Laboratory and Field Investigations for Heap Leach Remediation and Groundwater Restoration

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Vienna, 29-31 March 2010
Outline of the Presentation

Part II

Remediation strategy selection

• On site remediation
• Remediation with total relocation of HL residues
  • Heap and underlying soil investigation by drilling
  • Residues stabilization (for mitigation of uranium migration)
  • Radiological and chemical site characterisation upon the residue relocation
• Groundwater restoration practice
Site remediation steps

1. Removal of free water (200 000 m³)

2. Residue investigation

3. Washing (TDS, U)

4. Relocation of the residues and stabilization

5. Radiological mapping and clean-up

6. Revegetation

7. GW restoration directly in place

Mine water treatment

Waste rock pile N3

GW

Abandoned mine cavities
Pre-remediation site investigation

Drillings up to 26 m:
Core samples: U, Spec. act., water cont., chem. comp., \( \gamma \)-spectrometry

Pore water: Na, El.cond., Ca, Cl, SO\(_4\), U, As, Mo, etc.

Tv-12 Background

2.2 Mt
Soil contamination under the PVC foils (electric cond.)

Electric conductivity of pore water

Bottom of the heap

Soil contamination

k = 10^{-9} - 10^{-10} \text{ m/s}
Soil contamination under the PVC foils (U)

Uranium in pore water

- U~30 mg/l
- U~0.5-1 mg/l

Depth, m
Water content in core samples (w, %)

Soil under the liner is practically dry
Leaching test with the residues (investigation of the CaO-based PRB)

3 years experiment. 1m³ rain water

Open-air experiment

1. precipitation

H = 110 cm
F = 0.58 m²
400 kg heap wastes

2. precipitation

H = 110 cm
400 kg heap wastes

45 cm

lime-based RB
0.8 kg lime + 16 kg of wastes

Protecting sand

drainage made of pebble and sand
Uranium concentration in seepage from residues

Site remediation

CaO-based barrier reduces the uranium in the seepage

Duration of the exp.: 3 years

~10 gU/t

Original Residue

With CaO PRB (2 kg/t)
pH of the seepage from residues

- Without PRB
- With PRB

Site remediation
Site remediation

Layout of the field PRB

144 m²
Field experiment
Site remediation

Uranium in seepage from residues

The PRB is effective for stabilization of residues
Relocation of the residues
Surface map of the main objects of the ore processing
Implementation of the PRB

5 m lift
2 kgCaO/t
Investigations of the relocated residues

During the relocation the residues were sampled and analysed for:

- U in solids,
- U dissolved,
- Pore water composition
Uranium in the relocated residues

(\text{HL 2})

Average: 59 \text{ gU/t}

High U from more compacted areas
Uranium in residues vs. depth of heap

Height of the pile: 12
Samples: 145
### Pore water composition in the heaps

<table>
<thead>
<tr>
<th>El. Cond.</th>
<th>TDS</th>
<th>SO$_4$</th>
<th>Na</th>
<th>U</th>
<th>Cl</th>
<th>CO$_3$</th>
<th>HCO$_3$</th>
<th>pH</th>
<th>Water</th>
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<tbody>
<tr>
<td>µS/cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>%</td>
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<td>8663</td>
<td>~9450</td>
<td>2110</td>
<td>2293</td>
<td>13.7</td>
<td>320</td>
<td>440</td>
<td>3730</td>
<td>9.23</td>
<td>6.9</td>
</tr>
</tbody>
</table>

Average from 145 samples (depth: 1-12 m)
Revegetation of the former heap leaching sites

Contaminated soil was removed to get $\gamma < 250$ nGy/h
Site investigation after the relocation of the residues (Spec. activity of the soil)

Ion-exchange columns

Pumping station

Former ore storage area

Site remediation
Cleaned-up site
(γ-dose rate)

Contaminated soil was removed to get γ <250 nGy/h
Chemical contamination of the pore water of soil after relocation of the residues (el. cond. at dif. depth)

High contamination was observed only in some spots
Contamination has been found in the vicinity of the former pipelines and pumping stations and waste rocks.
Reculitivated HL sites

Site remediation
Natural attenuation of the uranium contamination on HL2 site
Site remediation

Monitoring results on HL 2 site (2000-2009)

A talajvíz urántartalmának változása a központi részterület kútjaiban (2000-2009)

U (µg/dm³)
Uranium contamination in GW (HL 2, 2009)

Contamination exists mainly on the area of the former pumping stations.

6 extracting wells are in operation.

Volume of extracted water \(\sim 17\) th m\(^3\) in 2008.
Uranium contamination in GW (October 2009)

12 extracting wells
49th m³/y
U~2.5 mg/l

6 extracting wells
Volume of extracted water 40 th m³
(~17 th m³/y, U~1.7 mg/l)

~250 th m³
250 kgU

~200 th m³
300 kgU
The distribution of the total cost between the sub-projects

Cost of remediation 83 Million EU
1. Groundwater contamination was found first of all on the area of the pumping stations and pipelines. The main polluting component is U and sodium sulfate. 2. The volume of contaminated GW amounted to 200-300 th m³ on both site. It is assumed that GW quality restoration needs at least 5 years using GW extraction for this. 3. CaO-based PRB is an effective method for mitigation of the uranium migration from HL residues.
Thank you for your kind attention.