material were used, how it is equipped and how it is used. Thus, the national IAQ action plan must focus on different target groups including policy makers, national bodies responsible for the maintenance of the school, teacher, parents and architects.

Recently, there is no consensus on how to regulate IAQ worldwide. There is a big effort to establish IA guidelines at national level in Hungary. Regulations might have a positive effect on IAQ.

B. Primary school education and the state of school buildings in Hungary

There are several national institutes and national bodies which collect and synthetize data on education in Hungary. The latest statistical data on public education can be found in the Statistical Mirror of the Central Statistical Office for 2016/2017 and from "Statistical Yearbook of Public Education 2016/2017" published by the Ministry of Human Capacities in 2018 and it contains mostly basic information.

In the school year of 2016/2017 approximately 741 000 students attended primary schools. Education for children usually takes 8 years (grades 1 to 8; from age 6 to age 14) in primary schools in Hungary. However, students can apply for long secondary programs which means that grades 5 to 8 or grades 7 and 8 can be completed in the eight-grade or six-grade general secondary school respectively. Approximately 25 000 students studied in grades 5 to 8 in long secondary programs in secondary schools. The number of students in primary schools in 2016/2017 decreased by 35.4% compared to the number of students in the school year of 1980/1981 which is in line with the changes in the demographic features of Hungary. Approximately 74 000 teachers were working full- or part-time in primary schools in the school year of 2016/2017. In contrast to the considerable change in the number of students, only a slight decrease (6.2%) could be observed in the number of teachers in the past 25 years. The student/teacher ratio was 10% in the school year of 2016/2017 with an average class size of 20.2. The number of institutes for primary education was 3 589 in 2016/2017. Approximately 36 500 classrooms were counted in the primary schools in the school year of 2016/2017. The state is responsible for providing public education, thus most of the schools (81.0%) are maintained by the state (e.g., Klebelsberg Institute Maintenance Centre, public bodies) (Figure 1). However, the contribution of other participants such as churches (14.6%) to the maintenance is also considerable. Nowadays, there are more and more primary schools which are being taken over by churches. Accordingly, the amount of financial support for reconstruction works can differ significantly among the schools.

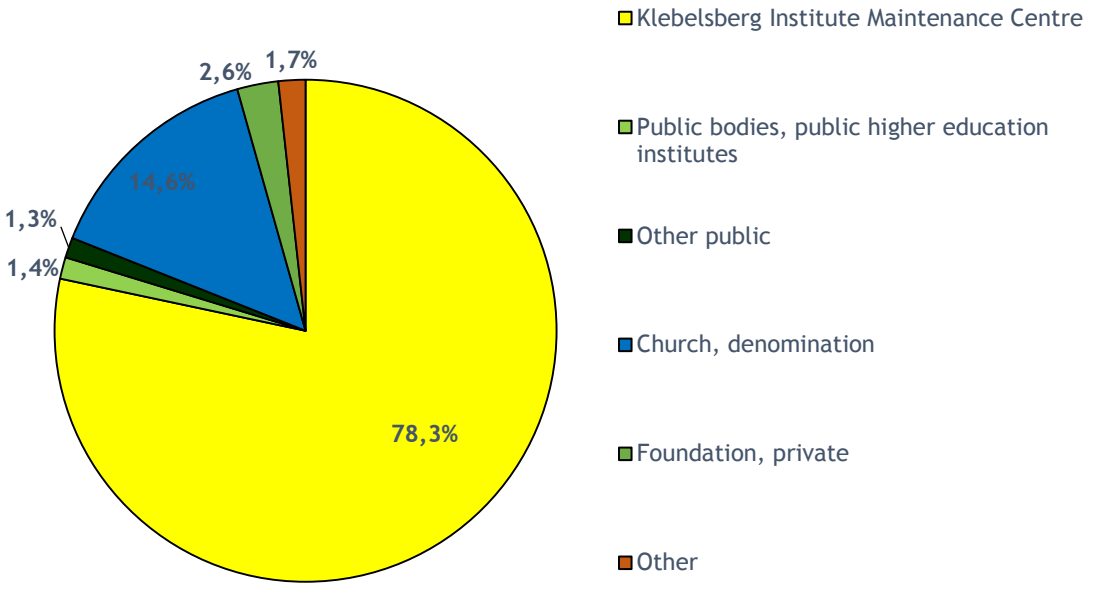


Figure 1. Maintainer of the school

To the best of our knowledge, there is no statistical data on the age of the primary school buildings. However, it must be noted that the year of construction of the educational buildings varies considerably. The school construction activity was the most intense between 1950 and 1990; however, lots of primary school buildings were built before 1900. The school buildings can be grouped into different types according to their year of construction (Table 1). Each group has its own building characteristics; they differ in the building materials used, dimensions of the classrooms or energy consumption.

Table 1. Typology of school buildings (Source: National Building Energy Performance Strategy)

Year of construction	Type of building
before 1900	3-storey regular-shaped school building
	2-storey U-shaped school building
1900-1945	3-storey regular-shaped school building
	2-storey U-shaped school building
1946-1979	School building from the 1950s built in the socialist realist style
	School building from the 1970s built from self-supporting prefabricated panels
1980-1989	3-storey regular-shaped school building
	2-storey U-shaped school building
after 1990	3-storey regular-shaped school building
	2-storey U-shaped school building

In general, most of the school buildings were in bad condition in the 1990s. In the past decade, funds (e.g., energy efficiency programs) made some renovation works possible including the replacement of windows and/or the modernization of lighting, insulation and heating. Recently, a greater number of renovation works are in process since some more funds are available. Primary school buildings maintained by churches or foundations are generally in better condition due to the higher amount of financial support provided by the maintainer, while state school buildings still need renovation in many fields (e.g., water-system, electric cables and furniture). The state provided financial support mostly to improve the educational tools (e.g., new computers and boards) and less support remained for the renovation works. In addition, the duration of these works usually takes longer in the case of school buildings maintained by the state. Accordingly, the renovation work is often carried out during the school term in the case of school buildings maintained by the state and, consequently, students might be exposed to higher level of noise and air pollution. Natural ventilation is used in the primary schools in Hungary which requires the good practice of windows opening in order to avoid high carbon dioxide concentration values indoors.

Besides the renovation works carried out during the school term, there are other potential sources of air pollution as well as factors which might have an influence on children`s health and well-being.

School buildings built prior to the 1980s might contain water-pipe systems made of lead. Lead can leach from the pipe into the drinking water and might cause adverse health effects even at low concentration levels. Lead is particularly dangerous to children because their growing bodies absorb more lead than adults do and their brains and nervous systems are more sensitive to the damaging effects of lead.

Asbestos was a frequently used material during the construction of buildings mainly between 1970 and 1985. There might be several primary school buildings in Hungary which still contain asbestos. Exposure to asbestos fibers is associated with respiratory diseases including mesothelioma. The risk associated with asbestos in the indoor environment is still not investigated in Hungary.

The selection of new flooring material and furniture has to be done with care during renovation works. Several consumer/building products emit volatile organic compounds which might cause sensory irritation in the eyes and airways and deterioration of performance. Recently, the replacement of old windows to airtight ones in the primary schools could lead to the reduction of energy used for heating; however, the concentration of indoor air pollutants (e.g., volatile organic compounds, carbon dioxide) might be higher due to the lower air exchange rates. In addition, several windows cannot be opened because they are either fixed or dangerous (poor quality).

Several primary school buildings were built at sites which are characterized by significant air pollution and noise level. The proximity of busy roads is one of the most important determinants of air quality and noise level. Easy access through major roads and public transport was probably one of the most important parameters that people take into consideration when the school buildings were built. Accordingly, actions should be taken in order to decrease the concentration of air pollutants outdoors and the noise level around the primary school buildings.

Further information on the primary school buildings can also be found in the National Survey of Children's Respiratory Health reports prepared by the National Public Health Center in 2005 and 2010. Both surveys were carried out in all primary schools in Hungary. New data will be collected in 2017 during a nationwide survey.

C. Policies on the indoor environment in school buildings

One of the main purposes of the vulnerability assessment was to review the existing policies, i.e. officially adopted documents on the indoor environment. Based on the type of policy, legally binding standards or regulations, legally non-binding recommendations or guidelines as well as action plans or programs are distinguished. Furthermore, policies exist at different levels such as international, national and sub-national (regional) levels. International bodies have developed several regulations and guidelines on selected air pollutants outdoors; however, there are still no regulations on the concentration of air pollutants indoors. In 2010, the World Health Organization (WHO) published a book ("WHO guidelines for indoor air quality: selected pollutants") in which some common indoor air pollutants are reviewed and guidelines are recommended. Besides the international bodies, there is a big effort to establish IAQ guidelines at national or at sub-national levels in several countries all over the world. The WHO collected the relevant information by the "Environment and health policy action questionnaire" from the member states and the results of the work were published in late 2014.

In Hungary, the National Public Health Center is responsible for (i) highlighting that adequate IAQ is needed in the classrooms, (ii) investigating both the IAQ and the health of the schoolchildren and (iii) encouraging policy makers to develop national strategies. Recently, there is no consensus on how to regulate IAQ in school buildings in Hungary. A draft Ministerial Order has already been developed by the National Public Health Center in the past decade and its latest version has already been submitted to the Ministry of Human Capacities for harmonization and adoption is expected in 2020. The indoor air pollutants covered by this draft Ministerial Order as well as the recommended limit values and averaging periods are listed in Table 2.

Table 2. Recommended limit values and averaging periods for some selected air pollutants in Hungary (draft Ministerial Order).

Pollutant	Concentration	Averaging period
$PM_{2.5}$	25 μg m^{-3}	24 h
PM_{10}	50 μg m^{-3}	24 h
Nitrogen dioxide	40 μg m^{-3}	1 week
	100 μg m^{-3}	24 h
	200 μg m^{-3}	1 h
Ozone	50 μg m^{-3}	24 h
	80 μg m^{-3}	1 week
Carbon monoxide	3 000 μg m^{-3}	24 h
	8 000 μg m^{-3}	1 week
Carbon dioxide	1 500 ppm	1 week
Benzene	5 μg m^{-3}	1 week
	10 μg m^{-3}	24 h
Formaldehyde	30 μg m^{-3}	1 week
	50 μg m^{-3}	24 h
Trichloroethylene	10 μg m^{-3}	1 week
Tetrachloroethylene	250 μg m^{-3}	1 week
Radon	400 Beq m^{-3}	1 year

The draft Ministerial Order contains recommendations also for the biological contaminants (i.e. mould, dust mite, bacteria and endotoxins) in the indoor environment.

There is no regular IAQ monitoring or surveillance to assess the levels of indoor air pollutants in schools buildings in Hungary; however, there have been two international research projects focusing on assessing exposures to indoor air pollutants in school buildings.

The SEARCH (School Environment and Respiratory Health of Children) project was carried out between 2006 and 2013 in two phases: SEARCH I (2006-2010) and SEARCH II (2010-2013). In total, 10 school buildings were investigated in Hungary.

The SINPHONIE (Schools Indoor Pollution and Health: Observatory Network in Europe) project was carried out between 2011 and 2013 and 6 school buildings were investigated in Hungary.

Details of the research projects are presented in Section 6 (Review of indoor air quality data).

It is well-known that the temperature in the classrooms is matter of human comfort. Thus, there are three national policies that set requirements or recommendations on the indoor temperature controlled by different systems in school buildings in Hungary. The minimum and maximum operational temperature values in school buildings were set to 20 and 26°C respectively. The temperature has to be controlled in the case of both heating (between 20 - 24°C) and cooling (between 22 and 26 °C).

The following policies are in force regarding this issue:

- Ministerial Decree 7/2006. (V. 24.) of TNM on the specification of energy performance of buildings (Annex 1: Table V/1.) (year of adoption: 2006).
- Standard on recommended average indoor temperatures: National Standards on the requirements for design of institutions for education: MSZE 24203-2:2012 (year of adoption: 2012).
- Standard on indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics: MSZ EN 15251:2007 (year of adoption: 2007).

The minimum ventilation rate was set at 25.2 m^3/h/person and is described in the Ministerial Decree 7/2006. (V. 24.) of TNM on the specification of energy performance of buildings (Annex 1: V.2.1.) (year of adoption: 2006).

According to this Ministerial Decree, the indoor carbon dioxide level can exceed the corresponding outdoor concentration value by not more than 500 ppm (applicable only for non-residential buildings).

In order to prevent children`s exposure to carbon monoxide in educational buildings in Hungary, it is compulsory to install carbon monoxide detectors if open-fire combustion

sources (e.g. gas central heating) are present indoors and the combustion by-products can spread in the building by air exchange. Further details can be found in the Act XC. of 2012 on the public service of chimney sweeping (9. § (5)) (year of adoption: 2013).

Regulation on the minimum distance (10 m) between school building and parking space or bus stop exists to prevent significant outdoor air pollution at school buildings. Further details are provided in the Government Decree 253/1997. (XII. 20.) on the national urban planning and building requirements (10. § (3), 42. § (9) b)) (year of adoption: 1998). Furthermore, the draft Ministerial Order titled "Public health and health protection requirements of design, construction and operation of buildings" contains a section about the minimum distances (>50 m) between educational buildings and certain air pollution sources (industrial sites, railway stations, petrol stations, busy road) that might affect air quality. The recommendations in the draft Ministerial Order are stricter compared to the Government Decree.

To prevent non-smokers from tobacco smoke, strict regulations are in force in Hungary. Indoor smoking is strictly prohibited in workplaces and public places (including bars, pubs, restaurants). Smoking is permitted only at designated outdoor places (distance from the entrance of the building is at least 5 m). However, smoking is not permitted at outdoor places in educational and other children facilities and health care facilities (e.g., courtyard). Details can be found in the Act XLII. of 1999 on the protection of non-smokers (modified by Act CCXII. of 2012) (year of adoption of the modification: 2012).

D. SWOT analysis

SWOT is an acronym for *strength, weaknesses, opportunities and threats* to be assessed – in this case – concerning the IAQ in schools. SWOT analysis is a method to identify the internal and external factors which may have favourable or unfavourable impact on the school environment.

The SWOT categories provide important information:

- **S**trengths: internal positive attributes of the school environment that can facilitate activities aimed to improve the IAQ.
- **W**eaknesses: internal attributes of the school environment that may hinder activities aimed to improve the IAQ.
- **O**pportunities: external conditions that may facilitate activities aimed to improve the IAQ in schools.
- **T**hreats: external conditions that may complicate activities aimed to improve the IAQ in schools.

Identification of SWOTs is important because they can inform later steps of planning to achieve the objective. Users of SWOT analysis must ask and answer questions that generate meaningful information to each category.

The SWOT analysis groups key pieces of information into two main categories:

a.) internal factors (strength and weaknesses within the project)

b.) external factors (the opportunities and threats presented by the external environment)

The SWOT analysis has been carried out for the Hungarian situation as follows:

1. **The internal analysis** has been performed. It examined the advantages and drawbacks of school environment on the IAQ. This was achieved by the analysis of the

current state of school environment (*Strengths and Weaknesses*) and the impact of the school environment on the IAQ.

2. The **external analysis** has also been performed. It examined the main relevant points in the analysis of the actual state of policy-related factors which are independent of the schools (e.g. legislation in force, financial environment). They were identified as *Opportunities or Threats* or obstacles to be addressed in future.

3. The collected information (according to points 1 and 2) was filled in the SWOT analysis tool (enclosed table).

In the SWOT analysis the **following parameters were taken into account**:

- education policy;
- demographic trends
- legislation(s) in force;
- financial environment;
- stakeholders (including authorities) involvement;
- current state of the applied technology (including building technology, HVAC systems, building finishing and furnishings);
- possibility of modern technology development and innovation (including building technology, HVAC systems, building finishing and furnishings);
- dissemination of knowledge and increase of awareness of school managements regarding to ensure the good IAQ;
- trends in public health that may affect the IAQ.

SWOT Analysis Tool

Improvement of the Indoor Air Quality in the school environment

Identified Strengths, Weaknesses, Opportunities and Threats limited to the maximum of ten under each heading (according to the agreed methodology).

	Internal analysis	
SWOT analysis tool	**STRENGTHS** ***What has a positive impact on the school environment regarding IAQ?*** 1. The ownership of schools (the management can accelerate the renovation of buildings) 2. The involvement of management, technical personnel and teachers. 3. Municipal heating (the vast majority of schools). 4. Mean number of pupils is 20.2. 5. Renovation of buildings, windows (due to operational programs). 6. Direct contact with the parents of the pupils.	**WEAKNESSES** ***What has a negative impact on the school environment regarding IAQ?*** 1. Low awareness of indoor air quality. 2. Age of school buildings. 3. Old water pipes containing Pb. 4. Asbestos as insulation. 5. New furniture emitting VOCs, aldehydes. 6.Classroom walls painted with water-resistant paints; plastic floor in the classrooms 7. Ambient noise exposure. 8. Overcrowding of classes. 9. Lack of the proper equipment to check the airflow value in the ventilation ducts. 10. Lack of air conditioning system in classrooms.

External analysis	**OPPORTUNITIES** ***What are the opportunities to improve the IAQ in the school environment?*** 1. A questionnaire survey of the Public Health Department of Governmental Agencies every 5 year. 2. Inspection of schools by Public Health Departments. 3. Post-inspection recommendations of Public Health Departments. 4. Guidance and recommendations developed in the frame of projects aimed at improving the indoor air quality in schools. 5. Ongoing process of thermo-modernization of schools in line with the EU directive. 6. 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. Proper selection of materials and technological processes used in the thermo-modernization of the school. 2. Use of guidance and recommendations developed in projects aimed at improving the indoor air quality in schools. 3. Repair / clean the ventilation ducts during the thermo-modernization process. 4. The possibility of regulating the activity of children depending on outside air quality. 5. Observation of the incidence of respiratory diseases, allergies listed in the literature as associated with air pollution among pupils and undertaking of	**Opportunity-Weakness (OW) Strategies** ***How can we overcome Weaknesses by taking advantage of Opportunities?*** 1. Frequent ventilation of classes (opening of the windows). 2. Proper timing of painting the classrooms with water soluble paints. 4. Optimization of the daily routine cleaning and thorough cleaning. 5. New furniture should be bought during summer and kept in rooms with proper ventilation. 6. Conducting of the literature review and disseminate selected publications among school personnel to raise awareness of air quality. 7. Training and educating cleaning personnel about the proper technology of cleaning.

		activities in case of increased morbidity among school children (e.g. in selected classes). 6. Introduction of proper cleaning technology: non-irritant cleaning chemicals, proper timing and frequency of cleaning.	
	THREATS ***What are the threats that can negatively influence the IAQ in the school environment?*** 1. Surroundings of schools (industry, PM emission). 2. Heavy traffic. 3. Infiltration of the large amounts of PM into the inside school environment from the outside. 4. Lead exposure due to old water pipes. 5. Legal regulations in force – lack of detailed requirements for ensuring proper indoor air quality in the school classes. 6. Lack of funds for necessary repairs.	**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 (e.g. 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 owners on the basis of the post-inspection	**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 students. 2. Improvement of the involvement of school staff and parents to take actions towards the improvement of the indoor air quality in schools.

	7. The schools belonging to the state are managed by one agency. 8. Lack of funds for the installation of modern HVAC systems. 9. Low awareness of indoor air quality among the school management. 10. Low awareness of parents – less parental pressure on the school management.	recommendations of the Public Health Authorities. 5. Conducting of the literature review and disseminate selected publications among parents to raise awareness of air quality.	

E. Outdoor air pollution in Hungary

Outdoor air pollution has a significant influence on IAQ, thus information on the concentration of air pollutants outdoors is important. The Hungarian Air Quality Monitoring Network provides recent and historical air quality data nationwide. Fifty-four automatic air quality monitoring stations are operating in Hungary; 12 of them are located in the capital city, Budapest. One mobile air quality monitoring station is also in use to perform measurements in those sites where automatic monitoring stations are not available. The monitoring stations are located in urban (traffic, industrial or background), suburban (traffic, industrial or background) and rural (background or industrial) areas. The investigated air pollutants are nitrogen oxides (NO, NO_2, NO_x), sulphur dioxide, carbon monoxide, ozone and PM_{10} at all stations. In addition, there are some stations where the concentration of $PM_{2.5}$, PM_1 and BTEX (benzene, toluene, ethylbenzene and xylenes) is also measured. All data (hourly mean) are available at the webpage of the Hungarian Air Quality Network (Figure 2). The collected data are analysed by the Air Hygiene Group at the National Public Health Center every day. An Air Hygiene Index (including 4 categories: 1: good; 2: moderate; 3: unhealthy; 4 hazardous) is calculated for all monitoring stations and used for reporting daily air quality.

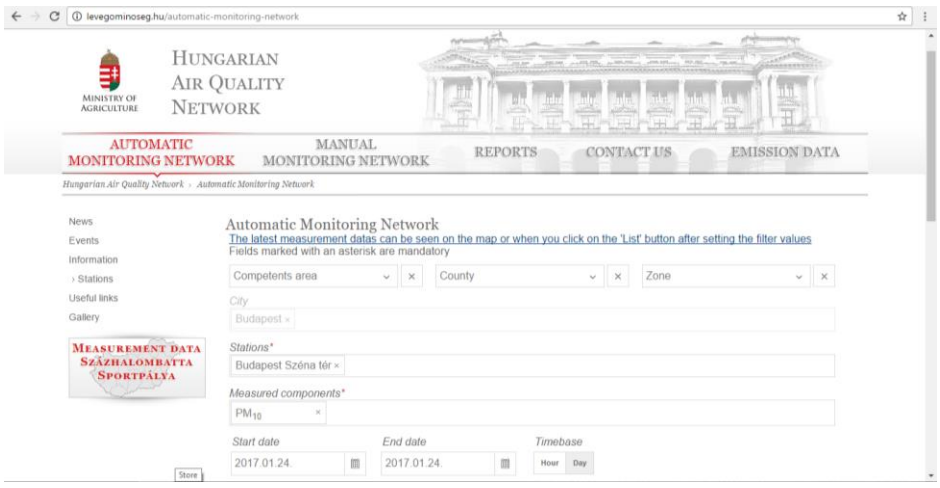


Figure 2. Webpage of the Hungarian Air Quality Network

Based on the location of the schools selected in the InAirQ project, the monthly mean concentration values of some regularly measured air pollutants are listed in Table 3-9 for 2016, 2017 and 2018 for the areas of interest (Hungary, Budapest, Várpalota).

Table 3. Monthly mean concentration values of some regularly measured air pollutants for 2016 for Hungary.

	SO_2	NO_2	CO	O_3	NO_X	PM_{10}
January 2016	7.0	27.8	848	24.8	56.1	42.2
February 2016	5.4	23.5	555	35.2	43.2	22.3
March 2016	4.1	21.1	518	44.3	33.6	21.8
April 2016	3.8	18.7	410	57.3	24.3	23.0
May 2016	3.1	17.6	354	61.9	25.2	17.4
June 2016	3.5	15.9	298	55.8	23.9	17.9
July 2016	4.0	14.7	314	56.5	21.4	18.1
August 2016	3.6	16.5	327	53.7	24.7	16.7
September 2016	3.7	22.7	409	44.7	38.5	24.9
October 2016	4.4	19.3	485	25.1	39.0	21.1
November 2016	6.0	26.9	627	23.8	57.8	32.8
December 2016	6.0	27.4	800	22.3	56.8	39.1
Annual mean	*4.5*	*21.0*	*495*	*42.1*	*37.1*	*24.8*

Table 4. Monthly mean concentration values of some regularly measured air pollutants for 2016 for Budapest.

	SO_2	NO_2	CO	O_3	NO_X	PM_{10}
January 2016	4.7	42.4	855	18.8	97.7	48.3
February 2016	3.6	38.6	536	28.8	72.0	23.6
March 2016	3.6	33.8	479	38.9	54.1	24.4
April 2016	3.9	30.6	374	51.9	47.4	26.6
May 2016	3.9	30.2	380	56.0	42.7	20.4
June 2016	3.7	28.8	291	52.4	42.5	21.1
July 2016	4.6	24.4	273	49.8	34.2	20.3
August 2016	5.7	25.4	381	48.8	37.9	20.5
September 2016	4.6	37.0	437	36.4	65.7	28.0
October 2016	4.6	26.8	556	19.7	59.4	21.9
November 2016	4.9	35.7	685	18.2	79.0	35.4
December 2016	4.7	37.4	838	20.5	95.8	40.4
Annual mean	*4.4*	*32.6*	*507*	*36.7*	*60.7*	*27.6*

Table 5. Monthly mean concentration values of some regularly measured air pollutants for 2016 for Várpalota.

	SO_2	NO_2	CO	O_3	NO_X	PM_{10}
January 2016	n.a.	21.6	1203	8.5	65.6	42.6
February 2016	4.8	24.9	690	17.4	50.4	25.4
March 2016	4.2	22.6	603	25.0	32.7	21.1
April 2016	n.a.	19.2	1 385	34.1	97.9	13.6
May 2016	n.a.	20.7	434	25.5	36.3	21.3
June 2016	n.a.	20.3	266	19.5	32.5	18.0
July 2016	n.a.	15.6	204	25.0	22.7	19.5
August 2016	n.a.	16.7	149	21.4	24.9	16.6
September 2016	n.a.	23.2	463	16.7	36.4	20.5
October 2016	n.a.	17.9	591	13.3	41.7	17.8
November 2016	4.1	23.8	862	13.3	56.2	28.8
December 2016	4.1	23.3	903	15.0	53.5	32.7
Annual mean	*n.a.*	*20.8*	*646*	*19.5*	*45.9*	*23.2*

Table 6. Monthly mean concentration values of some regularly measured air pollutants for 2017 for Budapest.

	SO_2	NO_2	CO	O_3	NO_X	PM_{10}
January 2017	15.5	48.6	95.7	921	24.7	55.1
February 2017	16.8	44.7	89.4	791	21.8	37.4
March 2017	8.3	38.9	65.7	481	36.2	25.6
April 2017	6.7	28.8	40.9	375	46.5	19.3
May 2017	7.3	28.3	37.8	357	52.3	16.9
June 2017	7.6	26.6	35.1	267	69.1	17.1
July 2017	7.1	25.6	33.0	307	53.5	15.7
August 2017	6.0	38.3	43.8	366	52.2	19.5
September 2017	3.4	26.0	51.3	500	35.4	14.0
October 2017	6.3	31.6	70.7	483	30.5	20.7
November 2017	12.8	32.7	75.5	579	17.8	21.7
December 2017	15.4	40.0	89.4	670	18.1	29.0
Annual mean	9.4	34.2	60.7	508	38.2	24.3

Table 7. Monthly mean concentration values of some regularly measured air pollutants for 2018 for Budapest.

	SO_2	NO_2	CO	O_3	NO_X	PM_{10}
January 2018	6.2	37.4	89.1	675	15.9	34.2
February 2018	4.2	35.4	72.3	648	26.9	32.8
March 2018	4.1	31.9	52.6	718	36.0	36.5
April 2018	4.1	36.7	57.8	568	48.9	29.5
May 2018	6.2	30.2	42.3	446	55.0	26.9
June 2018	5.3	21.8	27.8	374	59.2	19.1
July 2018	5.1	24.9	33.5	410	65.1	21.5
August 2018	4.5	26.1	32.7	555	62.8	26.4
September 2018	4.8	34.5	52.5	534	50.9	29.2
October 2018	5.2	37.4	65.6	646	41.6	34.5
November 2018	5.4	33.8	74.2	813	18.6	36.8
December 2018*	5.1	32.3	71.6	814	16.8	34.6
Annual mean	5.0	31.9	56.0	600	41.5	30.2

* until 12 December 2018

Table 8. Monthly mean concentration values of some regularly measured air pollutants for 2017 for Várpalota.

	SO_2	NO_2	CO	O_3	NO_X	PM_{10}
January 2017	5.2	26.2	903	22.6	51.5	45.0
February 2017	5.2	32.1	927	14.8	69.8	36.2
March 2017	4.2	15.5	709	33.4	24.6	17.9
April 2017	4.4	8.3	951	41.0	13.9	14.9
May 2017	5.2	n.a.	961	37.9	n.a.	n.a.
June 2018	5.4	15.9	n.a.	41.3	18.9	n.a.
July 2017	5.8	13.6	n.a.	33.4	17.1	n.a.
August 2017	n.a.	25.3	n.a.	38.5	69.7	n.a.
September 2017	n.a.	19.9	n.a.	31.0	35.1	n.a.
October 2017	8.7	19.9	505	29.4	37.2	n.a.
November 2017	n.a.	23.1	839	18.1	53.8	n.a.
December 2017	n.a.	19.9	1224	22.6	38.8	30.5
Annual mean	5.5	20.0	877	30.3	39.1	28.9

n.a. = not available

Table 9. Monthly mean concentration values of some regularly measured air pollutants for 2018 for Várpalota.

	SO_2	NO_2	CO	O_3	NO_X	PM_{10}
January 2018	n.a.	24.1	1751	15.0	60.7	39.4
February 2018	n.a.	22.1	976	33.9	37.8	35.7
March 2018	n.a.	33.1	n.a.	28.6	54.0	41.5
April 2018	n.a.	24.7	795	31.7	35.2	33.8
May 2018	n.a.	26.1	356	23.7	38.9	11.4
June 2018	n.a.	18.3	488	n.a.	29.8	8.9
July 2018	n.a.	14.2	368	50.0	21.0	13.6
August 2018	1.0	17.9	278	61.8	32.3	n.a.
September 2018	0.7	20.5	370	369.7	62.3	10.5
October 2018	1.4	24.5	339	50.3	48.2	25.5
November 2018	2.3	28.7	668	16.4	74.1	42.1
December 2018*	n.a.	22.1	1178	20.2	49.1	35.2
Annual mean	n.a.	23.0	631	35.8	43.3	24.8

n.a. = not available
* until 12 December 2018

The annual mean values measured in the three years in Hungary were below the limit values set by the European Commission. Due to the higher traffic density, the PM_{10} mass concentration and the NO_2 concentration values are higher in the capital city compared to the results obtained in the countryside. Hungary has a typical continental climate characterized by cold winters and warm summers. Accordingly, the concentration of several air pollutants (e.g., PM_{10} mass concentration, O_3, CO) showed seasonal variation. During the winter period, the PM_{10} mass concentration values often exceed the 24-h limit value.

F. Review of indoor air quality data

IAQ measurements were performed only in the frame of international projects (i.e. SEARCH and SINPHONIE) in Hungary. Besides the investigation of IAQ, the health effects of indoor air pollutants were investigated in the case of both projects.

The SEARCH initiative was financially supported by the Italian Ministry for the Environment, Land and Sea (IMELS) through the Italian Trust Fund (ITF). It was carried out at two stages. The first phase of the SEARCH initiative (2006–2009) led to the creation of a comprehensive database of the concentration of several air pollutants (PM_{10}, NO_2, formaldehyde, benzene, ethylbenzene, xylenes, toluene and CO_2) measured indoors and outdoors. In total, 10 primary school buildings were investigated in Hungary and the results are summarized in Table 10. The second phase of the SEARCH initiative (2010-2013) introduced a new component: the assessment of energy use in school buildings and the impact of building materials on children's health to compile recommendations for improving the quality of school environments and school buildings and improving energy efficiency.

Table 10. Summary of the results of indoor air quality measurements in primary school buildings in Hungary (first phase of the SEARCH initiative).

Pollutant	Mean ± SD	Median	Min.	Max.
PM_{10} (μg m^{-3})	56.2 ± 28.2	56	9	115
NO_2 (μg m^{-3})	15.6 ± 7.2	14	4	39
Formaldehyde (μg m^{-3})	2.4 ± 0.9	2.2	0.9	5.5
Benzene (μg m^{-3})	2.4 ± 1.7	1.7	0.4	5.9
Ethylbenzene (μg m^{-3})	1.7 ± 2.4	0.9	0.0	12.9
Xylenes (μg m^{-3})	7.4 ± 12.4	3.1	0.4	69.3
Toluene (μg m^{-3})	4.7 ± 4.0	3.2	1.0	21.4
CO_2 (ppm)	1 493 ± 500	1 433	728	3 061

The main findings of the SEARCH I and the SEARCH II phases were summarized in reports and are available online.

The SINPHONIE project aimed to gather new IAQ and associated health data from school buildings across Europe. The ultimate goal was to compile a number of recommendations to inform existing and future policies and to propose a set of guidelines towards a healthy school environment in Europe. During the project (2010-2012) 6 school buildings were investigated in Hungary and the results are summarized in Table 11. More IAQ parameters were investigated in the SINPHONIE project compared to the SEARCH initiative.

Table 11. Summary of the results of indoor air quality measurements in primary school buildings in Hungary (SINPHONIE project).

Pollutant	Mean ± SD	Median	Min.	Max.
Formaldehyde (μg m^{-3})	9.0 ± 4.0	9.0	3.7	17.2
NO_2 (μg m^{-3})	11.5 ± 5.0	10.8	4.6	21.9
$PM_{2.5}$ (μg m^{-3})	46.6 ± 26.6	41.5	12.0	105.6
Benzene (μg m^{-3})	6.6 ± 5.6	4.3	2.0	19.7
Lead (μg m^{-3})	3.5 ± 3.3	2.5	0.0	11.9
Naphthalene (μg m^{-3})	3.2 ± 2.1	3.1	0.3	9.0
Limonene (μg m^{-3})	37.3 ± 41.8	13.2	4.9	149.5
Trichloroethylene (μg m^{-3})	9.7 ± 24.0	<LOD	<LOD	86.2
Tetrachloroethylene (μg m^{-3})	0.06 ± 0.25	<LOD	<LOD	1.0
Radon (Bq m^{-3})	127 ± 71	126	43.4	339
Relative humidity (%)	33.9 ± 5.4	34.1	24.6	46.8
Temperature (°C)	22.3 ± 1.7	23.0	19.0	25.4
Air exchange rate (h^{-1})	0.36 ± 0.16	0.37	0.14	0.64
CO_2 *(ppm)*	1 456 ± 251	1 485	964	1 815

LOD = limit of detection

The final report of the SINPHONIE project is available on the webpage of project.

G. Characterization of the health impact of indoor air quality

Air quality in buildings is associated with occupants' health and comfort. IAQ can be affected by many parameters, such as the emission of indoor pollutants, the intrusion of outdoor pollutants, chemical reactivity, sorption and desorption phenomena, air change rate, indoor temperature and relative humidity. To facilitate the understanding of IAQ issues by nonprofessionals and to promote the improvement of IAQ, indexes have been created worldwide over the past decades. These indexes have often been incorporated into indoor environment quality (IEQ) evaluations. Within IEQ indexes, IAQ, thermal comfort, acoustic comfort and visual comfort are the primary areas considered in the proposed frameworks. In Green Building certifications, IAQ is also evaluated as a part of the life-cycle assessment of the building's sustainability.

Many indexes are available for the evaluation of IAQ in buildings. Two different approaches are commonly employed to construct IAQ indexes: questionnaires and indoor measurements. Existing IAQ indexes are frequently based on a single approach. IAQ indexes based on questionnaires include questions related to perceived IAQ and/or the indoor comfort of occupants, or checklists describing building facilities, including ventilation performances. Approaches and questions vary because the objective differs among indexes.

More frequently, IAQ indexes are measurement-based, common indoor parameters include indoor temperature, relative humidity, airborne pollutants in the gas phase, and particles, measured on a given time-scale. The score of an IAQ index can be calculated using complex equations. Alternatively, the score of an IAQ index can be obtained by comparing the measured values in a given time interval to the thresholds associated with the same exposure duration.

The IAQ can also be assessed by questionnaires. By checklists, the authorities or the management of the buildings can identify the major problems, sources of pollution.

Questionnaires on evaluation of the perceived risks can give a further input to identify problems, most often the complaints are related to thermal comfort.

If there is a possibility to measure the concentration of major pollutants the results can be used for hazard identification and risk assessment and can launch interventions.

In case of real time monitoring of IAQ there is a possibility to evaluate the actual quality of indoor air and take immediate actions.

Within the InAirQ project a recommendation for Indoor Health Index was developed. The InAirQ.project recommended to consider the highest score of any of the pollutants as the most important pollutant defining the quality of air indoors.

In the InAirQ proposal a five scale categorization of the most important and frequent chemical air pollutants ($PM_{2.5}$, benzene and formaldehyde) was applied using different threshold values for the cut off points. A colour scale is recommended to distiguish between the different categories (Table 12).

Table 12. Categorization of air pollutant concentration values based on their health effects

Category	$PM_{2.5}$ (µg/m^3)	benzene (µg/m^3)	formaldehyde (µg/m^3)
Healthy	<10	<1.7	<10
Moderate	10-24.9	1.7 - 4.99	10 - 19.9
Unhealthy	25-49.9	5 - 7.5	20 - 50
Very unhealthy	50-75	7.51 - 10	51 - 100
dangerous	>75	>10	>100

Indoor comfort is influenced by temperature, carbon dioxide concentration and relative humidity. Indoor temperature is ideal between 18.5 – 25.1°C. Relative humidity is optimal between 43% and 67%. Both too dry air (RH<37%) and too humid air (>73%) can cause health problems. Indoor CO_2 concentration is ideal if it is twice as high as the

outdoor concentration (~800 ppm). InAirQ proposes 1200 ppm as acceptable level, between 1200-1800 ppm concentration CO_2 has moderate health effect, above 1800 ppm it is unhealthy. The recommendations are summarized in Table 13.

Table 13. Categorization of comfort parameters

Category	RH (%)	T (˚C)	CO_2 (ppm)
Healthy	43<RH<67	18.5<T<25.5	<1200
Moderate	37<RH<43 67<RH<73	10 - 19.9	1200 - 1800
Unhealthy	RH<37 RH>73	20 - 50	>1800

H. The monitoring campaign carried out within the InAirQ project (2017-2018)

The InAirQ project has officially started in July 2016 to investigate IAQ in primary school buildings in 5 Central European countries and to develop and test action plans in order to improve IAQ. In Hungary, the monitoring campaign took place during the heating season of 2017/2018 (11/06/2017 – 28/03/2018). In total, 16 school buildings were investigated across the country (Figure 3). The school buildings were selected based on several criteria developed in the project. Buildings IDs were used in the survey.

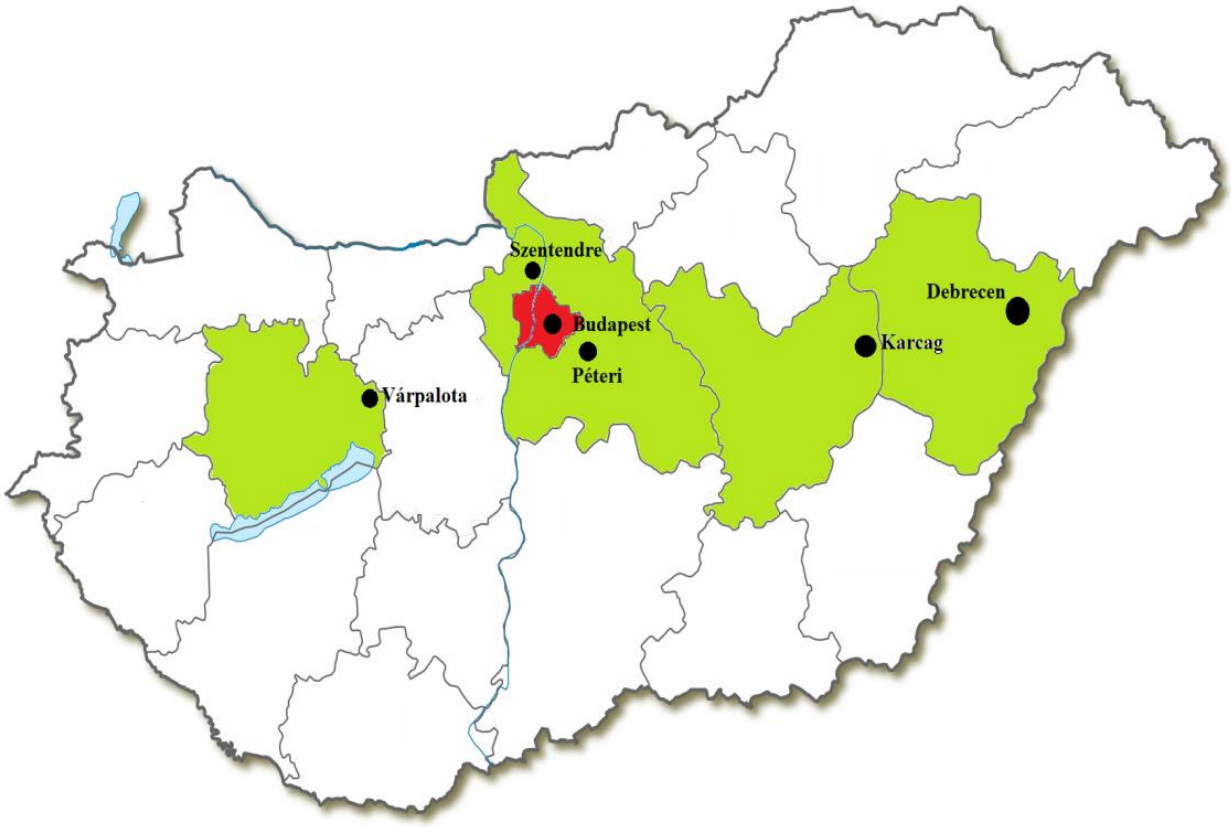


Figure 3. Geographical distribution of the schools surveyed in the frame of the InAirQ project

The following parameters were investigated:

- Relative humidity (RH) and temperature (T)
- Nitrogen dioxide (NO_2)
- Ozone (O_3)
- Carbon dioxide (CO_2)
- Polycyclic aromatic hydrocarbons (PAHs)
- Volatile organic compounds (VOCs)
- Aldehydes
- Particulate matter ($PM_{2.5}$)
- Radon (Rn)

The measurements were carried out by using the instruments listed in Table 14. Indoor and outdoor sampling/monitoring took place simultaneously (one classroom and one outdoor location).

Table 14. Description of the equipment used in the survey in Hungary

Parameters	Equipment used	Equipment's accuracy (if relevant)	Minimum Detection Limit (ppm)
Relative humidity (RH) temperature (T)	Testo 174H	±3 %rF ±0,5 °C	-
NO_2	Aeroqual S500	<±0.02 ppm	0.005
O_3	Aeroqual S500	<±0.005 ppm	0.001
CO_2	TSI-7545	±50 ppm	-
PAHs	SKC pump with PUF plug	-	-
VOCs, aldehydes	Radiello	-	-
$PM_{2.5}$	Pump (SKC Flite 3) with $PM_{2.5}$ sampling head	-	-
Radon (Rn)	Passive sampler	-	-

The comfort of the schoolchildren is influenced by temperature, carbon dioxide level and relative humidity. Moreover, these parameters can affect the health of children and adults and may affect student learning ability and teacher's productivity. Table 15 shows the results of the measurements indicating the categories of the Indoor Health Index.

Table 15. Temperature, relative humidity and carbon dioxide concentration in the surveyed Hungarian schools (2017-2018)

School building ID	T (°C)		RH (%)		CO_2 (ppm)	
	IN	OUT	IN	OUT	IN	OUT
HU05	23.1	15.8	45.7	50.5	1405	405
HU07	20.7	8.3	34.4	67.3	784	412
HU04	22.9	7.8	38.6	81.2	941	400
HU17	24.5	4.4	29.3	68.1	1214	409
HU20	22.1	5.5	38.1	63.4	1777	415
HU21	21.7	9.8	54.8	73.7	2328	420
HU19	21.3	7.8	44.4	72.4	1339	410
HU15	23.3	4.6	36.7	66.2	1244	406
HU06	21.6	6.2	29.3	62.5	767	428
HU09	24.3	4.1	28.2	65.7	1081	418
HU01	23.0	-3.0	35.3	51.9	1539	417
HU22	23.2	8.5	31.4	58.3	1245	420
HU23	22.9	6.5	28.8	41.3	1467	396
HU24	21.3	4.7	35.7	74.5	1136	424
HU25	22.7	16.9	38.1	46.6	1012	397
HU26	24.1	11.8	39.6	51.7	1911	395

The temperature values were within the acceptable range in all cases; however, the relative humidity values were in the moderate and unhealthy range in the case of four and nice classrooms, respectively. The air was dry in the majority of the investigated

classrooms. Concerning the CO_2 concentration values, there were only six classrooms in which the measured concentration values were in the healty range.

Table 16. Results of the measurements for NO_2, O_3 and $PM_{2.5}$ for Hungary

School building ID	NO_2 ($\mu g/m^3$)		O_3 ($\mu g/m^3$)		$PM_{2.5}$ ($\mu g/m^3$)	
	IN	OUT	IN	OUT	IN	OUT
HU05	21.9	29.3	nd	13.4	21	19
HU07	29.7	27.2	nd	6.3	72	8
HU04	22.0	26.8	nd	12.7	47	38
HU17	23.0	31.1	nd	4.8	38	50
HU20	14.2	28.0	nd	18.4	62	42
HU21	19.7	30.1	nd	17.8	53	23
HU19	24.3	22.4	nd	2.9	47	41
HU15	27.2	32.7	nd	8.8	50	20
HU06	-	-	nd	10.4	35	41
HU09	60.4	80.2	nd	23.6	29	24
HU01	34.9	69.4	nd	33.2	45	45
HU22	79.0	85.4	nd	14.4	51	49
HU23	31.9	43.0	nd	9.0	42	85
HU24	-	59.0	nd	9.9	38	44
HU25	47.0	82.8	nd	15.2	46	45
HU26	20.1	45.3	nd	26.2	59	67

Ozone was not detected indoors (Table 16). The indoor NO_2 concentration is not characterised by the Indoor Health Index; however, it is clear that the indoor concentration values were higher when the outdoor NO_2 were also high. The $PM_{2.5}$ mass concentration was always out of the healthy range; moderate concentration value was measured in only one classroom while in nine and six rooms were characterised by unhealthy and very unhealthy categories, respectively.

Table 17. The benzene and formaldehyde concentration values obtained for Hungary

School building ID	Benzene ($\mu g/m^3$)		Formaldehyde ($\mu g/m^3$)	
	IN	OUT	IN	OUT
HU01	7.0	8.8	6.7	2.0
HU04	3.4	4.2	4.2	0.6
HU05	3.3	4.8	9.0	1.7
HU06	7.0	6.3	5.6	1.5
HU07	3.1	3.2	3.4	0.9
HU09	4.9	5.1	9.4	1.0
HU15	4.4	4.1	8.9	1.8
HU17	3.4	3.3	5.0	1.7
HU19	4.6	4.1	11.4	1.2
HU20	2.4	3.5	12.1	1.2
HU21	1.9	2.7	17.6	1.9
HU22	8.3	6.9	10.4	2.5
HU23	5.9	3.4	9.5	1.8
HU24	5.6	5.8	8.4	1.3
HU25	-	1.2	7.9	1.2
HU26	4.1	4.4	9.3	1.7

Based on the Indoor Health Index, the concentration of benzene was in the healthy range in one classroom, it was in the moderate range in the majority of the classrooms (n=10) and only four classrooms were characterized by unhealthy benzene concentration values.

Concerning formaldehyde exposure, the measured values were in the healthy and moderate ranges.

To sum up our findings on the IAQ measurements, it can be stated that the major IAQ problems were related to the comfort parameters and high $PM_{2.5}$ mass concentration values. The high indoor CO_2 levels are among the leading problems together with the low relative humidity values.

I. Indoor Air Quality Action Plan for Hungary

The primary aim is to minimize the impact of the outdoor and indoor environment on pupils' health. The action plan is based on the assessment of the the current state of the school environment and on the identification of the problems. The action plan can only be fulfilled if there is a supportive legislation, group of public health experts, supportive school management, intersectoral cooperation and financial background. Some of the action should be carried out by using structural funds (eg. EU funded operational programs for modernizing the heating and ventilation system of the buildings, change of the lead containing water pipes, elimination of asbestos-containing insulation etc. Some other programs can be incorporated in the plans of regular maintenance of the school building (like timing of the painting of the rooms, changing furniture. etc). Some practical actions can be done without money like ventilation of the classrooms by opening the windows.

The regular check-ups of the school buildings should remain the task of the public health services. However monitoring – either ad hoc or regular - of concentration of the indoor air pollutants needs a regular line in the national budget.

The National Strategy of healthy school environment should be a part of the National Public Health Strategy, based on national and international evidences, regulations, guidelines and good practices.

I.1. General action plan for improving IAQ in the school buildings

The proposed protocol for each primary school building in Hungary is the following:

School building: _____ (name, location)

Stage 1.

Set up a group responsible for the environmental health issues in the school (director, school manager, public nurse)

Define an IAQ manager: _____

Define the contact person representing the public health service: _____

Stage 2. Vulnerability assessment and SWOT analysis

- School building (surroundings, technical characteristics of the building), 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 (questionnaire)
- Evaluate the results of the regular health monitoring run by school paediatricians and nurses

Stage 3. Regular check-ups based on standardized checklists run by the public health service (professional assessment of the building status, examples are given in Annex 1 and Annex 2)

Stage 4. Defining the periodical monitoring of IAQ in school buildings (frequency, methods, control and action) and defining exceptions.

Stage 5. Action plans for improvement of indoor air quality (priority list based on the advices of public health service and the 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
- Checklist of action
- Evaluation of action
- Quality control of action

Furthermore, the following activities should be carried out at national level:

Capacity building trainings

Capacity-building is a crucial part of the national strategy based on special training materials. The target groups for the trainings:

- school employees
- cleaning specialists
- building sector

Monitoring campaign

Based on the regular school check-ups, ad hoc monitoring campaigns should be planned in order to measure the level of indoor air pollutants with special regard to their health risks. The preventive measures should be adjusted to the results in order to lower emissions. control emission sources and reduce the potential health impacts.

Awareness raising

Education and training of the key target groups such as architects, local authorities and representatives of the maintaining organizations, as well as the parents should be improved. The authorities' supervisory responsibility with respect to inadequate indoor environments needs to be extended.

Some awareness raising actions should be aimed at:

- Informing the general population (with special regard to parents) about the importance of IAQ in primary schools.
- Dissemination of the results of the monitoring campaigns.
- Presentation of best practices from other countries based on benchmark visits.

Legislations

The IAQ has not been regulated within the EU; however, there is a guideline proposed by the WHO. In Hungary a governmental order on IAQ has been elaborated, but has not been accepted yet. The task is to update the list of indoor air pollutants and their proposed limit values based on the latest scientific evidences.

The ministerial order should define the tasks and responsibilities of the different ministries in order to reduce the health risks of indoor exposures in public buildings. The ministerial order should be prepared by the Ministry of Human Capacities.

Concerning the maintenance of the school buildings the following principles should be followed:

The materials and furniture used for building and equipping the schools should have (i) a certificate of toxicological tests, (ii) low emission of toxic substances and (iii) low energy consumption.

Some basic actions

Education of the housekeeping staff about the ways how the housekeeping procedures and products may affect IAQ.

- Preparation of written protocols about the procedures, and the use of equipment in the buildings
- In the procurement process prefer the use of more natural cleaners, avoid using colours, paints

Actions regarding the maintenance (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

I.2. Examples for technical improvements

The actions should be based on guidance and recommendations developed in projects aimed at improving the IAQ in schools. In the future actions should be aimed at the maintenance, repair and cleaning of the ventilation ducts introduced during the thermo-modernization process.

Natural ventilation:

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

Mechanical ventilation:

- A plan should be prepared for the maintenance of HVAC system. The plan should include monitoring, inspection 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:

- Changing the floor cover with healthy building materials, avoiding carpets and plastic covers containing phthalates.

I.3. Examples for 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.

I.4. Specific actions aimed at reducing the health risks due to chemical pollutants indoor

Proposed action plans to lower the concentration of formaldehyde:

- Select suitable, dedicated furniture and cover materials, equip the rooms with interior equipment that does not contain formaldehyde or as little as possible.
- If you plan to change the furniture of the class rooms, do it during the summer holiday. Ascertain that the furniture can be ventilated by keeping the windows open as long as possible. Collect information about the furniture (date of productions, ventilation and other characteristics of the material of the furniture).
- Plan the use of products containing formaldehyde concerning the proper ventilation during and after the use of them.
- Maintain the temperature and relative humidity of the school environments at the lowest comfort levels (formaldehyde emission and indoor concentrations increases by increasing temperature and humidity).
- Put special flowers in the classrooms which can absorb formaldehyde (Scindapsus /Golden Lotus, Sansevieria, Dracena marginata, Filodendron, Peace lily etc). Besides formaldehyde, these plants can absorb several volatile organic compounds like benzene, xylene, toluene etc). Take care of the soil of these plants, use special material which hinders the growth of fungi.

- Increase the 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).

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.).
- Strict control of the smoking ban indoors.
- Do not use benzene inside the building except in case you have an extraction chamber.
- Ventilate the indoor areas during and after using products containing benzene (eg during painting/ use of colors).
- Handle as hazardous waste the rest of benzene containing colors by following the instructions for separating/handling hazardous waste).

Proposed action plans to lower the concentration of VOC:

- Prevent the entry of VOCs from the outside air (eg parking lots).
- Choose products that do not contain VOCs
- Do not store products that are a source of VOCs in rooms where children stay.
- When using products that are sources of VOCs (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 sources of VOCs in the quantities to be spent immediately. 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 the exposure to formaldehyde, benzene and perchlorethylene in a living environment at school.

Proposed action plans to lower the concentration of PM_{10}:

- Regularly follow the Air Quality Health Index issued by the National Public Health Center daily. Plan the outdoor activity of pupils according to the forecast.

"Prevention" of the entry of particles from the outside air:

- Thoroughly ventillate the classrooms when the outdoor traffic is low (usually in the early morning hours, before the traffic jams).
- When PM concentration is elevated in the ambient air and the ventilation possibilities are limited, 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:

- Clean the classrooms after the lessons
- Use wet cleaning practices for the floor and furniture. Undust the rooms and furniture every day. The best solution is the use of wet 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.
- Install air cleaning devices that absorb PM and chemical pollutants.
- In case the school building is heated by stoves burning solid fuels, use dry hard wood. Keep the general instructions on fire.

- Replace solid fuels with cleaner fuels and energies (eg solar energy, electricity, natural gas) as soon as possible considering the reduction of emissions from these stoves.
- Regularly clean and maintain 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.
- Install a CO monitoring device in the rooms.

Proposed action plans to lower the concentration of CO_2:

- If you do not have a mechanical ventillation system,. open the windows of the classrooms during every break. Ventillate the rooms thoroughly in the morning and in the afternoon before and after the lessons.
- Install a CO_2 concentration monitor in the classroom.

Proposed action plans to maintain optimal temperature and humidity:

- Put a thermometer in the classroom. Ensure optimal temperature during winter, do not overheat the rooms.
- Be aware of the impact of climate change, prepare for the high outdoor temperature during late spring and early autumn months.
- Prepare plan for the insulation of the buildings and increase the heat resilience by installing curtains, shades indoor and outdoor.
- Plant hypoallergic trees and bushes around the school building.
- Monitor the humidity in the classrooms, avoid dry air by placing plants and humidifiers in the classrooms.

Annex 1. Checklist and questionnaire about the classroom (example)

Instructions for completing the checklist and questionnaire (only one questionnaire for each classroom. It would be desirable that the questionnaire is completed with the cooperation of all teachers who use the classroom).

- When you are asked to write a text (e.g. name of the school/country/city, some specifications...), write clearly, if possible in capital letters, and in the space provided.
- Tick the box or cross out the number corresponding to your response option. Tick only one option unless otherwise instructed. Examples:

- When were the walls of the classroom painted last time?

1. Within 1 year
2. 1-2 years ago
3. 3 or more years ago

- Are the windows open during cleaning of the classroom? ☐ **No** ☒ **Yes**

- During the day, when is this classroom cleaned?
(More answers are possible)

☒ In the morning, before school-time
☐ In the evening, after school-time
☒ At noon, between classes

- If you make a mistake, circle the wrong answer and tick the right one. Examples:

- 1 was ticked by mistake and 3 is right:
When were the walls of the classroom painted last time?

1. Within 1 year
2. 1-2 years ago
3. 3 or more years ago

- 'No' was ticked by mistake and 'Yes' is right:
Are the windows open during cleaning of the classroom? ☒ **No** ☒ **Yes**

Code: ☐☐ ☐☐ ☐
Country School Classroom

C_Q1. **Date of investigation:** (*Day/Month/Year*) __/__/____

C_Q2. **Name of the School:** .....

C_Q3. **City/Town:** ..... *C_Q4*. **Country:** .....

C_Q5. **Class:** ..... *C_Q6*. **Number of pupils in the school :** .....

C_1. **On which floor is this classroom situated?** .....

C_2. **Floor surface of the classroom:** ..... m^2

C_3. **Ceiling height of the classroom:** ..... m

C_4. **Windows area:** ..... m^2

C_5. **Orientation of the classroom I.:**
1. Facing the street
2. Facing the yard or garden
3. Other *(Please, specify)* .....

C_6. **Orientation of the classroom II.:**
1. East
2. North
3. West
4. South

C_7. **The floor material is made of:**
1. Parquet
2. Laminate
3. Plastic (Please, specify) .....
4. Stone or concrete
5. Tiles
6. Stone or concrete covered with carpet
7. Other *(Please, specify)*.....

2

C_8. **What is the main type of wall covering?**

1. Whitewash
2. Water-soluble paint
3. Water-resistant paint
4. Wallpaper
5. Wood-panel
6. Other *(Please, specify)*.....

C_9. **The ceiling is covered by:**

1. Whitewash
2. Water-soluble paint
3. Water-resistant paint
4. Wall-paper
5. Wood-panel
6. Other *(Please, specify)*.....

C_10. **When were the walls of the classroom painted last time?**

___/____ (Month/Year)

C_11. **Is there air conditioning (functioning) in the classroom?**

- ▫ No
- ▫ Yes

C_12. **Is there mechanical ventilation (functioning) in the classroom?**

- ▫ No
- ▫ Yes

C_13. **How frequently are the windows opened during a usual day in the heating period?**

1. In every interclass break
2. 2-3 times a day
3. Once a day
4. Never (i.e. mechanical ventilation and not openable windows)

C_14. **Is there any of the windows usually open during the classes in the heating period?**

1. Yes (.....% of the windows)
2. No, it is not needed (mechanical ventilation)
3. No, because of the outside noise

C_15. **How frequently is this classroom cleaned?**

1. Twice a day
2. Once a day
3. Once a week
4. 2 or more times a week

C_16. **During the day, when is this classroom cleaned?** *(Please tick any which apply)*
- ▫ In the morning before the arrival of the pupils/students
- ▫ In the afternoon/evening after school-time
- ▫ Between classes

C_17. **What is generally used for cleaning the floor of the classroom?** *(Please tick any which apply)*
- ▫ Vacuum cleaner
- ▫ Broom
- ▫ Mop
- ▫ Mop with bleach
- ▫ Other *(Please, specify)*.....

C_18. **Are the windows open during cleaning of the classroom?**
- ▫ No
- ▫ Yes

C_19. **When was the furniture in this classroom installed?** ..... (Year)

C_20. **What kind of board is used in this classroom?**
1. Blackboard with chalk
2. Whiteboard with alcohol-based markers
3. Other *(Please, specify)* .....

C_21. **What is the type of the window frame?**
1. Metal
2. Wood
3. PVC
4. Aluminium
5. Other *(Please, specify)*.....

C_22. **During school activities, do children use glue, paint, enamels or other products for artwork with an irritant smell?**
- ▫ No
- ▫ Yes

C_22.1. **Where are they stored?**
1. In an air-tight chest, into the classroom
2. In a normal chest or on the shelves, into the classroom
3. In an air-tight sealed chest, outside the classroom
4. In a normal chest or on the shelves, outside the classroom

C_22.2. **What precautions are taken when they are used?**
1. None
2. Windows are open
3. Used under a hood

C_23. **During the cold season, are there any days when it is very cold inside the classroom, so to be uncomfortable?**

1. Never 2. Rarely 3. Sometimes 4. Often

C_24. **During the cold season, are there any days when it is very hot inside the classroom, so to be uncomfortable, because the heating system is too high?**

1. Never 2. Rarely 3. Sometimes 4. Often

C_25. **During the cold season, are there any days when outside is cold and windows glasses become steamy?**

1. Never 2. Rarely 3. Sometimes 4. Often

C_26. **During the hot season, are there any days when it is so hot inside the classroom to be uncomfortable?**

1. Never 2. Rarely 3. Sometimes 4. Often

C_27. **In the classroom, does sunshine ever hit directly on some of the benches?**

▫ No ▫ Yes

C_28. **Have you ever noticed a mouldy/earthy or cellar-like odour inside the classroom?**

▫ No ▫ Yes

C_29. **Have there ever been visible signs of moisture damage such as damp stains or spots, deterioration or darkening of surface materials in the ceiling, walls, or floors, or signs of condensation of water on surfaces in the classroom?**

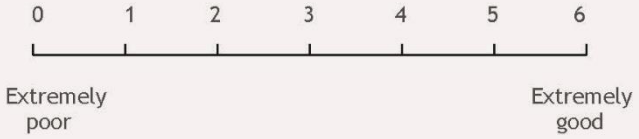
▫ No ▫ Yes

C_30. **How dusty is usually (frequently/often) the classroom?**

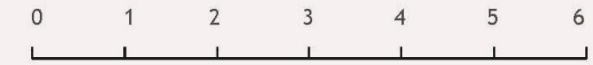
1. Not at all
2. Sometimes a little dusty
3. Usually a little dusty
4. Very dusty

MARK AN X ON A NUMBER OF THE SCALE FROM 0 TO 6:

C_31. **How do you perceive the natural illumination in the classroom?**

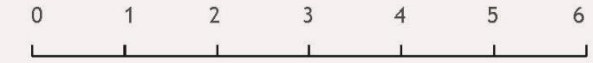


C_32. How do you perceive the artificial illumination in the classroom?



Extremely poor — Extremely good

C_33. How do you perceive the indoor air quality in your classroom?

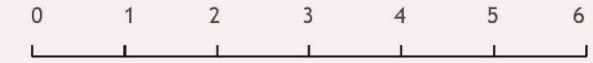


Extremely poor — Extremely good

If you think that indoor air quality is not good, try to explain why:

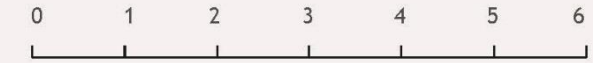
.....

C_34. How do you perceive the noise level (outdoor source) in your classrooms?



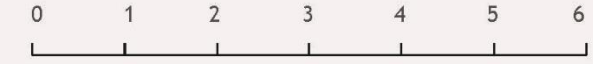
Not noisy — Extremely noisy

C_35. How do you perceive the temperature in your classrooms?



Extremely bad — Extremely good
(e.g. cold during winter, warm during summer)

C_36. How do you perceive the cleanliness of your classrooms?



Extremely clean — Extremely dirty

C_37. **How do you perceive <u>the decoration in your classroom</u>?**

0 1 2 3 4 5 6

Extremely poor — Extremely good

C_38. **Overall, how do you perceive the acoustics of this classroom?**
(Namely, what is the quality of speech communication between teachers and students?)

1. Very poor 2. Rather poor 3. Rather good 4. Very good

Why the acoustics is very/rather poor? *(Please tick any which apply)*

- ▫ The classroom is too reverberant for the speech sounds produced in it
- ▫ The classroom offers weak resistance to the penetration of noise from outside or from nearby rooms
- ▫ There is disturbing noise from ventilation system

C_39. **Overall, how comfortable is the classroom in your opinion?**

0 1 2 3 4 5 6

Very uncomfortable — Very comfortable

C_40. **How many children are <u>generally</u> in this classroom?** .....

C_41. **How much time usually they spend a day in this classroom?** .....hours

C_42. **Are there any nearby (within 50 m <u>from classroom windows</u>) potential sources of outdoor air pollution that might influence the indoor environment?**

Car park	▫ No	▫ Yes
Busy road	▫ No	▫ Yes
Industry (factory, plant)	▫ No	▫ Yes
Power plant	▫ No	▫ Yes
Incinerator	▫ No	▫ Yes

Waste storage site ▫ No ▫ Yes
Other polluting establishments ▫ No ▫ Yes *(Please, specify):*

.....

C_43. **Is there visible mould growth in the classroom?**
▫ No ▫ Yes

C_44. **Are there damp spots on walls, ceilings or floors?**
▫ No ▫ Yes

C_45. **Are there any major indoor air pollution sources present?**
1. No indoor air pollutant sources
2. Printers (number of printers: .....)
3. Air fresheners
4. Other *(Please, specify)* .....

C_46. **Are there plants present?**
▫ No ▫ Yes (number of plants: .....)

C_47. **What is the material of the desks?**
1. Wood
2. Plywood
3. Metal
4. Plastic laminate or composite
5. Other *(Please, specify)* .....

C_48. **Are there window blinds present?**
▫ No ▫ Yes

C_49. **What is the position of the window blinds (if they are present)?**
1. Outside
2. Inside
3. Both
4. Other *(Please, specify)* .....

C_50. **What is the material of the window blinds in the classroom?**
1. Window blinds are not present
2. Textile
3. Wood
4. Plastic
5. Metal
6. Other *(Please, specify)* .....

C_51. **What is the material of the schoolyard?**

5. Green space
6. Asphalt
7. Sand
8. Plastic material
9. Other *(Please, specify)* .....

C_52. **Do pupils have meal in the classroom?**

▫ No ▫ Yes

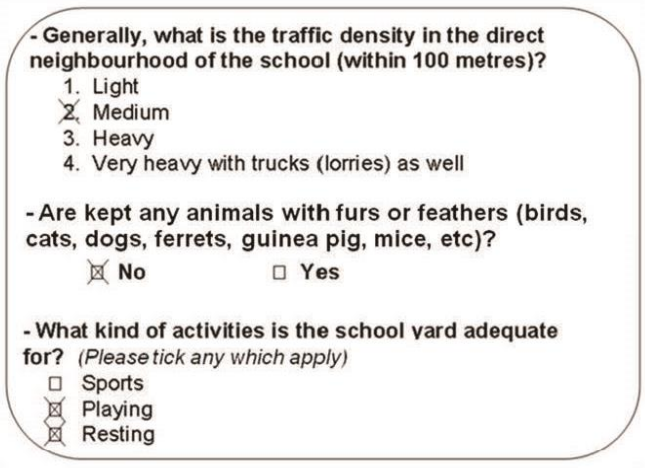
END - THANK YOU FOR YOUR COOPERATION!

Annex 2. Checklist and questionnaire about the school building (example)

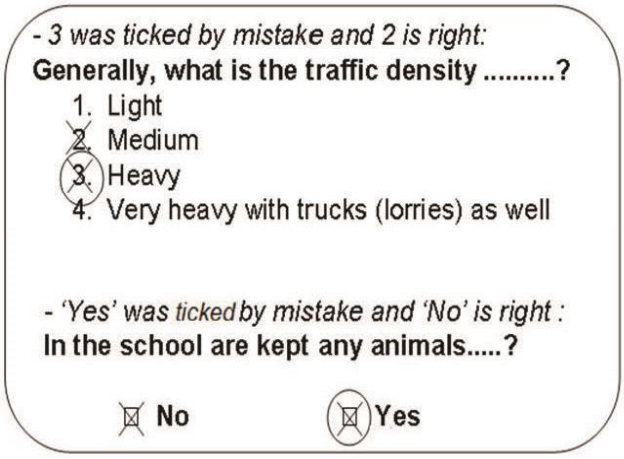
indoor

Instructions for completing the checklist and questionnaire (only one questionnaire for each school.

- When you are asked to write a text (e.g. name of the school/country/city, some specifications...), write clearly, if possible in capital letters, and in the space provided.
- Tick the box or cross out the number corresponding to your response option. Tick only one option unless otherwise instructed. Examples:



- If you make a mistake, circle the wrong answer and tick the right one. Examples:



Code: ☐☐ ☐☐ ☐
Country School Classroom

S_Q1. **Date of investigation:** *(Day/Month/Year)* __/__/____

S_Q2. **Name of the School:** .....

S_Q3. **City/Town:** ..... *S_Q4*. **Country:** .....

S_Q5. Location: ..... ***(e.g., city center, suburban, town, village, industrial area, residential area, commercial area, mixed)***

S_1. **Who is the Maintainer of the school:**
1. Municipality
2. Foundation
3. Church
4. Private
5. Institution
6. Other *(Please, specify)* .....

S_2. **When was the school building built?** *(Year)* .....

S_3. **What are the main building materials?** *(Please tick any which apply)*
☐ Brick
☐ Concrete
☐ Wood
☐ Mud
☐ Other *(Please, specify)* .....

S_4. **Was the school building built originally for being a school?** ☐ No ☐ Yes

S_5. **Number of storeys (occupied)** .....

S_6. **Was the school (as a whole) restored?**
☐ No
☐ Yes **When?** *(Year)* .....

S_7. During the last 5 years, were parts of the school restored?
☐ No ☐ Yes

Which ones? *(Please tick any which apply)*
☐ Electric cables
☐ Lighting
☐ Water-system
☐ Classrooms
☐ Windows
☐ Insulation

S_8. Generally, which is the traffic density in the direct neighbourhood of the school (within 100 metres)?
1. Light 2. Medium
3. Heavy 4. Very heavy with trucks (lorries) as well

S_9. Has the school got a yard?
☐ No ☐ Yes IF "No" GO TO QUESTION S_12

S_10. What kind of activities is the school yard adequate for? *(Please tick any which apply)*
☐ Sports
☐ Playing
☐ Resting
☐ Other *(Please, specify)* .....

S_11. When do the pupils use it? *(Please tick any which apply)*
☐ In the breaks between classes
☐ Only in the morning long break
☐ After school-time
☐ Almost never, or very seldom
☐ It is used for other purposes (e.g. car park)

S_12. Has the school got a green space around it? (sports-field, park, etc.)
☐ No ☐ Yes

S_13. Has the school got a gymnasium?
☐ No ☐ Yes

S_14. What kind of heating system is there in the school building?
1. Central or district heating with radiators
2. Electric heating appliances
3. Gas heaters
4. Coal or wood-fired ovens

S_15. Is there air conditioning in the school building?

1. Yes, there is air conditioning in the whole building
2. Yes, there is air conditioning in some parts of the building
3. No, there is no air conditioning in any parts of the building

S_16. Is there mechanical ventilation in the school building?

1. Yes, there is mechanical ventilation in the whole building
2. Yes, there is mechanical ventilation installed in some parts of the building
3. No, there is no mechanical ventilation in any parts of the building

S_17. Are there any nearby (within 100 m) potential sources of outdoor air pollution that might influence the indoor environment?

Car park	☐ No	☐ Yes
Busy road	☐ No	☐ Yes
Industry (factory, plant)	☐ No	☐ Yes
Power plant	☐ No	☐ Yes
Incinerator	☐ No	☐ Yes
Waste storage site	☐ No	☐ Yes
Other polluting establishments	☐ No	☐ Yes *(If Yes, please, specify)*:

.....

S_18. Are there any nearby (within 100 m) noise sources outside the building that might influence the indoor environment?

Car park	☐ No	☐ Yes
Busy road	☐ No	☐ Yes
Railway or station	☐ No	☐ Yes
Air traffic	☐ No	☐ Yes
Sea, river or canal traffic	☐ No	☐ Yes
Construction works	☐ No	☐ Yes
Factories	☐ No	☐ Yes
Community buildings (halls, churches, etc)	☐ No	☐ Yes
Other	☐ No	☐ Yes *(If Yes, please, specify)*:

.....

S_19. Are kept any animals with furs or feathers (birds, cats, dogs, ferrets, guinea pig, mice, etc.) in the school?

☐ No ☐ Yes

S_20. While the children are in the school, are ever used paints, soaps, or other cleaning products with an irritant smell (such as chlorine)?

☐ No ☐ Yes

S_21. Are there places in the school with much dust?

☐ No ☐ Yes

If Yes: Which ones? *(Please tick any which apply)*

☐ Any classroom
☐ Bathrooms
☐ Gym
☐ Corridors
☐ Kitchen
☐ Canteen
☐ Basement
☐ Offices
☐ Other places *(Please, specify)* .....

S_22. Do you notice a mouldy/earthy or cellar-like odour inside the school?

☐ No ☐ Yes

Where? *(Please tick any which apply)*

☐ Any classroom
☐ Bathrooms
☐ Gym
☐ Corridors
☐ Kitchen
☐ Canteen
☐ Basement
☐ Offices
☐ Other places *(Please, specify)* .....

S_23. Is there a history of water damage such as leakage from water pipes or washing machines, boiler, refrigerator, freezer, or cooling of the ventilation system in the school building?

☐ No ☐ Yes

Where? *(Please tick any which apply and indicate the time of it (Month/Year))*

☐ Any classroom (___/____)
☐ Bathrooms (___/____)
☐ Gym (___/____)
☐ Corridors (___/____)
☐ Kitchen (___/____)
☐ Canteen (___/____)
☐ Basement (___/____)
☐ Offices (___/____)
☐ Other places *(Please, specify)* ..... (___/____)

S_24. Have there ever been visible signs of moisture damage such as damp stains or spots, deterioration or darkening of surface materials in the ceiling, walls, or floors, or signs of condensation of water on surfaces in the school?

☐ No ☐ Yes

Where? *(Please tick any which apply)*

☐ Any classroom
☐ Bathrooms
☐ Gym
☐ Corridors
☐ Kitchen
☐ Canteen
☐ Basement
☐ Offices
☐ Other places *(Please, specify)* ....

S_25. Have you ever seen cockroaches inside the school?

1. Never 2. Rarely 3. Sometimes 4. Often

S_26. Are the teachers allowed to smoke in the school building (including during school-sponsored events)?

1. Yes, without any restrictions
2. Yes, but only in designated spaces
3. No, not at all

S_27. Are there any people who smoke tobacco in the school building?

☐ No ☐ Yes

Where? *(Please tick any which apply)*

☐ Any classroom
☐ Bathrooms
☐ Gym
☐ Corridors
☐ Kitchen
☐ Canteen
☐ Basement
☐ Offices
☐ Other places *(Please, specify)* .....

S_28. Are there materials containing asbestos in the building?

1. Yes, flocculate
2. Yes, but compact
3. Yes, but sealed
4. No

If Yes:

S_29. Is there an asbestos management plan?
☐ No ☐ Yes

S_30. Are there any lead components in the building?
☐ No ☐ Yes

If Yes: What ones?
☐ Lead water pipes
☐ Lead paints
☐ Other (*Please, specify*) .....

S_31. Is the building located in a radon-affected area?
1. Not designated as a radon-affected area
2. Radon area
3. Don`t know

S_32. Does the building contain potential radon bearing construction materials (e.g. gypsum, alum shale, granites or volcanic tuffs)?
☐ No ☐ Yes

S_33. Has there been any reported case of the presence of Legionella in the water supply system in the last 3 years?
☐ No ☐ Yes

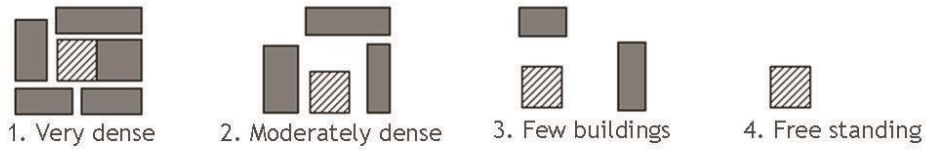
S_34. When generally are the classrooms cleaned?
1. In the morning before the arrival of the pupils/students
2. In the afternoon/evening after school-time
3. Between classes

S_35. How often does a deep clean of the classrooms take place?
1. Once a month or more often
2. Once every three months or more often
3. Once every six months or more often
4. Once every year or more often
5. Less often
6. Never

S_36. Are chemicals used for cleaning floors in the classrooms?
☐ No ☐ Yes

S_37. Are chemicals used for cleaning desks in the classrooms?
☐ No ☐ Yes

S_38. **What is the density of nearby obstructions?**



1. Very dense 2. Moderately dense 3. Few buildings 4. Free standing

MARK AN X ON A NUMBER OF THE SCALE FROM 0 TO 6

S_39. **How do you perceive the natural illumination in your school?**
(If the natural illumination is varying, try to give an average rating)

0 1 2 3 4 5 6

Extremely poor — Extremely good

S_40. **How do you perceive the artificial illumination in your school?**
(If the artificial illumination is varying, try to give an average rating)

0 1 2 3 4 5 6

Extremely poor — Extremely good

S_41. **How do you perceive the indoor air quality in your school building?**
(If the air quality is varying, try to give an average rating)

0 1 2 3 4 5 6

Extremely poor — Extremely good

If you think that indoor air quality is not good, try to explain why:

.....

8

S_42. How do you perceive the outdoor air quality outside your school?
(If the air quality is varying, try to give an average rating)

0 1 2 3 4 5 6

Extremely poor — Extremely good

S_43. How do you perceive the noise level (outdoor source) in the classrooms?
(If the noise level is varying, try to give an average rating)

0 1 2 3 4 5 6

Not noisy — Extremely noisy

S_44. How do you perceive the cleanliness of the classrooms in your school?
(If the cleanliness is varying, try to give an average rating)

0 1 2 3 4 5 6

Extremely clean — Extremely dirty

S_45. How do you perceive the decoration in the classrooms in your school?
(If it is varying, try to give an average rating)

0 1 2 3 4 5 6

Extremely poor — Extremely good

END - THANK YOU FOR YOUR COOPERATION!