REPORT ON VIRTUAL HEALTH REPOSITORY

Version 3
12.2018
Indoor air quality (IAQ) can be characterised by physical parameters (e.g., temperature, relative humidity, air exchange rate), chemical air pollutants (e.g., carbon dioxide, nitrogen dioxide, particulate matter, ozone, benzene, etc.) and biological agents (e.g., pollen, fungi). During the monitoring campaign 64 primary school buildings were investigated in Central Europe (Czech Republic, Hungary, Italy, Poland and Slovenia) where the concentration of the most important air pollutants as well as the physical parameters were monitored. Due to the complexity of this issue, a simple Indoor Health Index has been developed (i) to disseminate the results of the project among the public and stakeholders and (ii) to provide health relevant information about the IAQ.

The indoor health index applies benzene, formaldehyde and fine particulate matter (PM) as indoor pollutants; because for other pollutants there is not enough scientific based evidence available on how to develop categorization. In case the three main compounds the comfort and optimum (“healthy” and “moderate” category in IAQ) thresholds are set as follows:

- benzene: 0-4.99 µg/m³
- formaldehyde: 0-19.9 µg/m³
- PM$_{2.5}$: 0-24.9 µg/m³

An online platform called Virtual Health Repository is used for these purposes and it is available at https://www.oki.hu/virtual-health-repository-vhr-general-overview. Methodological related studies and the recent factsheet are available at https://www.interreg-central.eu/Content.Node/InAirQ/InAirQ.html. For more technical and methodological information please contact dr Tamás Szigeti at the National Public Health Center, Budapest.
Indoor Health Index

Indoor air quality, which is a function of outdoor and indoor air pollutants, thermal comfort, and sensory loads (odors, “freshness”), can affect the health of children and adults and may affect student learning and teacher productivity.

Pollutants are generated from many sources. Outdoor pollutants include ozone, which has been associated with absenteeism among students. Pollutants and allergens in indoor air—mold, dust, pet dander, bacterial and fungal products, volatile organic compounds, and particulate matter—are associated with asthma and other respiratory symptoms and with a set of building-related symptoms (eye, nose, and throat irritations; headaches; fatigue; difficulty breathing; itching; and dry, irritated skin). In some cases, outdoor pollutants react with indoor chemicals to create new irritants.

As shown in Figure 1 the complex interactions between indoor and outdoor pollutants, moisture/humidity, HVAC systems, operations and maintenance practices can affect occupants’ health, comfort, and productivity.

Figure 1: Relationships between pollutants, moisture, and ventilation and human comfort, health, and development
The review of the methodologies to determine indoor air quality indices has been completed within the InAirQ project. In order to elaborate a simple, easily applicable method, we developed an Indoor Health Index.

The calculation of the Indoor Health Index is based on different threshold values determined by the health effects of the air pollutants/physical parameters (recommendations of the WHO and/or EC and/or scientific papers).

We applied a five scale categorization of the most important and frequent chemical air pollutants using for the cut off points. Based on the guidelines provided by the World Health Organization for indoor air pollutants, only benzene, formaldehyde and fine particulate matter were used. In other cases, there is not enough scientific based evidence available on how to develop categorization. The five-scale categorization is very common in the case of air quality indices developed for the communication of both indoor and outdoor air quality.

Table 1. The calculation of Indoor Health Index.

<table>
<thead>
<tr>
<th>category</th>
<th>benzene (µg/m^3)</th>
<th>formaldehyde (µg/m^3)</th>
<th>PM_{2.5} (µg/m^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthy</td>
<td>&lt;1.7</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Moderate</td>
<td>1.7-4.99</td>
<td>10-19.9</td>
<td>10-24.9</td>
</tr>
<tr>
<td>Unhealthy</td>
<td>5-7.5</td>
<td>20-50</td>
<td>25-49.9</td>
</tr>
<tr>
<td>Very unhealthy</td>
<td>7.51-10</td>
<td>51-100</td>
<td>50-75</td>
</tr>
<tr>
<td>Dangerous</td>
<td>&gt;10</td>
<td>&gt;100</td>
<td>&gt;75</td>
</tr>
</tbody>
</table>

When applying the index in practice we characterize the actual air quality according to the worst category, indicating the pollutant.

The database in which the Indoor Health Index has been calculated is available upon request.

To characterize the thermal comfort, different cut-off points for two physical parameters, temperature and relative humidity, as well as for the concentration of carbon dioxide have been set (Table 2).
Table 2: Categories based on the measured temperature, relative humidity and carbon dioxide concentration values

<table>
<thead>
<tr>
<th>Category</th>
<th>RH (%)</th>
<th>T (°C)</th>
<th>CO₂ (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthy</td>
<td>43&lt;RH&lt;67</td>
<td>18.5&lt;T&lt;25.5</td>
<td>&lt;1200</td>
</tr>
<tr>
<td>Moderate</td>
<td>37&lt;RH&lt;43; 67&lt;RH&lt;73</td>
<td>17.5&lt;T&lt;18.5</td>
<td>1200-1800</td>
</tr>
<tr>
<td>Unhealthy</td>
<td>RH&lt;37; RH&gt;73</td>
<td>T&lt;17.5; T&gt;25.5</td>
<td>&gt;1800</td>
</tr>
</tbody>
</table>

Virtual Health Repository

The Virtual Health Repository is an online platform which consists of two items: (i) the description of the method for the calculation of the Indoor Health Index based on the IAQ data as well as (ii) the description of the IAQ results for all primary school buildings participated in the monitoring campaign. Only the building IDs are listed in the VHR, thus it is not possible to identify the schools by the readers. Besides the Index calculated for the school, some IAQ-relevant properties of the school environment (e.g., location, traffic density, renovation works) are listed. Furthermore, it is noted that the inappropriate indoor air quality is caused by either the outdoor air pollution or the indoor sources of air pollutants are responsible for the problem. The measured values are also listed in summary tables for all schools.

The National Public Health Center (NPHC) calculated the Indoor Health Index values and prepared the online platform. All project partners provided input to the description of the school environment. Examples are provided in Figure 2. The VHR can be updated by the NPHC once new IAQ data are collected.
VHR - Czech Republic

Number of school buildings investigated: 12

CZ01 is located in the residential area of the northwest quadrant of the city center of Prague. The road is characterized by moderate traffic density close to the school. The school building type is panel and it was built in the middle of the 20th century. The building is equipped with a leafy facade and the windows have been reconstructed in the past five years. The capacity of the school is 650 pupils. The indoor air quality was in the category 7 based on the indoor health index. The main air pollutant was the particulate matter (PM10). It should be noted that the outdoor value for the PM10 mass concentration was also high, thus the inappropriate indoor air quality was mainly caused by the outdoor air pollution. Furthermore, one of the comfort parameters was in the moderate range; the carbon dioxide concentration was relatively high in the classroom.

CZ02 is located in the residential area of the northwest quadrant of the city center of Prague, close to a relatively high traffic road. The school building was constructed in the 1970s. The school building is equipped with a leafy facade and the windows have been reconstructed in the past five years. The capacity of the school is 435 pupils. The indoor air quality was in the category 7 based on the indoor health index. The main air pollutant was the particulate matter (PM10). Furthermore, one of the comfort parameters was in the unhealthy range; the relative humidity was low in the classroom.

CZ03 is located in the residential area of the northwest quadrant of the city center of Prague, close to a relatively high traffic road. The school building type is panel and it was built in the middle of the 20th century. The building is equipped with a leafy facade and the windows have been reconstructed in the past five years. The capacity of the school is 435 pupils. The indoor air quality was in the category 6 based on the indoor health index. The main air pollutant was the particulate matter (PM10). Furthermore, one of the comfort parameters was in the unhealthy range; the relative humidity was low in the classroom.

VHR - Hungary

Number of school buildings investigated: 16

HU01 is located in the city centre of Veszprém, close to a relatively high traffic road. The school building was constructed in the 1970s. The school building is equipped with a leafy facade and the windows have been reconstructed in the past five years. The capacity of the school is 525 pupils. The indoor air quality was in the category 7 based on the indoor health index. The main air pollutant was the particulate matter (PM10). It should be noted that the outdoor value for the PM10 mass concentration was also high, thus the inappropriate indoor air quality was mainly caused by the outdoor air pollution. Furthermore, one of the comfort parameters was in the unhealthy range; the relative humidity was low in the classroom.

HU04 is a primary school in Pécs, close to a relatively high traffic road. The school building was constructed in the 1970s. The school building is equipped with a leafy facade and the windows have been reconstructed in the past five years. The capacity of the school is 525 pupils. The indoor air quality was in the category 7 based on the indoor health index. The main air pollutant was the particulate matter (PM10). It should be noted that the outdoor value for the PM10 mass concentration was also high, thus the inappropriate indoor air quality was mainly caused by the outdoor air pollution. Furthermore, one of the comfort parameters was in the unhealthy range; the relative humidity was low in the classroom.

HU05 is located in the residential area of Veszprém, far away from high traffic roads. The school building was constructed in the 1970s. The school building is equipped with a leafy facade and the windows have been reconstructed in the past five years. The capacity of the school is 525 pupils. The indoor air quality was in the category 7 based on the indoor health index. The main air pollutant was the particulate matter (PM10). It should be noted that the outdoor value for the PM10 mass concentration was also high, thus the inappropriate indoor air quality was mainly caused by the outdoor air pollution. Furthermore, one of the comfort parameters was in the unhealthy range; the relative humidity was low in the classroom.

VHR - Italy

Number of school buildings investigated: 13

IT01 is located in the southern suburbs of Turin city. The building, consisting of 3 floors above ground, was built in 1984 and is made of concrete. It also has lead roofs, very harmful to health but no component in asbestos. The school is located along a street with moderate traffic, and with moderate traffic and urban type driving speed (speed limit 50 km / h or less). In Turin, it is however, close to high traffic and high traffic density roads: the south ring road of Turin and the E35 transversal. As a result, the school building, despite being in a green area, is located in a heavily polluted neighborhood. Thanks to its proximity to an urban park, it is exposed to the air pollution generated by heavy traffic that develops nearby. Consequently, the main indoor air pollutant was benzene emitted by vehicular traffic, and the IAQ is in the very unhealthy category based on the indoor health index.

IT02 is located in the southern suburbs of Turin city. The building, consisting of 3 floors, is made of concrete with no asbestos or lead components. It is heated by central heating (district heating with condensation). The school is located in a main residential area with a moderate traffic and urban type driving speed (speed limit 50 km / h or less). It is, however, not far from high speed and high traffic density roads: Cigna Traversa and Cigna Unione Scudetto, i.e., the main roads to take the southern ring road of Turin. As a result, the school building is exposed to the air pollution generated by heavy traffic flowing nearby and the IAQ is strongly influenced by outdoor pollution, particularly for what concerns the benzene level, so high that they put the school (A7) in the dangerous category based on the indoor health index.

IT03
The Virtual Health Repository provide useful information to different target groups including the decision makers and also the people who are responsible for operating the schools daily.