The effects of improved energy efficiency on indoor environmental quality in multi-family buildings

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SUMMARY
INSULAtE project (www.insulateproject.eu) aimed to demonstrate the effects of improving energy efficiency (EE) on indoor environmental quality (IEQ) and occupant health. Data on building characteristic, IEQ parameters, as well as occupants’ perceptions were collected by measurements and questionnaires from a sample of 46 multifamily buildings from Finland and 20 from Lithuania. This paper presents some preliminary findings. After energy retrofits, significant changes in IEQ parameters were found, e.g., in concentrations of some indoor air pollutants. In addition, occupants reported higher satisfaction with indoor air quality (IAQ). The results will be further analyzed to support the implementation of the policies related to energy performance of buildings in Europe.

PRACTICAL IMPLICATIONS
Indoor environmental quality assessment could provide more comprehensive, additional information about the condition and performance of the building than traditionally used building investigation and energy auditing protocols.

KEYWORDS
Energy efficiency; retrofit; indoor environmental quality; satisfaction

1 INTRODUCTION
Within EU, the Energy Performance of Buildings Directive (EPBD, 2010) is the main policy aiming to reduce energy consumption in both new and existing buildings. According to World Health Organization (WHO, 2004), it is important to look for opportunities where health gains and sustainability objectives can be mutually reinforcing.

2 MATERIALS/METHODS
Data were collected utilizing long term data logging and measurements, environmental monitoring and sampling, and occupant questionnaires. Materials and methods, as well as baseline results (1st measurement), are presented more detailed by Du et al. 2015.

3 RESULTS AND DISCUSSION
In Finnish apartments, indoor temperatures (T) remained similar to the baseline (1st measurement) after retrofits (2nd measurement), while concentrations of PM₁₀, formaldehyde (CH₂O), VOCs (BTEX, incl. benzene, toluene, ethylbenzene and xylenes), and total fungi decreased (Table 1). In Lithuanian apartments, indoor T was significantly increased after retrofits. Also, concentrations of PM₁₀, CH₂O, and radon were increased, while concentrations of total fungi decreased.
Table 1. Median values of selected IEQ parameters based on the second measurement, and percentage of changes (Δ), as compared to the first measurement.

<table>
<thead>
<tr>
<th>Parameter, Unit</th>
<th>Case¹ Finland</th>
<th>Control Finland</th>
<th>Case¹ Lithuania</th>
<th>Control Lithuania</th>
</tr>
</thead>
<tbody>
<tr>
<td>T, °C</td>
<td>N²</td>
<td>Med</td>
<td>Δ, %</td>
<td>N²</td>
</tr>
<tr>
<td>RH, %</td>
<td>102</td>
<td>30.2*</td>
<td>4.1</td>
<td>21</td>
</tr>
<tr>
<td>CO₂, ppm</td>
<td>133</td>
<td>653</td>
<td>-4.9</td>
<td>30</td>
</tr>
<tr>
<td>Indoor PM₂.₅, µg/m³</td>
<td>107</td>
<td>4.3</td>
<td>-18.3</td>
<td>13</td>
</tr>
<tr>
<td>Indoor PM₁₀, µg/m³</td>
<td>107</td>
<td>12.4*</td>
<td>-15.0</td>
<td>13</td>
</tr>
<tr>
<td>CH₂O, µg/m³</td>
<td>103</td>
<td>16.4*</td>
<td>-9.9</td>
<td>13</td>
</tr>
<tr>
<td>NO₂, µg/m³</td>
<td>104</td>
<td>6.0</td>
<td>-3.2</td>
<td>13</td>
</tr>
<tr>
<td>BTEX, µg/m³</td>
<td>102</td>
<td>9.1*</td>
<td>40.0</td>
<td>13</td>
</tr>
<tr>
<td>Radon, Bq/m³</td>
<td>88</td>
<td>50</td>
<td>-16.7</td>
<td>12</td>
</tr>
<tr>
<td>Fungi, Cell/(m²*day)</td>
<td>56</td>
<td>97*</td>
<td>-79.7</td>
<td>10</td>
</tr>
</tbody>
</table>

¹ Corresponds to situation after retrofits ² Number of apartments *p<0.05 based on Mann-Whitney U Test (paired samples)

In Finland, a total of 234 occupants (response rates 94%) responded to the first questionnaire and 187 occupants (response rate 75%) responded to the second questionnaire. In Lithuania, the corresponding numbers were 57 and 27 occupants (response rates 59% and 28%), respectively. In Finland, occupants’ satisfaction with IAQ increased by 21%, while daily noise disturbance from building’s ventilation and plumbing systems increased by 6%. This could be related to that in Finland, many case buildings had updated mechanical ventilation systems. In Lithuanian case buildings, satisfaction with IAQ increased by 25%. Also thermal conditions were significantly increased.

These data have to be further analysed to account for temporal and spatial variations and to clarify the effects of retrofits. Additional analyses are also needed to study the associations between different measurement parameters and occupants’ behaviour, as well as their perceptions on IEQ and health.

4 CONCLUSIONS

After energy retrofits in Finnish and Lithuanian multifamily buildings, both positive and negative changes were observed on IEQ and occupants’ perceptions. Future analyses will focus on the clarification of the effects and finalization of the assessment protocol.

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5 REFERENCES

