VULNERABILTY ASSESSMENT - HUNGARY

Based on local, regional, national and international studies, surveys and field campaigns

Version 1

01.2017

Abstract

Indoor air quality is of paramount importance as people spend approximately 90% of their time indoors. Primary school students (approximately 748 000 students), a vulnerable population, spend approximately 8 h daily in school buildings in Hungary, thus the investigation of indoor air quality in primary school buildings is necessary to ensure children`s health and well-being.

The state of primary school buildings (n = 3 600) varies considerably in the country. Several renovation works including the replacement of windows and/or the modernization of lighting, insulation and heating have been carried out in the past years. However, there are several factors (e.g., ambient air pollution, consumer/building products, etc.) which might have an effect on indoor air quality.

Recently, there is no consensus on how to regulate indoor air quality worldwide. There is a big effort to establish indoor air quality guidelines at the national level in Hungary. The National Public Health Center has already prepared a draft Ministerial Order and the adoption is expected in 2017.

Indoor air quality 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 between 2006 and 2012. Some questions have already been answered regarding the indoor (school) environment; however, there are still several unanswered questions, thus there is a big need for research projects on the indoor air quality in school buildings.

1. 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 Yearbook of Public Education 2014/2015” published by the Ministry of Human Capacities in 2016 and it contains mostly basic information.

In the school year of 2014/2015, approximately 748 000 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 2014/2015 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 76 000 teachers were working full- or part-time in primary schools in the school year of 2014/2014. 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 9.9 in the school year of 2014/2015 with an average class size of 20.2. The number of institutes for primary education was 2 300 consisting of 3 600 school-sites in 2014/2015. Approximately 36 500 classrooms were counted in the primary schools in the school year of 2014/2015. 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.

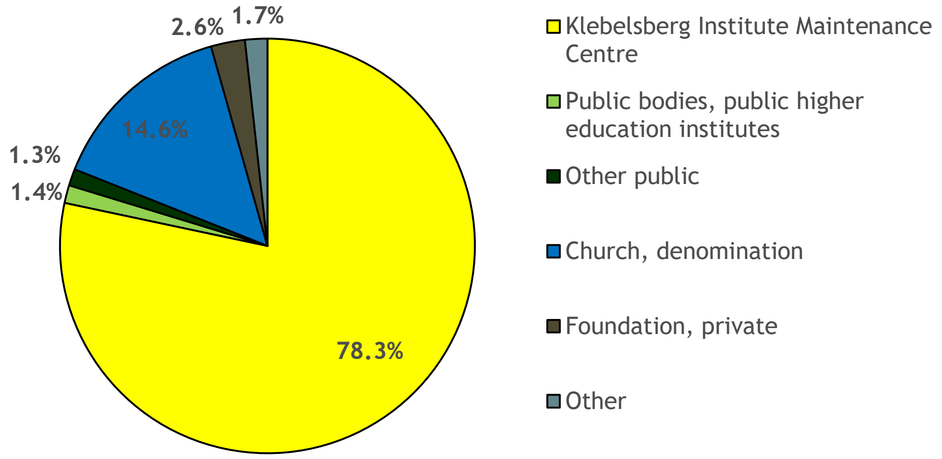

Figure 1. Maintainer of the school

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, 2015)

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 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 the 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 took 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.

2. 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 indoor air quality 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 and Medical Officer`s Service (ÁNTSZ) and its sub-national institutes are responsible for ensuring adequate indoor air quality in school buildings. Recently, there is no consensus on how to regulate indoor air quality in school buildings in Hungary. A draft Ministerial Order entitled "Public health and health protection requirements of design, construction and operation of buildings" 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 2017. 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 h
Carbon monoxide	3 000 µg m^{-3}	24 h
	8 000 µg m^{-3}	1 h
Carbon dioxide	1 500 ppm	1 h
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
Toluene	260 µg m^{-3}	1 week
Naphthalene	10 µg m^{-3}	1 week
Trichloroethylene	10 µg m^{-3}	1 week
Tetrachloroethylene	250 µg m^{-3}	1 week
Total volatile organic compounds (TVOC)	300 µg m^{-3}	1 week
Radon	400 Beq m^{-3}	1 year
Asbestos	1 000 fibres m^{-3} [a]	24 h
	500 fibres m^{-3} [b]	24 h

[a] by electron microscopy
[b] by optical microscopy

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 indoor air quality 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 3 (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 and 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 protect non-smokers from tobacco smoke exposure, 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).

3. Review of indoor air quality data

Indoor air quality measurements were performed only in the frame of international projects (i.e. SEARCH and SINPHONIE) in Hungary. Besides the investigation of indoor air quality, 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 in 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 3. 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 3. 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 indoor air quality 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 4. More indoor air quality parameters were investigated in the SINPHONIE project compared to the SEARCH initiative.

Table 4. 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 the project.

4. Outdoor air pollution in Hungary

Outdoor air pollution has a significant influence on indoor air quality, 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), sulfur 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.

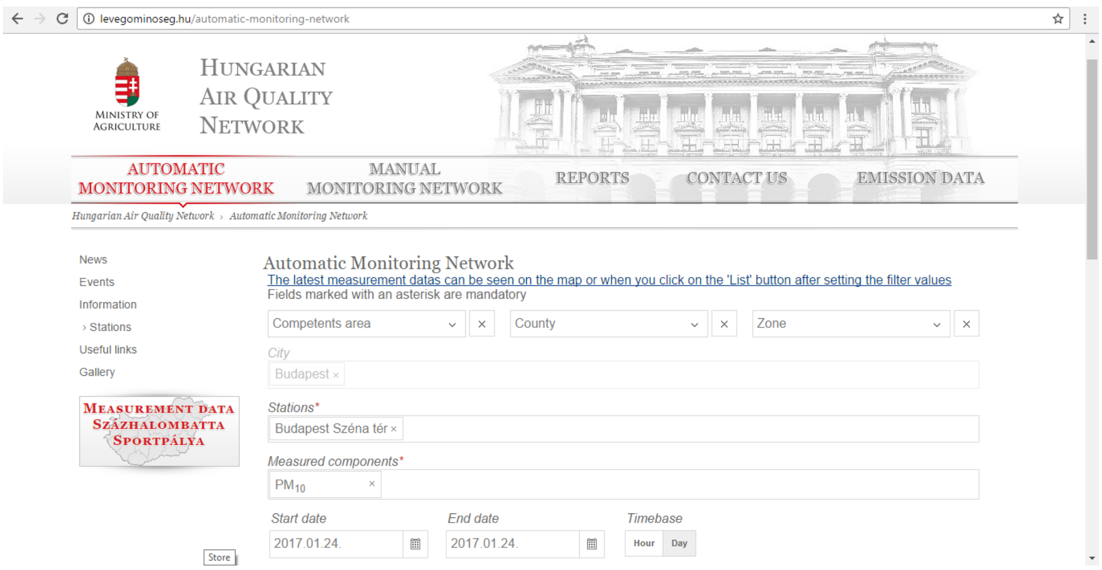

Figure 2. Webpage of the Hungarian Air Quality Network

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 5-7 for 2016 for the areas of interest (Hungary, Budapest, Várpalota).

Table 5. 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 6. 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 7. 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*

n.a. = not available

The annual mean values measured in 2016 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.