School Environment and the Children's Health Status in Hungarian Schools I.

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Abstract

Children spend about 6-8 hours a day in school therefore it cannot be neglected in what circumstances they do it. They are also more sensitive to environmental impacts than adults. In this paper the aim was to present data on indoor and outdoor school environment, and to describe the pupils' health status in Hungarian schools. In the frame of two international projects (SEARCH: School Environment And Respiratory health of Children and SINPHONIE: Schools INdoor Pollution and Health Observatory Network In Europe) altogether 1,114 children and their 61 classrooms in 16 schools were examined in Hungary. Indoor and outdoor air parameters (temperature, humidity, CO, CO_2, NO_2, PM_{10} or $PM_{2.5}$, ozone, formaldehyde, benzene, ethyl-benzene, xylols, toluene, trichloroethylene, pinene, limonene, naphthaline, and radon) were measured in the classrooms in one or the other or both projects. (In addition, in one of the projects perception of comfort, in the other one, biological pollutants, concentration and attention capacity as well as school absenteeism, while lung function measurement in both projects was also evaluated. These will be the subject of subsequent papers.) The children's health status was assessed by questionnaires completed by the parents. Most of the measured indoor air parameters were in the normal range, however concentrations of particulates (PM_{10} or $PM_{2.5}$, respectively), benzene, and CO_2 were higher than the recommended values. In some schools inadequate floor space and in the majority of schools insufficient ventilation were the most striking shortcomings. Some data on the respiratory health of children was similar to those found in the country-wide surveys in Hungary while others were lower. Regulations with indoor air guideline values are urgently needed in Hungary and further efforts are to be done to educate wide circles of the society, to inform various actors of school design and maintenance about the health aspects of indoor air quality in order to be able to provide healthy school environment for our children.

Key Words: school environment, indoor, children, respiratory symptoms, asthma, allergies

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INTRODUCTION

In Europe children spend about 6-8 hours a day in school where they perform intensive intellectual activity, as well. Therefore it cannot be neglected in what circumstances they do it. The school is a special environment because it has to ensure optimum conditions for teaching and learning various kinds of subjects (mathematics, natural sciences, literature, physical education, foreign languages, etc.) for both the children and the teachers. At the same time we have to take into account that children – as developing organisms – are more sensitive to environmental impacts than adults.

The Parma Declaration (2010) of WHO Europe, endorsed by 53 countries during the Fifth Ministerial Conference on Environment and Health, called on member states of the WHO Europe region to implement measurable actions in order to reach the targets set. Its Regional Priority Goal 3 "on preventing disease through improved outdoor and IAQ" stated: "We aim to provide each child with a healthy indoor environment in childcare facilities, kindergartens, schools and public recreational settings, implementing WHO's indoor air quality guidelines…"

However, in Hungary there is no regulation about the indoor air quality requirements in schools or other childcare facilities as far as chemical or biological pollutants are concerned, only temperature and humidity requirements are detailed (TNM decree, 2006; MSZE, 2012).

In the last twelve years, in the frame of international collaborations, we have been engaged in conducting research on the effects of school environment on the children's health by measuring indoor (and outdoor) concentrations of air pollutants in the classrooms on the one hand and assessing the respiratory health of children on the other hand. Our Institute, the National Institute of Environmental Health (one of the predecessors of the present National Public Health Center), in close cooperation with the Regional Environmental Center for Central and Eastern Europe, played important role in both the SEARCH[1] and the SINPHONIE[2] projects. In the former one 10 countries while in the latter one experts from 23 countries of Europe participated which offered the possibility to get a Europe-wide picture about the school environment and the children's health and to draw up a European guideline for healthy school environment (EU, 2014). In the present paper, as the first publication of a three-part series, we want to summarize the results of indoor air measurements and the health status assessment carried out in the Hungarian schools.

METHODS

In the frame of SEARCH project 4 - 4 classrooms with their pupils of 10 schools and in the SINPHONIE project 3 - 3 classrooms with their pupils of 6 schools were involved. At the selection of schools not representativeness but rather the presence of divers conditions was the

[1] *The SEARCH (School Environment And Respiratory health of CHildren) Project was financially supported by the Italian Ministry for Environment, Land and Sea, and coordinated by the REC (Regional Environmental Center for Central and Eastern Europe).*

[2] *The SINPHONIE (Schools INdoor Pollution and Health Observatory Network In Europe) Project was supported by the European Parliament according to the Contract between EU DG SANCO and REC.*

most important criterion (urban or rural environment, various regions of the country, busy roads nearby or far away, etc.). This way in the two projects altogether 16 schools participated, six schools from Budapest, two from Debrecen, Miskolc, and Pécs, respectively, and one school from Dunakeszi, Szigethalom, Nagykáta and Veszprém, respectively.

Assessment of the school environment

- ***by questionnaires***
  Separate questionnaires were used to assess the characteristics of the school building (location, age, building material, heating, ventilation, green space, etc.) and those of the investigated classrooms (orientation, size, occupancy, openable windows, ventilation regime, wall and floor coverings, blackboard, means and regime of cleaning, etc.).

- ***by measurements***
  - *Continuous active sampling:* carbon monoxide (CO), carbon dioxide (CO_2), particulate matters (PM_{10} and $PM_{2.5}$, respectively), relative humidity (RH), and temperature (T).
  - *passive sampling, 4-days exposure:* nitrogen dioxide (NO_2), benzene, xylenes, toluene, ethyl-benzene, formaldehyde, and only in SINPHONIE: trichloroethylene, pinene, limonene, and naphthalene. In each classroom there was an indoor sampling point at a height of 1.5-2.0 metres, the outdoor passive sampler was fixed on the outside wall, near to the classroom window.
  - *passive sampling, 1 month exposure:* radon (only in SINPHONIE)
  - *biological pollutants (only in SINPHONIE):* endotoxin and moulds (results will be presented in a subsequent paper)

Assessment of the children's health status

- ***by anonymous questionnaires*** completed by the parents with questions on the child's bronchitic, asthmatic and allergic symptoms and the known confounders (socio-economic situation and smoking habits of the family, the child's past medical history, including perinatal circumstances)
  (the results of following examinations will be presented in subsequent papers)

- ***by lung function measurements*** – using Spiro Tube spirometer

- ***by attention/concentration test*** (only in SINPHONIE) – solving 36 simple mathematical tasks (additions, subtractions, multiplications)

- ***by recording absenteeism (***only in SINPHONIE***)*** – between 1st November and 28th February

Statistical analysis

Descriptive analysis of the measurement results produced mean and median, minimum and maximum values, while that of the questionnaire data presented prevalence of the various symptoms

and other variables. Means of continuous variables were compared by Student's t-test (in case of normal distribution) or non-parametric Mann-Whitney U-test (in case of non-normal distribution).

RESULTS AND DISCUSSION

Outdoor school environment

Distribution of the studied schools according to traffic density and presence of neighbouring polluting establishments is presented in *Table I*. More than half of the children went to school in a high traffic area. Power plant, waste disposal site or waste incinerator did not exist in the neighbourhood of either school studied in Hungary.

Table I.

Distribution (%) of children of the studied schools according to quality of the outdoor environment

Outdoor characteristics	SEARCH project	SINPHONIE project
High traffic density	60.5	48.7
Industry < 100 m	21.1	11.9

Indoor school environment.

Classroom characteristics

Percent of children present in classrooms with various characteristics is shown in *Table II.* Most of the studied classrooms were located on the lower three levels, their windows facing the street and the yard almost evenly. Mean floor area per pupil was 2 square metres. However, about 44% of the children were staying in classrooms with less than 2 m^2 per person floor area. Almost 90% of children in the SINPHONIE project and half of the children in the SEARCH project used classrooms with plastic floor. Most of the classrooms were painted with water-soluble paints, water-resistant (synthetic) paints were used in classrooms of 26% and 16% of children, respectively. 2.9% and 16.5% of the children used classrooms where windows were not opened every break. *(Table II.)*

Data of the various pollutants and other parameters measured in the studied Hungarian classrooms are detailed in *Tables III* (SEARCH project) *and IV* (SINPHONIE). Most of the concentrations were within the acceptable range, however, those of PM_{10} and $PM_{2.5}$, respectively, were higher than the WHO guideline values for 24 hours *(Table V).* There was no indoor NO_2 source in the classrooms, so the measured indoor NO_2 concentrations, as well as the CO_2 ones reflected the reported traffic density *(Figures 1 and 2)*. PM_{10} and CO_2 concentrations differed significantly between classes facing the yard or the street *(Figures 3 and 4).* Formaldehyde levels were much lower than those measured in Hungarian schools more than two decades earlier (Rudnai et al., 1990). Indoor levels of VOCs, especially of benzene in SINPHONIE, were higher than the recom-

mended guideline value *(Table V)*. Recent wall-painting showed highly significant associations with the measured benzene levels *(Figure 5)*. Although the absolute VOC levels were lower in the SEARCH than in the SINPHONIE project, the impact of recent wall-painting on the measured indoor pollutants was still obvious *(Figure 6)*. The relatively high CO_2 concentrations reflected also the effects of insufficient ventilation (an average of 0.36 per hour, with a minimum of 0.14 per hour!) and crowdedness (inadequate floor space) similar to those of $PM_{2.5}$ *(Figures 7 and 8)*.

Table II.

Distribution (%) of children according to the various classroom characteristics

Indoor characteristics	SEARCH project	SINPHONIE project
Floor level		
Ground floor	44.2	52.8
1st floor	34.9	22.3
2nd floor	18.6	18.4
3rd floor	2.3	6.5
Together	100.0	100.0
Window orientation		
Street	58.1	42.4
Yard	41.9	57.6
Together	100.0	100.0
Occupancy		
< 2 m^2/pupil	47.6	41.6
≥ 2 m^2/pupil	52.4	58.4
Together	100.0	100.0
Floor covering		
Wood	48.8	10.9
Plastic	48.8	89.1
Stone/Concrete	0.0	0.0
Carpet	2.4	0.0
Together	100.0	100.0
Wall covering (> 1 answer possible)		
Whitewash	11.9	33.7
Water-soluble painting	78.6	49.6
Water-resistant painting	26.2	16.7
Wallpaper	9.5	0.0
Wood panel	23.8	0.0
Frequency of window openings		
Every break	97.1	83.5
2-3 times a day	0.1	10.4
Once a day	2.8	6.1
Together	100.0	100.0
Means of cleaning (> 1 answer possible)		
Vacuum cleaner	11.6	0.0
Broom	83.7	77.2
Mop	81.4	70.9
Mop with bleach	33.8	22.5

Table III.

Pollutant concentrations measured in classrooms of the SEARCH project

Measured pollutants	Mean (± SD)	Median	Min.	Max.	I/O
PM_{10} (μg/m³)	56.2 ± 28.2	56	9.0	115.0	1.11
NO_2 (μg/m³)	15.6 ± 7.2	14	4.0	39.0	0.52
Formaldehyde (μg/m³)	2.4 ± 0.9	2.2	0.9	5.5	4.8
Benzene (μg/m³)	2.4 ± 1.7	1.7	0.4	5.9	1.29
Ethyl-benzene (μg/m³)	1.7 ± 2.4	0.9	0.0	12.9	3.2
Xylenes (μg/m³)	7.4 ± 12.4	3.1	0.4	69.3	4.67
Toluene (μg/m³)	4.7 ± 4.0	3.2	1.0	21.4	2.3
CO_2 (ppm)	1498 ± 488	1457	728	3061	3.5

I/O: ratio of concentrations measured indoor and outdoor

Table IV.

Pollutant concentrations measured in Hungarian classrooms of the SINPHONIE project

Measured parameters	Mean (± SD)	Median	Min.	Max.
Formaldehyde (μg/m³)	9.0 ± 4.0	9.0	3.7	17.2
NO_2 (μg/m³)	11.5 ± 5.0	10.8	4.6	21.9
$PM_{2.5}$ (μg/m³)	46.6 ± 26.6	41.5	12.0	105.6
Benzene (μg/m³)	6.6 ± 5.6	4.3	2.0	19.7
Ozone (μg/m³)	3.5 ± 3.3	2.5	0.0	11.9
Naphthalene (μg/m³)	3.2 ± 2.1	3.1	0.3	9.0
Limonene (μg/m³)	37.3 ± 41.8	13.2	4.9	149.5
Trichloroethylene (μg/m³)	9.7 ± 24.0	0.0	0.0	86.2
Tetrachloroethylene (μg/m³)	0.06 ± 0.25	0.0	0.0	1.0
Radon (Bq/m³)	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
Ventilation/hour	0.36 ± 0.16	0.37	0.14	0.64
CO_2 (ppm)	1456 ± 251	1485	964	1815

Table V.

Recommended indoor guideline values of some air pollutants

Pollutants	Unit	Value	Averaging time	References
Formaldehide	µg/m^3	100	30 perc	WHO Guidelines for Indoor Air Quality: Selected pollutants, 2010
Benzene	µg/m^3	Safe exposure level can not be recommended		WHO Guidelines for Indoor Air Quality: Selected pollutants, 2010
		5	1 year	Directive 2008/50/EC
Toluene	µg/m^3	260	1 week	WHO air quality guidelines for Europe, 2nd edition (2000) – outdoor
NO_2	µg/m^3	200 40	1 hour 1 year	WHO Guidelines for Indoor Air Quality: Selected pollutants, 2010
PM_{10}	µg/m^3	50	24 hours	WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide (2005)
$PM_{2.5}$	µg/m^3	25	24 hours	WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide (2005)
CO_2	ppm	700 ppm difference between the indoor and outdoor CO_2 concentrations		ASHRAE 62.1-2004

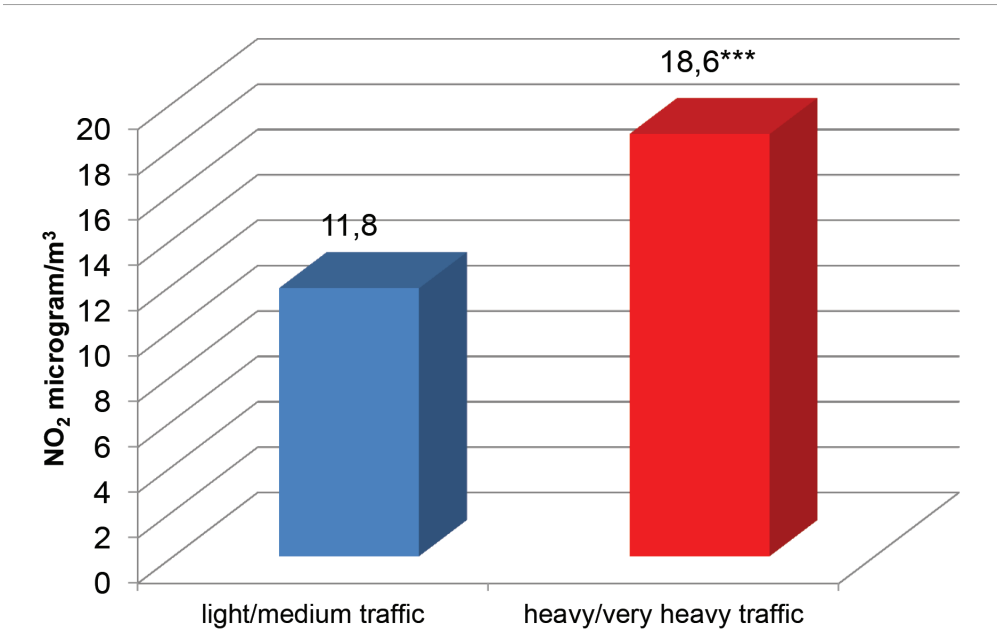

Figure 1. Association between the NO_2 levels measured in the Hungarian classrooms and the reported traffic density near the school (SEARCH project.
****$p < 0.001$*

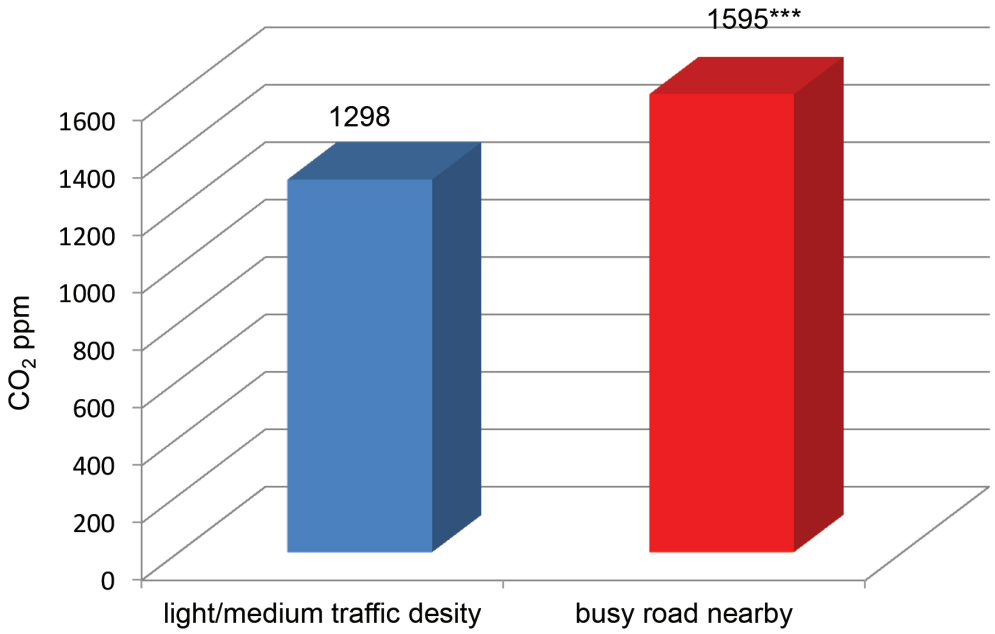

Figure 2. Association between the CO_2 levels measured in theHungarian classrooms and the reported traffic density near the school (SINPHONIE project)
****p < 0.001*

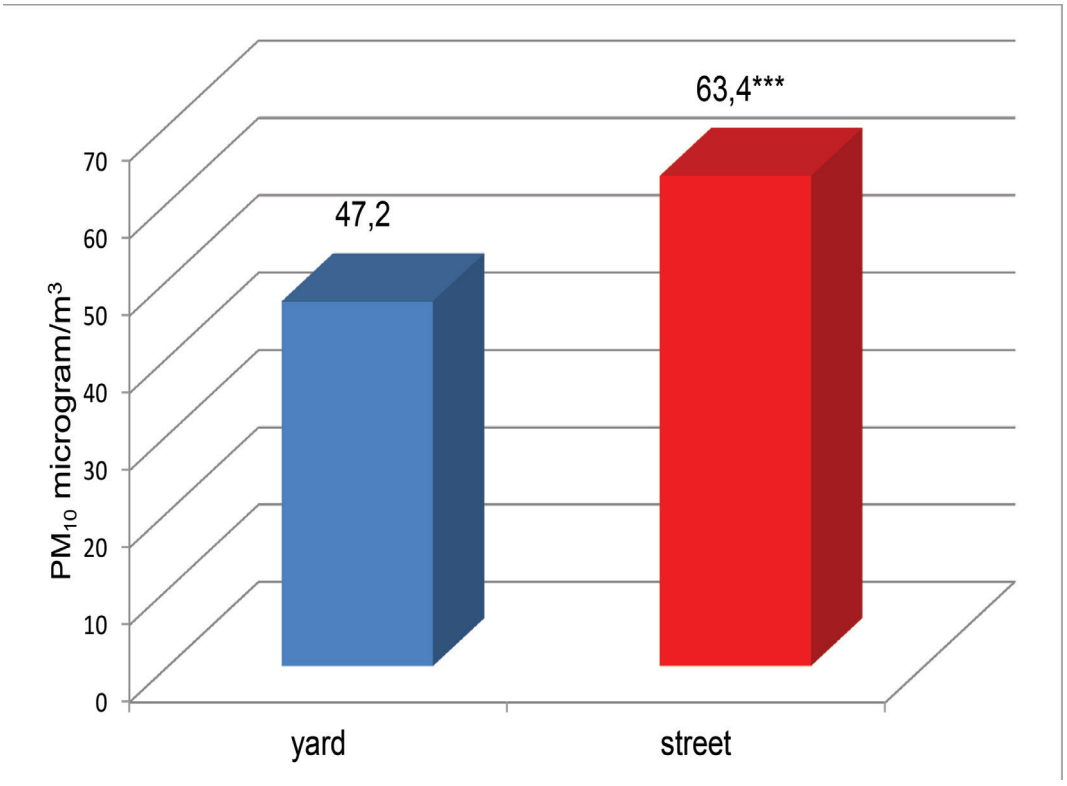

Figure 3. Mean PM_{10} concentrations measured in Hungarian classrooms with windows facing the yard or the street (SEARCH project).
****p < 0.001*

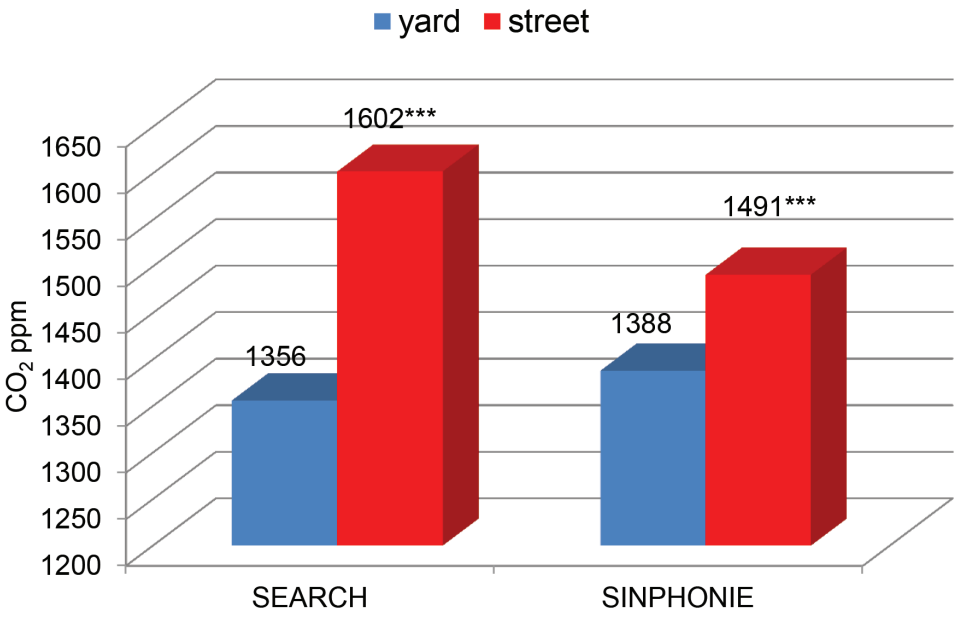

Figure 4. Mean CO_2 concentrations measured in Hungarian classrooms with windows facing the yard or the street.
****p < 0.001*

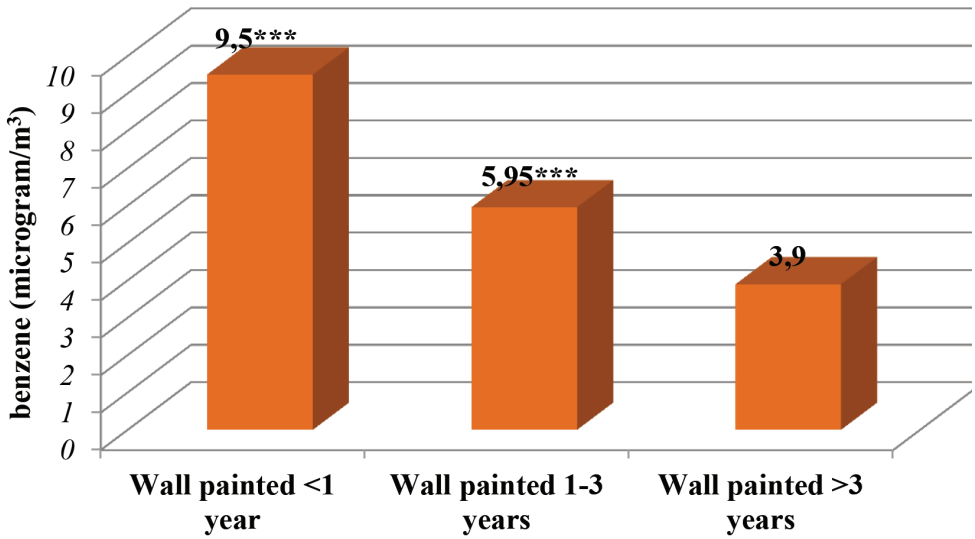

Figure 5. Mean benzene concentrations measured in Hungarian classrooms painted in various time span before air sampling (SINPHONIE project)
****p < 0.001*

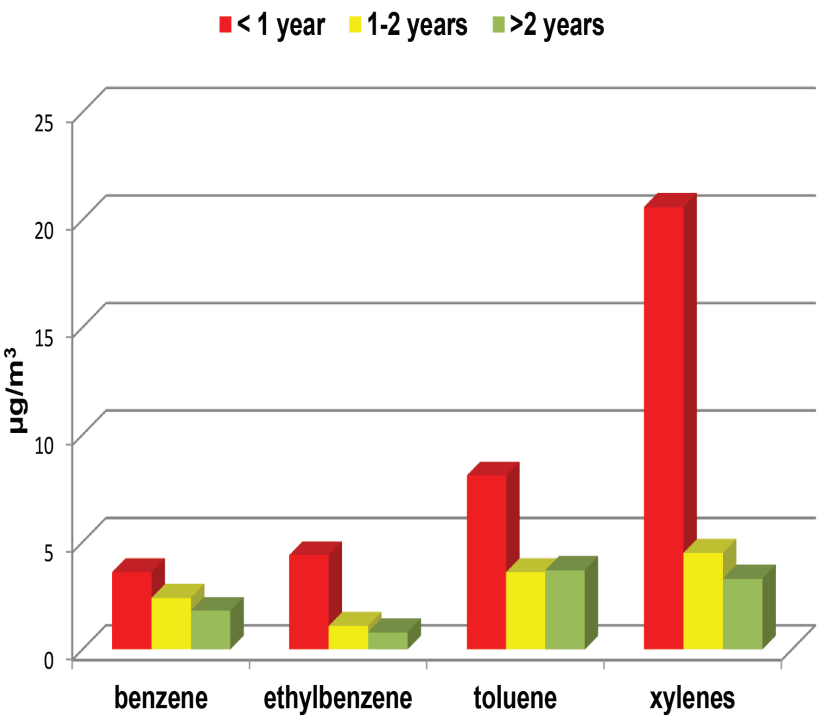

Figure 6. Associations between VOC concentrations measured in Hungarian classrooms and the time elapsed since class renovation (SEARCH project)

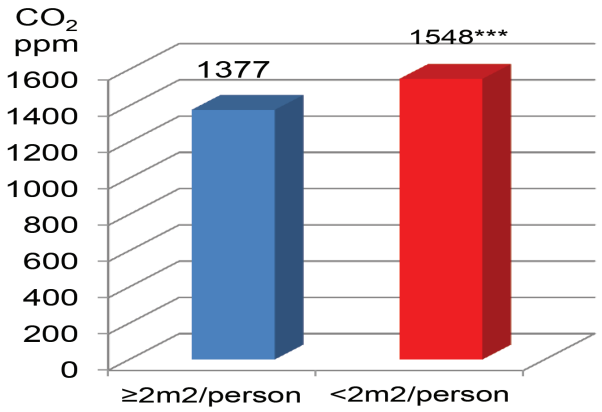

*Figure 7. Mean CO_2 concentrations measured in Hungarian classrooms with recommended (≥ 2 m²/ person) or reduced (< 2 m² /person) floor space (SINPHONIE project) ***p < 0.001*

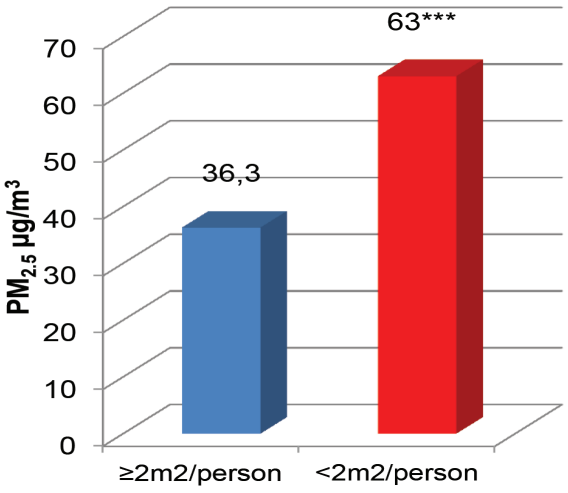

*Figure 8. Mean $PM_{2.5}$ concentrations measured in Hungarian classrooms with recommended (≥ 2 m²/ person)or reduced (< 2 m² /person) floor space (SINPHONIE project) ***p < 0.001*

Prevalence of respiratory symptoms and diseases among the participating children are displayed in *Tables VI – VII*. Questionnaires of the two projects were differently formulated, though there were several questions where the wording was exactly the same (e.g. woken up by wheeze in the last 12 months; wheeze after exercise in the last twelve months; doctor-diagnosed asthma ever; asthma treatment during the last 12 months, etc.), still the prevalence rates varied substantially. The same was true of the prevalence of doctor-diagnosed allergies and allergic symptoms, too *(Tables VIII – X)*.

The prevalence of any bronchitis or asthmatic symptoms found in the SEARCH project was not very different from that we found in the country-wide survey (17.3% and 18.4%, respectively, Rudnai et al., 2014), but the relevant data found in the SINPHONIE project were much lower. The number of Hungarian children participating in the two projects was not large enough to reveal statistically significant associations between the studied elements of school environment and the children's health, so the tables below provide only descriptive information. The associations are subject of reports and publications by the international working groups using merged datasets of the participating countries.

Table VI.

Prevalence (%) of respiratory symptoms and diseases among Hungarian participating schoolchildren in the SEARCH project

Bronchitis symptoms	Prevalence (%)	Asthmatic symptoms	Prevalence (%)	Asthma bronchiale	Prevalence (%)
Morning cough	8.4	Wheeze in the last 12 months	8.2	Doctor-diagnosed asthma, ever	7.1
Day/night cough	6.5	Wheeze after exercise, last 12 months	5.8	Asthma treatment, last 12 months	3.7
Cough >3 months	3.3	Dry cough at night, last 12 months	10.9		
Cough with phlegm	3.6	Woken up by wheeze, last 12 months	2.0		
ANY BRONCHITIS SYMPTOM	**13.4**	**ANY ASTHMATIC SYMPTOM**	**16.9**		

Table VII.

Prevalence (%) of respiratory symptoms and diseases among Hungarian participating schoolchildren in the SINPHONIE project

Bronchitis symptoms	Prevalence (%)	Asthmatic symptoms	Prevalence (%)	Asthma bronchiale	Prevalence (%)
Cough with phlegm	0.5	Wheeze after exercise, last 12 months	4.2	Doctor-diagnosed asthma, ever	9.1
ANY BRONCHITIS SYMPTOM	**7.4**	Woken up by wheeze, last 12 months	4.2	Asthma treatment, last 12 months	6.2
		ANY ASTHMATIC SYMPTOM	**7.4**		

Table VIII.

Prevalence (%) of doctor-diagnosed allergies among the Hungarian participating children in the SEARCH project

ALLERGIES	PREVALENCE (%)
House-dust mites	9.5
Animal fur, feather	9.7
Pollen	12.2
Mould	7.2
Food	8.8
Drug	10.8
ANY ALLERGY	**23.7**

Table IX.

Prevalence (%) of doctor-diagnosed allergies among the Hungarian participating children in the SINPHONIE project

ALLERGIES	PREVALENCE (%)
House-dust mites	12.1
Animal fur, feather	6.0
Pollen	11.7
Food	5.8

Table X.

Prevalence of Hungarian children with allergic symptoms in the SEARCH and the SINPHONIE projects

ALLERGIC SYMPTOMS	SEARCH	SINPHONIE
Conjunctivitis	8.2	11.0
Blocked/runny nose	34.8	28.5
Hay fever	6.1	14.1

CONCLUSIONS

Due to the lack of regulations on indoor air quality of schools in Hungary various actors of school planning and design, construction and maintenance are not aware of the impact of indoor air quality on the health and performance of this particularly sensitive population group, the children. Besides increased education and training activities for the interested professional groups, official regulations are also needed to ensure healthy school environment in Hungary like in other EU member countries.

REFERENCES

EU (2014). European Commission's Directorates General for Health and Consumers & Joint Research Centre. Guidelines for healthy environments within European schools. Luxembourg.

MSZE (2012) MSZE 24203-2:2012: Requirements for design of institutions for education. Part 2: Primary schools. (in Hungarian) https://waldorf-godollo.hu/wp-content/uploads/2014/01/MSZE-Iskolai-szabv%C3%A1ny-24203-2-2012-01.pdf (Accessed on 28.04. 2019)

PARMA Declaration (2010).
http://www.euro.who.int/__data/assets/pdf_file/0011/78608/E93618.pdf (accessed on 28.04.2019).

RUDNAI P**.**, FARKAS I., BÁCSKAI J.G., et al. (1990). Epidemiological study on indoor formaldehyde exposure of children. In: Proceedings of the Fifth International Conference on Indoor Air Quality and Climate, Toronto, Canada, July 29-August 3, 1990, vol 1, 459-464

RUDNAI P., VARRÓ M.J., MÁCSIK A., et al. (2014). Urban-rural differences in the prevalence of respiratory symptoms of school children in Hungary. Centr. Europ. J Occup Environ Med 20(1-2): 67-78

TNM decree (2006). 7/2006 (V.24.) TNM decree on the assessment of energetic characteristics of buildings. Annex 1. Prescriptions concerning the building engineering system (in Hungarian)