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Microbial synthesis of Schwertmannite from lignite mine water and its utilization for removal of arsenic from mine waters

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Outline

- **Lignite mining in the Lusatian mining area**
- **Water quality in the open cast mine Nochten**
- **Microbial ferrous iron oxidation and Schwertmannite synthesis**
- **Design and function of the pilot plant**
- **Use of Schwertmannite for removal of arsenic from mine water**
- **Conclusions**

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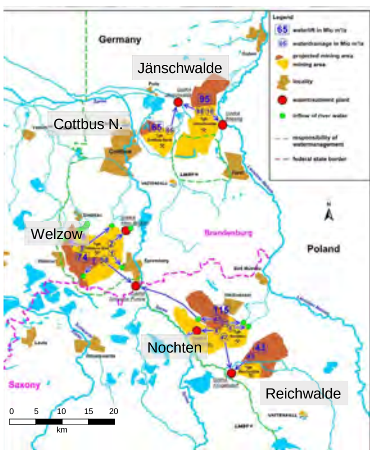

Open cast mines:	5
Coal production:	60 Mio. t/a
Water lift:	400 Mio. m³/a
Coal/Water:	4.4-11 m³/t
Water treatment:	300 Mio. m³/a
Treatment plants:	6

Technology of water treatment:
Lime neutralization and chemical ferrous iron oxidation

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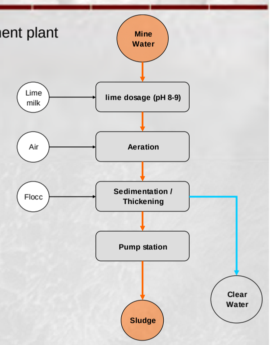
Water quality

Open cast mine Nochten - Tzschelln treatment plant

Parameter	*Value*
pH-value	5.3
dissolved oxygen	< 0.5 mg/L
electr. Conductivity (25°C)	2,930 µS/cm
TIC	65 mg/L
Chloride	34 mg/L
Sulfate	1,970 mg/L
Iron, total	382 mg/L
Iron, dissolved	324 mg/L
Iron(II), dissolved	324 mg/L
Manganese	4 mg/L
Acidity	14 mmol/L

This water can be used for mircobial iron oxidation and synthesis of Schwertmannite !



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Microbial iron oxidation & Schwertmannite formation

Reaction equation

$Fe^{2+} + MO + O_2 + CO_2 \xrightarrow{pH\ 2,5\ ...\ 3,5} Fe^{3+} + biomass$

$Fe^{3+} + SO_4^{2-} + H_2O \longrightarrow Fe_{16}O_{16}(OH)_x(SO_4)_y \times n\, H_2O + H^+$

$y = 2,0 – 3,5$
$x = 16 – 2y$
Schwertmannite (SHM)

Reasons for saving lime

- Stripping of physically dissolved CO_2
- Incomplete iron hydrolysis

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Microbial iron oxidation & Schwertmannite formation

Advantages

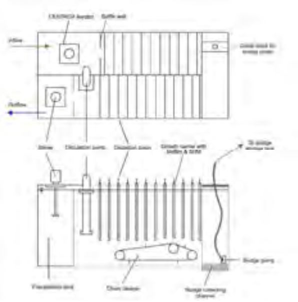
- Savings potential for lime
- Separation of sulphate from water to some extent
- Precipitation of pure SHM
- Easy dewatering of SHM
- Useful applications of SHM

<u>Open cast mine Nochten:</u> high iron load in the water 8,850 t/a
possible production of SHM: 12,000 t/a

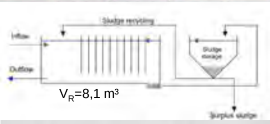
Unanswered questions

- Controllability of the process at pilot and full scale
- Stability of used microbes community
- Maintenance requirements for removing crusts of SHM
- Reaction rates under technical conditions

Design of the pilot plant



Schematic drawing of the pilot plant



Hybride type of bioreactor

characteristics of a fixed-bed reactor and in parallel with a circulation reactor

Technical data

Oxidation basin:	8,1 m³
Flow:	0 - 5 m³/h
Fe(II)-In:	300-400 mg/L
Fe(II)-Out:	100-200 mg/L
Ox-Rate (av.)	25 mg/(L·h)
Ox-Rate (max)	55 mg/(L·h)

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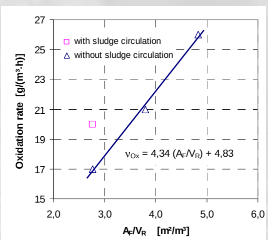
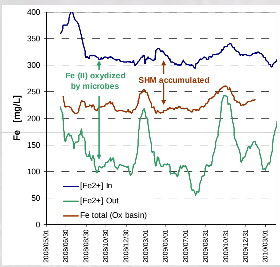
Results of the pilot treatment





$$v_{Ox} = \frac{Fe(III)_{ges}}{\tau} = \frac{Fe(III)_{ges}}{V_R}\cdot Q_{Zu} = v_{Ox-F}\cdot\frac{A_F}{V_R} + v_{Ox,A_F=0} \quad [g/(m^3\cdot h)]$$

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Use of SHM for arsenic removal

Water quality in Schlema treatment plant

Parameter	*Unit*	*Inflow*	*Outflow Limit*
pH-value		6.95	
electr. Conductivity (25°C)	µS/cm	2,260	
TIC	mg/L	120	
Chloride	mg/L	57	
Sulphate	mg/L	780	
Iron, total	mg/L	5.7	< 2.0
Manganese	mg/L	4.0	< 3.0
Arsenic	mg/L	1.0	< 0.1
Uranium	mg/L	2.0	< 0,5
Radium	mBq/L	1,580	< 400

$2\ Fe_{16}O_{16}(OH)_{11}(SO_4)_{2,5} + 10\ H_2O$

Hydrolysis of SHM ↓

$32\ FeO(OH) + 10\ H^+ + 5\ SO_4^{2-}$

Adsorption of As ↓

$[> FeOH]^{2+} + HAsO_4^{2-} \rightarrow FeAsO_4 + H_2O$

Task formulation:

Can SHM from Tzschelln pilot plant be used for enhancement of arsenic removal in Schlema?

Advantages vs. $FeCl_3$ dosing:

Lower salinity in the treated water
Lower acid formation (Lime savings)

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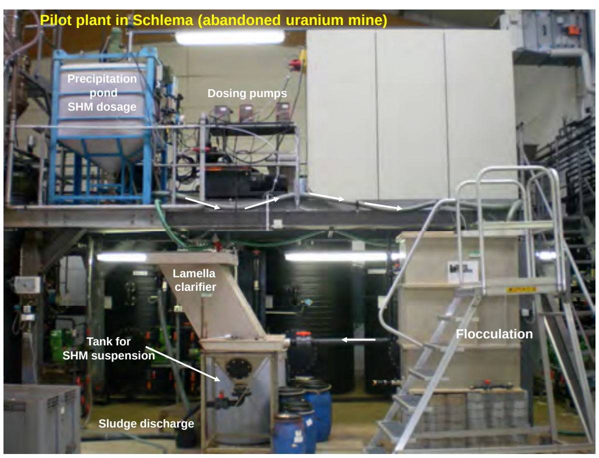
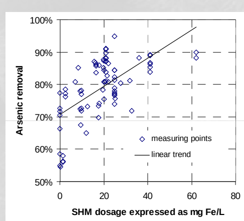


Results of arsenic removal



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Conclusions

- Microbial iron oxidation can be used as a pre-treatment stage for mine water treatment
- Microbial processes are stable and don‘t break down
- Microbial iron oxidation takes place in bulk volume and in biofilms on the carrier surface as well
- Oxidation rate can be increased by sludge recycling and enlargement of the carrier surface area
- Biosynthesized SHM is suitable for arsenic removal from mine water, but the dosage is higher in comparison to $FeCl_3$

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