Requirements for mine flooding / water treatment at low water discharge
Case Study of mine Schlema-Alberoda, Wismut GmbH

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Magdeburger Gewässerschutzseminar 18.-19.10.2018, Prag
1946 Start of uranium mining under supervision of Soviet military

1954 Establishment of the binational Soviet-German Stock company (SDAG) Wismut

231,000 t cumulative uranium production making Wismut the world’s fourth-largest uranium producer

1991 Remediation company Wismut GmbH
Remediation sites of Wismut GmbH in Germany

All sites are located in the Elbe catchment area

The site Schlema-Alberoda has an impact on the Zwickauer Mulde water and sediment quality
Remediation activities at the Schlema site

- Coverage of waste rock piles
- Dismantling of operating areas
- Controlled mine flooding
- Water treatment

Greif et al. (2018): Requirements for mine flooding / water treatment at low water discharge
Remediation area of Schlema-Alberoda

- Mine up to 1,800 m depth → mine water
- A lot of large-scale complex dumps (48 million m³) → seepage water
  * partially treated
- One tailing pond (0.3 million m³)
- Water treatment plant, capacity up to 1,200 m³/h
Flooding of mine Schlema-Alberoda

- Flooded volume 36 million m³
- Non-floodable voids 2 million m³
- Mine internal working and buffer storage system for WTP (0.5 million m³)
Flooding of mine Schlema-Alberoda

Mean concentrations in mine water 2017:

- Ra-226: 2,100 Bq/l
- Arsenic: 1.5 mg/l
- Iron: 4.0 mg/l
- Uranium: 1.3 mg/l

data: Wismut GmbH
Greif et al. (2018): Requirements for mine flooding / water treatment at low water discharge

**Water treatment plant Schlema-Alberoda**

- **Mine water pumping**
- **Precipitation basins**
- **Lamella separator**
- **Discharge in receiving water**

**Treatment principle**
- based on modified lime precipitation

**Treatment steps**
- Solid / liquid separation
- Sludge dewatering
- Immobilisation with cement
Requirements for WTP Schlema-Alberoda

Flow rate-independent limits

- Uranium, Ra-226 → from radiation protection permit
- additional pH value, filterable solids, Iron, Manganese, Sulfate, Chloride → from water legislation permit

<table>
<thead>
<tr>
<th>pH</th>
<th>filterable solids [mg/l]</th>
<th>Fe [mg/l]</th>
<th>Mn [mg/l]</th>
<th>SO₄ [mg/l]</th>
<th>Cl [mg/l]</th>
<th>U [mg/l]</th>
<th>²²⁶Ra [mBq/l]</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.5…8.5</td>
<td>20</td>
<td>2</td>
<td>3</td>
<td>2,500</td>
<td>1,000</td>
<td>0.5</td>
<td>400</td>
</tr>
</tbody>
</table>

and Arsenic?
Requirements for WTP Schlema-Alberoda

Flow rate-dependent limits

- only for Arsenic → from water legislation permit

<table>
<thead>
<tr>
<th>Gauge Niederschlema / Zwickauer Mulde [m³/s]</th>
<th>Discharge of WTP Schlema-Alberoda [m³/h]</th>
<th>Arsenic concentration of WTP [mg/l]</th>
<th>Arsenic load of WTP [g/h]</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 10</td>
<td>1,200</td>
<td>0,3</td>
<td>-</td>
</tr>
<tr>
<td>7 ... 10</td>
<td>1,200 / 750</td>
<td>0,2 / 0,3</td>
<td>-</td>
</tr>
<tr>
<td>4 ... 7</td>
<td>1,200 / 750 / 500</td>
<td>0,1 / 0,2 / 0,3</td>
<td>-</td>
</tr>
<tr>
<td>3 ... 4</td>
<td>1,200</td>
<td>-</td>
<td>84</td>
</tr>
<tr>
<td>&lt; 3</td>
<td>800...1,200</td>
<td>-</td>
<td>56</td>
</tr>
</tbody>
</table>

Are there natural discharge relations?
Relation between river and mine water discharges

River
Zwickauer Mulde
 MQ\textsubscript{Niederschlema} = 12.6 m\textsuperscript{3}/s

Mine
WTP Schlema-Alberoda
Q\textsubscript{expected} 6.5 million m\textsuperscript{3}/a = 0.21 m\textsuperscript{3}/s

Both since 2014 below long-term mean discharge
Mean relation \textit{river} : \textit{mine} discharge about 60 : 1
Case study 2017

- When are detailed requirements indicated?

<table>
<thead>
<tr>
<th>Gauge Niederschlema / Zwickauer Mulde [m³/s]</th>
<th>&gt; 10 m³/s: about 150 days (40 %)</th>
<th>WTP: 0.3 mg/l for arsenic</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 ... 10</td>
<td>&lt; 10 m³/s: about 220 days (60 %)</td>
<td>WTP: detailed requirements for arsenic</td>
</tr>
<tr>
<td>4 ... 7</td>
<td>&lt; 4 m³/s: about 18 days</td>
<td>WTP: arsenic load limits</td>
</tr>
<tr>
<td>3 ... 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Most critical time: the summer period,

- Additional the river: mine discharge decreases

data: LfULG, 2017
Management of river catchment

- Compensation of flow rate in Zwickauer Mulde by reservoir Eibenstock
  - to preserve a minimal water level particularly in case of low water discharges

Management of arsenic load emission from WTP in case of low river discharges

- Primarily by adaption of discharge volume from WTP
  - limitation of mine inflow volume using the internal working and buffer storage system

- Secondary by optimization of water treatment process
  - commissioning of both plant units
  - adjustment of internal water flows between both plant units
  - change of the addition of chemicals (FeCl₃-dosage)
Situation in the river Zwickauer Mulde

- Increase of arsenic and uranium concentrations during passage of remediation area Schlema-Alberoda (including ancient Schneeberg mine)
- Concentrations indirect proportional to the flow rate → seasonal effects

![Graphs showing arsenic and uranium concentrations over time](image)

- Increase of arsenic and uranium loads
- Avoidance of excessive concentrations during periods of low water levels

<table>
<thead>
<tr>
<th></th>
<th>As load [t/a]</th>
<th>U load [t/a]</th>
</tr>
</thead>
<tbody>
<tr>
<td>upstream</td>
<td>0.87</td>
<td>0.45</td>
</tr>
<tr>
<td>downstream</td>
<td>3.0</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Performance of water treatment = performance for river water quality

- Mine water Schlema-Alberoda
  - before water treatment
  - after water treatment
- Seepage water of dumps (with connection to the receiving water)
- Mine water Schneeberg (ancient mining, no treatment)

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<th>As load [t/a]</th>
<th>U load [t/a]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8.9</td>
<td>7.7</td>
</tr>
<tr>
<td></td>
<td>0.36</td>
<td>0.74</td>
</tr>
<tr>
<td></td>
<td>0.044</td>
<td>0.41</td>
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<tr>
<td></td>
<td>1.4</td>
<td>0.12</td>
</tr>
</tbody>
</table>

Emission into river Zwickauer Mulde

Disposal as residues at dump 371/I

-8.5

-7.0

Summary

The Wismut GmbH takes care for remediation of the Schlema site by coverage of waste rock piles, by dismantling of facilities and site clean-up, by mine flooding and water treatment, and by safe disposals of water treatment residues,

- whereby water treatment remains as a long-term task.

The WTP Schlema-Alberoda treats millions of m$^3$ per year of mine and seepage water,

- whereby it keeps tons of pollutants away from watercourse system.

The residual emissions from the WTP inevitably lead to an increase of the element concentrations in the receiving water,

- whereby flow rate-dependent arsenic limits avoid excessive concentrations during periods of low water levels.
Thanks for your attention.

Glück Auf!
Shaping the future: Long-term experiences and innovations in mine remediation

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