Geogenic radon potential mapping in Pest and Nógrád counties in Hungary

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Introduction

- Our former work → soil gas radon from laboratory measurements of soil samples
- Radon exhalation of soil samples + soil porosity → soil gas radon activity concentration
- Indoor radon measurements (RADLabor, NRIRR)
Aims

- Take the first step to mapping the geogenic radon potential in Hungary
- Categorize the geological formations into radon potential categories
- Determine the daily, weekly, monthly and annual variation of soil gas radon concentration and the meteorological influences on it
- Create radon potential map for the studied area based on geological background
Geogenic radon mapping in Hungary

- Diverse geology of the studied area
  - Mesozoic sedimentary rocks (limestone and dolomite)
  - Tertiary volcanic rocks (andesite, dacite and rhyolite)
  - Tertiary sedimentary rocks (marl, clay and sandstone)
  - Quaternary sediments (loess, sand, gravel and clay)
- Soil gas radon activity concentration
- Gas permeability of soil

*Geological map of Central Region of Hungary, Gyalog L., 2005: Geological map of Hungary 1:100 000 (Budapest), ©Geological Institute of Hungary*
**Methods**

Soil gas radon

- RAD7 radon monitor (solid state, ion-implanted, planar silicon alpha detector) coupled with soil gas probe
- Sampling depth: 70-80 cm generally
- Mapping: GRAB protocol
- Radon annual variation: SNIFF protocol
Methods

Gas permeability of soil

- RADON - JOK portable permeameter
- at the same depth (70-80 cm)
**Methods**

Categorization of geological formations into radon potential

- **Soil gas radon activity concentration**
  - 0-10 kBq/m³ → **LOW**
  - 10-100 kBq/m³ → **MEDIUM**
  - 100-500 kBq/m³ → **INCREASED**
  - >500 kBq/m³ → **HIGH**
  - after Kemski et al. (2001)

- **Gas permeability of soil**
  - <4.0×10⁻¹³ m² → **LOW**
  - 4.0×10⁻¹² - 4.0×10⁻¹³ m² → **MEDIUM**
  - >4.0×10⁻¹² m² → **HIGH**
  - after RADON-JOK MANUAL
Methods

Sampling soil gas radon derived different geological formations

*Geological map of Pécel and Piliscsaba, Gyalog L., 2005: Geological map of Hungary 1:100 000 (Budapest), ©Geological Institute of Hungary*
Methods

- Easy Weather station
  - humidity
  - temperature
  - pressure
  - wind
  - rain

Meteorological parameters
# Results

Soil gas radon activity concentration of soils derived different geological formation

<table>
<thead>
<tr>
<th>Geological formations</th>
<th>number of sampling sites</th>
<th>range (kBq/m³)</th>
<th>median (kBq/m³)</th>
<th>average (kBq/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mesozoic sedimentary rocks (limestone and dolomite)</td>
<td>4</td>
<td>2,9-10,2</td>
<td>4,7</td>
<td>5,6</td>
</tr>
<tr>
<td>Tertiary sedimentary rocks (marl, clay and sandstone)</td>
<td>7</td>
<td>1,4-9,3</td>
<td>2,8</td>
<td>3,8</td>
</tr>
<tr>
<td>Quaternary sediments (loess, sand, gravel and clay)</td>
<td>36</td>
<td>0,7-10,3</td>
<td>4,4</td>
<td>4,9</td>
</tr>
</tbody>
</table>
Results

Daily and monthly variation of soil gas radon activity concentration and the meteorological influences

Budapest 1 - Kispest
Results

Monthly changes of soil gas radon activity concentration and the meteorological influences

Budapest 2 - Gilice tér
Results

Weekly variation of soil gas radon activity concentration and the meteorological influences

Nagytarcsa
## Results

Linear correlation between soil gas radon and meteorological parameters in 1 week periods

<table>
<thead>
<tr>
<th>Soil gas radon</th>
<th>Outdoor humidity</th>
<th>Outdoor temperature</th>
<th>Pressure</th>
<th>Wind</th>
</tr>
</thead>
<tbody>
<tr>
<td>Budapest 1 - Kispest</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.06</td>
<td>-0.04</td>
<td>0.47</td>
<td>-0.02</td>
<td>0.19</td>
</tr>
<tr>
<td>-0.36</td>
<td>0.13</td>
<td>0.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-0.31</td>
<td>0.22</td>
<td></td>
<td></td>
<td>0.19</td>
</tr>
<tr>
<td>Budapest 2 - Gilice tér</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.47</td>
<td>-0.6</td>
<td>0.43</td>
<td>0.1</td>
<td>0.14</td>
</tr>
<tr>
<td>0.37</td>
<td>-0.03</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nagytarcsa</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.58</td>
<td>-0.42</td>
<td>-0.06</td>
<td>-0.46</td>
<td></td>
</tr>
<tr>
<td>0.40</td>
<td>-0.46</td>
<td>-0.45</td>
<td>-0.09</td>
<td></td>
</tr>
</tbody>
</table>
## Results

Variability of soil gas radon activity concentration time series 1 week periods

<table>
<thead>
<tr>
<th>Soil gas radon</th>
<th>average (Bq/m³)</th>
<th>standard deviation (Bq/m³)</th>
<th>relative deviation %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Budapest 1 - Kispest</td>
<td>2580</td>
<td>290</td>
<td>11%</td>
</tr>
<tr>
<td></td>
<td>3460</td>
<td>200</td>
<td>6%</td>
</tr>
<tr>
<td></td>
<td>4220</td>
<td>250</td>
<td>6%</td>
</tr>
<tr>
<td>Budapest 2 - Gilice tér</td>
<td>2810</td>
<td>510</td>
<td>18%</td>
</tr>
<tr>
<td></td>
<td>3400</td>
<td>750</td>
<td>22%</td>
</tr>
<tr>
<td>Nagytarcsa</td>
<td>3970</td>
<td>360</td>
<td>9%</td>
</tr>
<tr>
<td></td>
<td>5420</td>
<td>330</td>
<td>6%</td>
</tr>
</tbody>
</table>
Summary

- Soil gas radon activity concentration derived different geological formations
  - Mesozoic sedimentary rocks – LOW
  - Tertiary sedimentary rocks - LOW
  - Quaternary sediments – LOW

- Higher soil gas radon activity concentration than 10 kBq/m³ (with higher than 15% probability)
  - Quaternary sediments 1 site
  - Mesozoic sedimentary rocks 1 site
Summary

- Soil gas radon
  - daily variation is $7.5 \pm 1\%$
  - weekly variation is 6-9%, 6-11%, 18-22%
  - monthly variation is 25%

- Correlation between soil gas radon and meteorological parameters from 7 one week measurements
  - outdoor humidity: 6 moderate correlation
  - outdoor temperature: 2 moderate and 1 strong correlation
  - pressure: 4 moderate and 1 high correlation
  - wind: 1 moderate correlation
THANK YOU FOR YOUR ATTENTION!