MAPPING OF GEOCHEMICAL CONTAMINATION IN URBAN AREAS OF LITHUANIA

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Mapping of Geochemical Contamination in Urban Areas of Lithuania, 2007 meeting NATO/CCMS Pilot study
OBJECTIVES

- Revelation of **spatial geochemical properties of urban soil** with regard to distribution of hazardous substances
- Sanitary assessment of **topsoil contamination level**
- Detection of:
  - **contamination sources**
  - its geochemical matrix;
  - its impact areas
  - pathways of contamination spread
  - impact of soil contamination on **ground water quality**
• Spatial topsoil sampling grid varies:
  • from 100 m to 500 m, in *residential* areas with regard to suspected contamination
  • from 20 m to 100 m in *industrial* areas with attempt to collect statistically significant sample population

• Sampling pattern depends on soil sealing pattern, but always is seeking the regular one
• Observable suspected **hotspots** must be sampled

• Samples of:
  
  • **industrial dust** from the factory vents and filters (to detect the individual “fingerprints”),
  
  • **stream & dug well sediments,**
  
  • **vadose zone** and
  
  • **snow** (to estimate pathway and area of contamination) are in use if necessary

• Follows the standard: ISO 10381-5: 2005 Soil quality – sampling – Guidance on the procedure for the investigation of urban and industrial sites with regard to soil contamination
ANALYTICAL PROCEDURES

**Formal procedures:**

- **Total contents** of macro- and trace elements (Al, Ca, Fe, Mg, Ag, B, Ba, Be, Bi, Cd, Ce, Co, Cr, Cu, Ga, Ge, Hf, La, Li, Mn, Mo, Nb, Ni, P, Pb, Sb, Sc, Sn, Sr, Ti, V, W, Y, Yb, Zn, Zr)
- LOI, pH

**Extra procedures**, subject to suspected type of contamination:

- Hg, As, other **extractable forms** (aqua regia, bioavailable) of toxic heavy metals
- aromatic **hydrocarbons**, PAH, oil products
- PCB, EOX, **pesticides**
- **ions** of sulphate, nitrate, fluoride and potassium chloride

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ASSESSMENT OF SOIL CONTAMINATION LEVEL  (according HN 60:2004)

According to criteria:

- **maximum permissible concentrations** (also, reference values related to the background values for sand & sandy loam soil as well as for loam & clay)

- **risk index** $K_0$, calculated by formula
  
  \[ K_0 = \frac{C}{MPL}, \]

  where

  - $C$ – content of particular element in soil sample (mg/kg)
  - $MPC$ – maximum permissible concentration of the same element (mg/kg)

- **index of total contamination** $Z_s$, calculated by formula
  
  \[ Z_s = \sum K_{ki} - (n-1), \]

  where

  \[ K_{ki} = \frac{C_i}{C_b}, \]

  - $C_i$ – measured content of $i$ element-pollutant in soil sample (mg/kg),
  - $C_b$ – background value of $i$ element-pollutant (mg/kg),
  - $n$ – number of elements-pollutants,
In residential areas:

<table>
<thead>
<tr>
<th>Contamination level</th>
<th>Zs value</th>
<th>Change of population health indices in the contaminated areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Permissible</td>
<td>&lt; 16</td>
<td>The lowest level of sick children rate and minimum frequency of functional divergences</td>
</tr>
<tr>
<td>II. Medium dangerous</td>
<td>16 – 32</td>
<td>The increase of total sick rate</td>
</tr>
<tr>
<td>III. Dangerous</td>
<td>32 – 128</td>
<td>The increase of total sick rate, number of children that are frequently sick, have chronic diseases or cardiovascular disorders</td>
</tr>
<tr>
<td>IV. Extremely dangerous</td>
<td>&gt; 128</td>
<td>The increase of sick children rate, disturbance of reproductive function of women (increase of pregnancy intoxications, premature child birth, number of still-born and hypotrophic newborns)</td>
</tr>
</tbody>
</table>
LINK between SOIL CONTAMINATION and HUMAN HEALTH (2)

Methodology developed in 1980-90 in IMGRE, Moskow, Russia by Revich and Saet (Recomendations concerning eco-geochemical assessment of environment in industrial urban areas, 1982:

Ревич Б.А., Саеt Ю.Е., Смирнова Р.С., Е.П. Сорокина. Методические рекомендации по геохимической оценке загрязнения территории городов химическими элементами. М.: ИМГРЭ, 1982


• sick’ rate of children neurotoxicosis and alopecia are related to anomalies of heavy metals in urban topsoil

• pregnancy intoxications, premature child birth, children neurotoxicosis, alopecia and tumours are reputed as eco-genic diseases
### ACTIONS in SITES with CONTAMINATED TOPSOIL

In residential, recreational and agricultural areas:

<table>
<thead>
<tr>
<th>Contamination level</th>
<th>Z_s value</th>
<th>K_0 value</th>
<th>Required actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Permissible</td>
<td>&lt; 16</td>
<td>K_0 ≤ 1</td>
<td>Detailed <strong>soil investigation</strong> and monitoring is recommended.</td>
</tr>
<tr>
<td>II. Medium dangerous</td>
<td>16 – 32</td>
<td>1 &lt; K_0 ≤ 3</td>
<td>Reducing of impact from pollution sources. Quality <strong>control</strong> of surface and ground <strong>water</strong>.</td>
</tr>
<tr>
<td>III. Dangerous</td>
<td>32 – 128</td>
<td>3 &lt; K_0 ≤ 10</td>
<td>Obligatory is <strong>soil remediation</strong> (liming, adding of compost, dilution with clean soil) up to permissible level in residential and recreation areas. Agriculture areas must be used for technical crops or afforestation.</td>
</tr>
<tr>
<td>IV. Extremely dangerous</td>
<td>&gt; 128</td>
<td>K_0 &gt; 10</td>
<td>Polluted <strong>soil</strong> layer must be <strong>removed</strong> to landfill of hazardous substances or remiadiated <em>in situ</em> up to superior level of contamination.</td>
</tr>
</tbody>
</table>
Mapping of Geochemical Contamination in Urban Areas of Lithuania, 2007 meeting NATO/CCMS Pilot study

GEOCHEMICALY MAPPED URBAN AREAS

1. Vilnius
2. Šiauliai
3. Panevėžys
4. Alytus
5. Klaipėda
6. Mažeikiai
7. Biržai
8. Pasvalys
9. Rokiškis
10. Radviliškis
11. Kėdainiai
12. Kupiškis
13. Jonava
14. Joniškis
15. Trakai
16. Šilutė
Geochemical soil mapping in **Vilnius** since 1985:

- elaboration and monitoring of geochemical data in **whole town**
- detailed geochemical mapping in **industrial** Naujamiestis and Žirmūnai districts
- assessment of soil contamination level in Šnipiškės district due to the shift of district’ function from **industrial-residential to public-administrative**
- assessment of topsoil sanitary state according the $Z_s$ index in **residential** districts: Old town, Žvėrynas and Antakalnis
Geochemical mapping of Šiauliai town in 1989–1992:

• topsoil, lake and stream sediments

• main elements-pollutants – Zn, Pb, Cr (leather&footwear), Cu, Ni, Sn, Mo, Ag

• anomalies of heavy metals in topsoil reflects historical industrial contamination and allow to identify impact zones of these enterprises

• secondary pathways of contamination were found (usage in gardens of contaminated peat from foot-slope of municipal landfill)
Geochemical mapping of **Alytus** town in 1996–1997:

- topsoil & snow
- anomalies of heavy metals in topsoil reflects distribution of **factories and uncontrolled sanitary landfills**
- topsoil contamination was observed also in the modern residential suburbs, where sludge from Dalidė lake (former sewage reservoir) was used for soil recultivation
- main elements-pollutants – Pb, Ag, Zn, Cu, Sn
Geochemical mapping of **Kédainiai** town in 1989–1992 and revision-monitoring in 1997:

- main elements-pollutants – Sr, La, P – waste & emissions of phosphorous fertilizers industry
- municipal elements-pollutants - Cu, Zn, Pb, Ag, Sn – typical in urban areas
- impact area to soil from JSC “Lifosa” was detected
Geochemical mapping of Mažeikiai town in 1999–2000:

- contamination of topsoil (92% of samples) is at the permissible level according the total index of contamination $Z_s$, main element-contaminant – Zn

- anomalies of heavy metals were found in the old town, along railway
Assessment of topsoil contamination in towns **Panevėžys, Pasvalys, Biržai, Rokiškis, Kupiškis** is presented in Geochemical Atlas of Panevėžys County, 2004;

- the worst contaminated is **Panevėžys** town – administrative and industrial seat of County – content of some element in 60% of samples was higher than MPC
- dangerous and extremely dangerous contamination was found in **industrial areas** and close to them; old towns and areas along railways were contaminated at medium dangerous level
- main contaminants – Zn, Pb, Cu, Ni, Sn, Ag, V
Assessment of topsoil contamination level at every urban area is carried out in comparable way, i.e. using element contents versus background values. Background values of elements in soil of various texture (sand, loamy sand, loam, clay, peat), different genesis (glacial, glaciofluvial, glaciolacustrine) and of different administrative districts are published in Geochemical Atlas of Lithuania, 1999.
CONCLUDING REMARKS

• Geochemical data of urban soil in Lithuania is circumstantial enough:
  • geochemically mapped are the main urban areas:
    • with highest population density,
    • with the most hazardous pollution sources – enterprises (former and present),
    • with socially important sites (change of site function, e.g. from industrial or military to residential),
  • national geochemical data is comparable to the international data due to:
    • participation in the laboratory intercalibration projects,
    • participation in the international geochemical projects (BSS, Geochemical Atlas of Europe, NEG)
  • most of geochemical data is well organized and is kept in DB “Rock Chemistry” of LGT
  • LGT administers DB of “Pollution Sources”, too
• National legislation concerning assessment of soil contamination is developed:
  • hygiene standards with obligatory limit values of toxic substances (heavy metals, pesticides, hydrocarbons, PAH and PCB) are prepared,
  • standards valid in topsoil of residential, recreational and agricultural areas
  • non-valid in industrial areas and subsoil
  • required actions in contaminated areas at different level often are missed
Thank You for attention