Business from technology

Arsenic removal from mine waters with sorption

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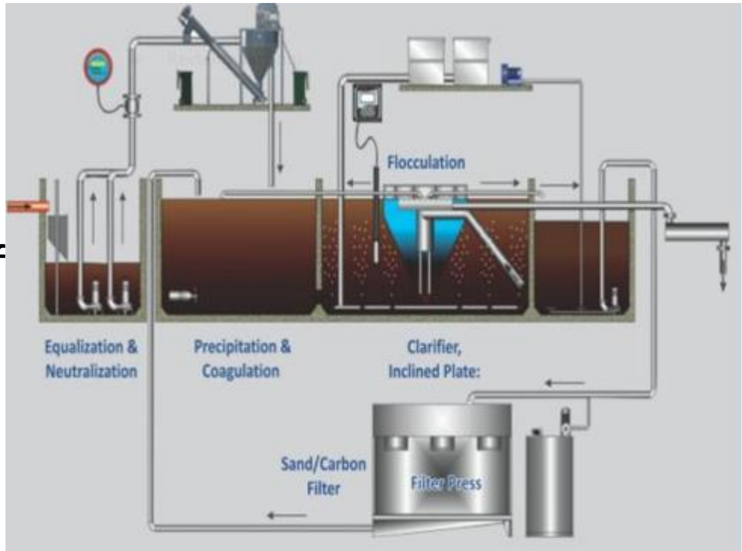
Background 1

- Results presented are part of a TEKES-funded joint research project: ARSENAL – Arsenic Control in Mining Processes and Extractive Industry aiming at developing e.g.:
  - New mineral processing and **water treatment solutions** for arsenic removal
  - Novel bio-based treatment processes for arsenic containing wastes and streams
  - Monitoring and environmental risk assessment tools
- Research partners: GTK and TUT
- Industrial partners: Outotec, Kemira, Ekokem-Palvelu, Agnico Eagle Finland, Endomines, Nordic Mines, Pyhäsalmi Mine, YARA, Mondo Minerals
- Schedule: 1.1.2011 – 31.8.2013

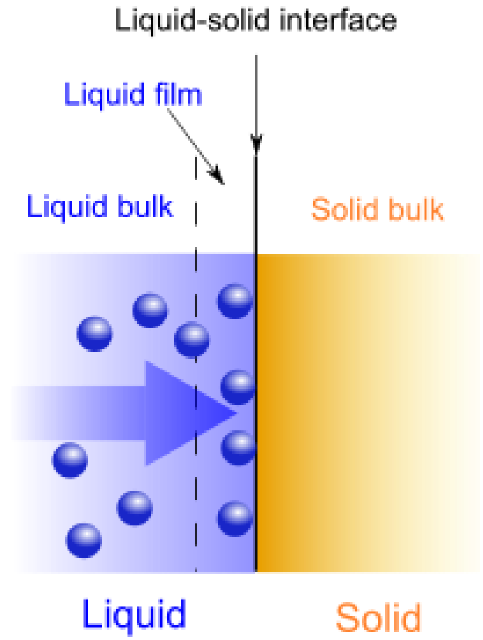
Background 2

- Arsenic is a world-wide challenge (drinking water, industrial waste waters)
- Arsenic is commonly associated with ores containing metals such as gold
- It is often leached in mineral processing
- Tightening environmental permits may create the need to treat mine effluents for removal of As
- Precipitation with Fe/Al salts is the “default” method for As removal from water
  - Proven technology
  - Requires chemicals, facilities and energy for mixing and clarification
  - Produces sludge to be disposed of
- Other methods include e.g membrane technologies, **sorption**, ion exchange and wetlands



Background 3

- Sorption is a physical and chemical process by which one substance becomes attached to another*
- Sorption could be a viable option for at least trace level As removal (before discharge to a river, lake etc.)
  - Could be operated as semi-passive processes (e.g. reactive barrier, filter-type solution)
  - No chemicals and less process control needed in comparison with precipitation-clarification techniques
  - Disposal/regeneration of spent sorption material
- Huge water volumes call for cost-effective sorption materials
- One of the focal points of present research was to find industrial by-product materials capable of removing arsenic efficiently from mine waters



* Wikipedia

As-removal from mine waters

- Focus on sorption techniques for removal of trace As-concentrations from water (final polishing step)
- Cost effective sorption materials (industrial by-products) and comparison to a commercial material
  - Granulated steel slag
  - Cast iron chips
  - Ash pellet
  - Waste rock
  - Glass beads (inert reference material)
  - Granulated ferric oxo-hydroxide (Kemira CFH12)
- Material pre-treatment for better comparability of results
- Comparison to precipitation tests

Kemira CFH12 (1-2 mm)

Granulated steel slag (1-2 mm)

Ash pellet (5 x 10 mm)

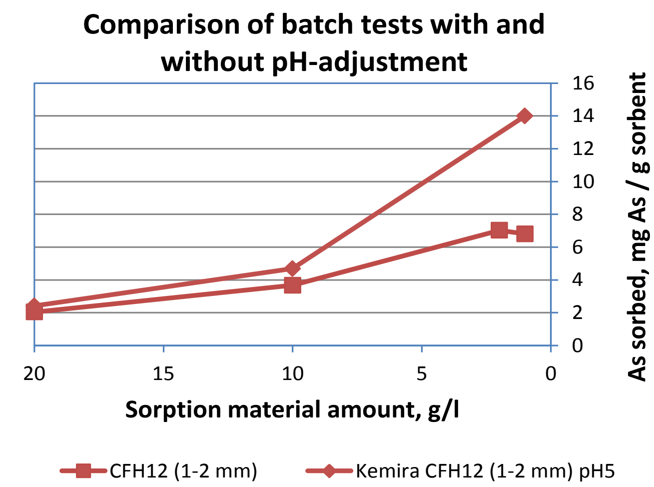
Cast iron chips 1-2 mm (vs. original)

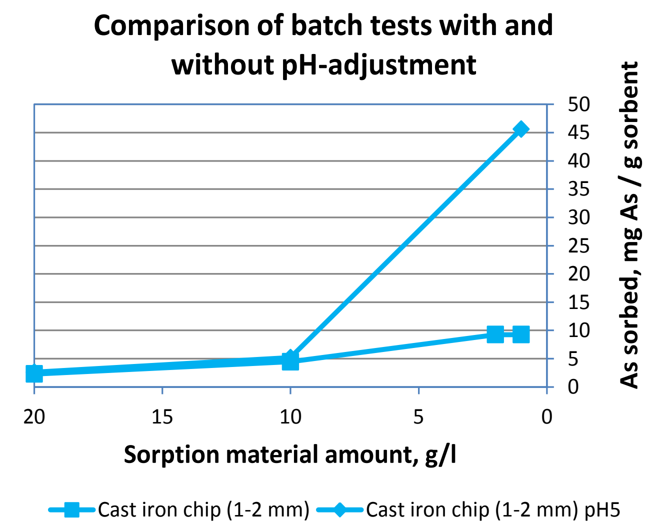
Lab scale experimental work on As removal

Task	Content	Objectives
Characterization of sorption materials	• Environmental properties (preliminary) • Surface area (BET)	Leaching from sorption materials, technical suitability of materials
Characterization of waters (mine waters from Finnish gold mine)	• Concentration of elements and salts • Arsenic speciation	Basis for planning of experiments
Assessment of maximum removal capacity	• Batch tests with varying solid to liquid ratios, pH-adjustment	Removal capacity, scaling of kinetic experiments
Assessment of removal kinetics	• Batch tests with varying contact times (most promising materials)	Removal efficiency, scaling of kinetic experiments
Kinetic experiments	• Up-flow percolation tests (most promising materials)	Material behaviour in close-to-real conditions
Precipitation tests	• Batch tests with ferric salts	Comparison to sorption tests

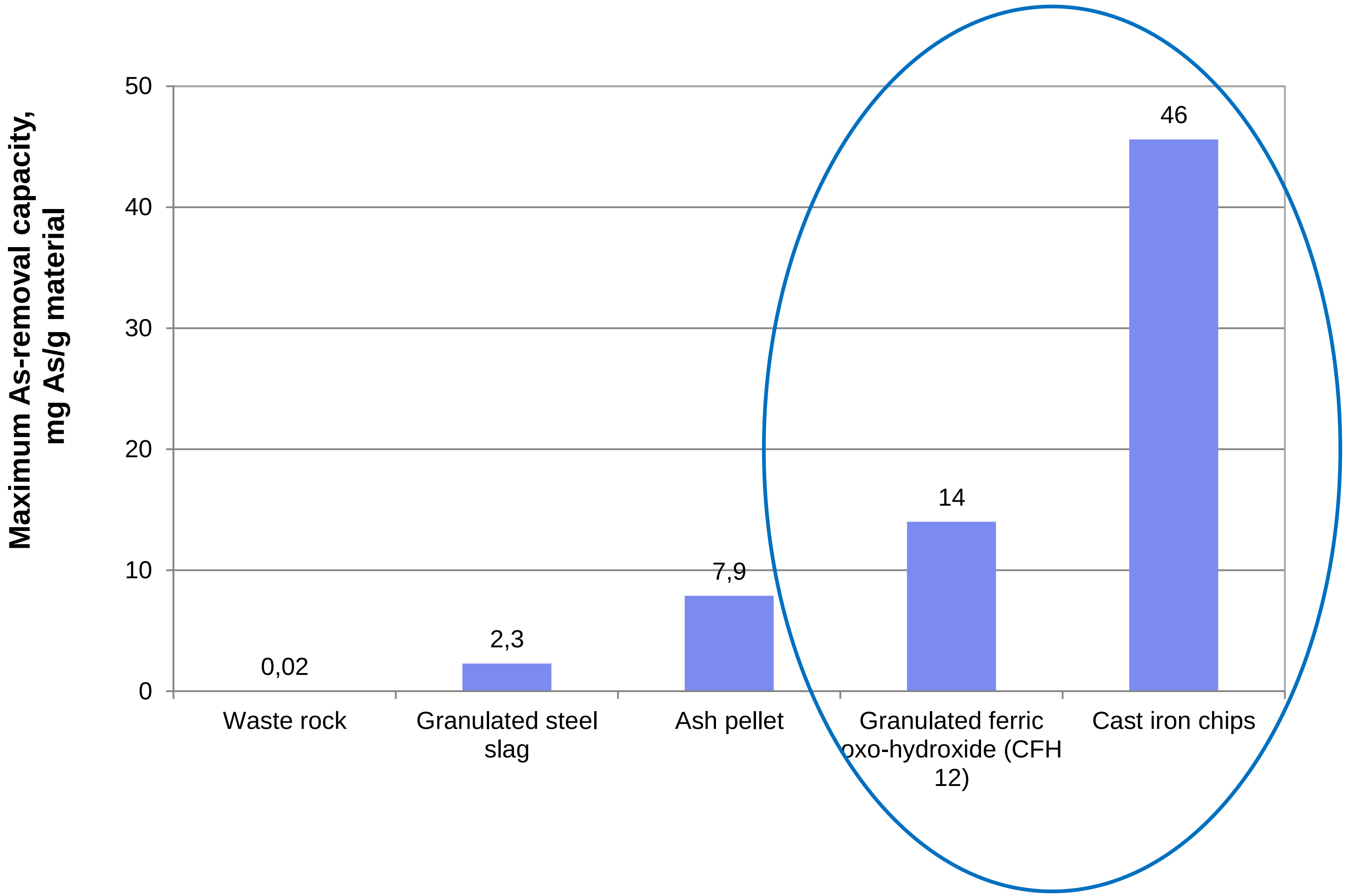
Batch sorption tests for As removal

- Batch tests with 24 h contact time, ion exchanged water spiked with As mixed with sorption material at varying solid to liquid ratios
- Initial As concentration 40 mg/l (As^{5+})
- Analysis of As from water before and after test
- As-standard solution dominated the pH at lower solid to liquid ratios and material-pH at higher solid to liquid ratios
  - pH-fixed tests to evaluate the effect of pH
- As a result the maximum As-removal capacity of the materials (mg As / g material)





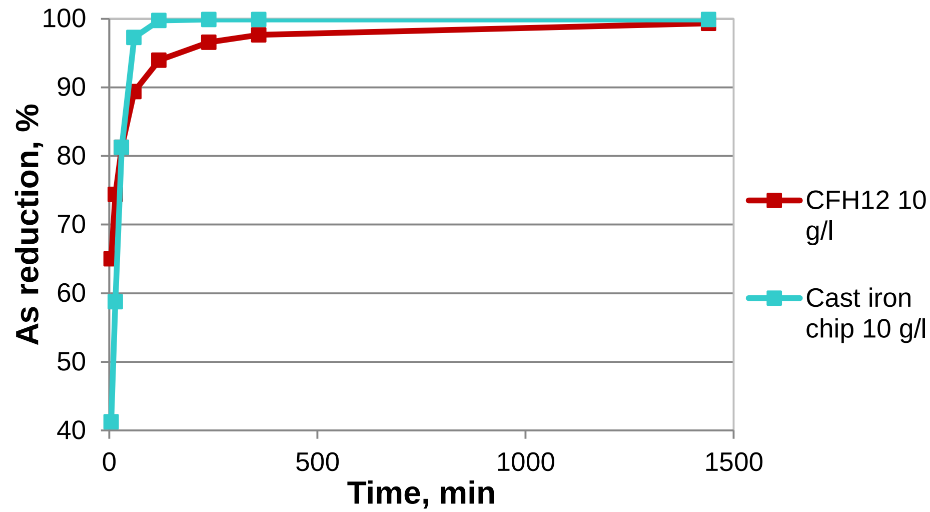
Maximum As-removal capacities from batch tests

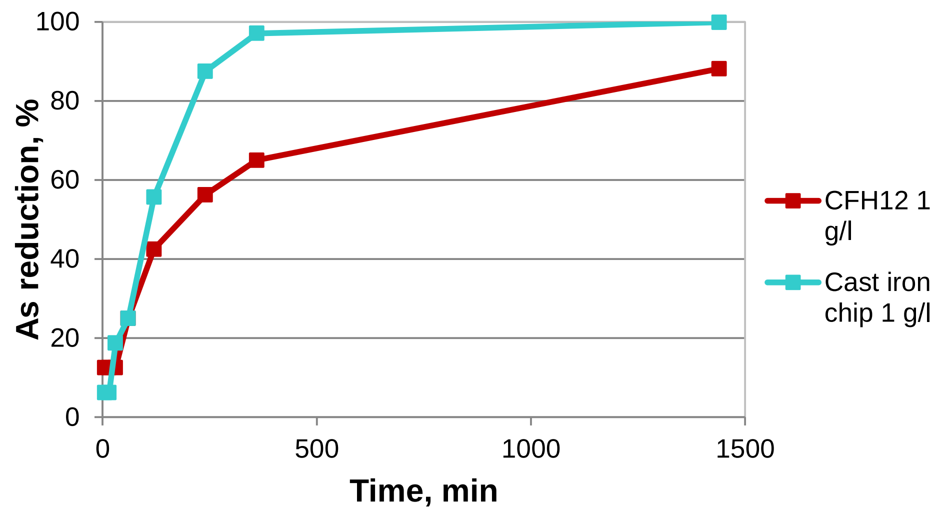


Studies continued with these materials

Assesment of As removal kinetics

- Batch tests with variyng material to water ratios
- Mine water from a Finnish gold mine, As-concentration 1,5 mg/l (initial 0,8 mg/l, spiked with As^{5+}), SO_4^{2-} 5 000 mg/l, pH 8,1
- Intermediate samples taken during tests to assess kinetics

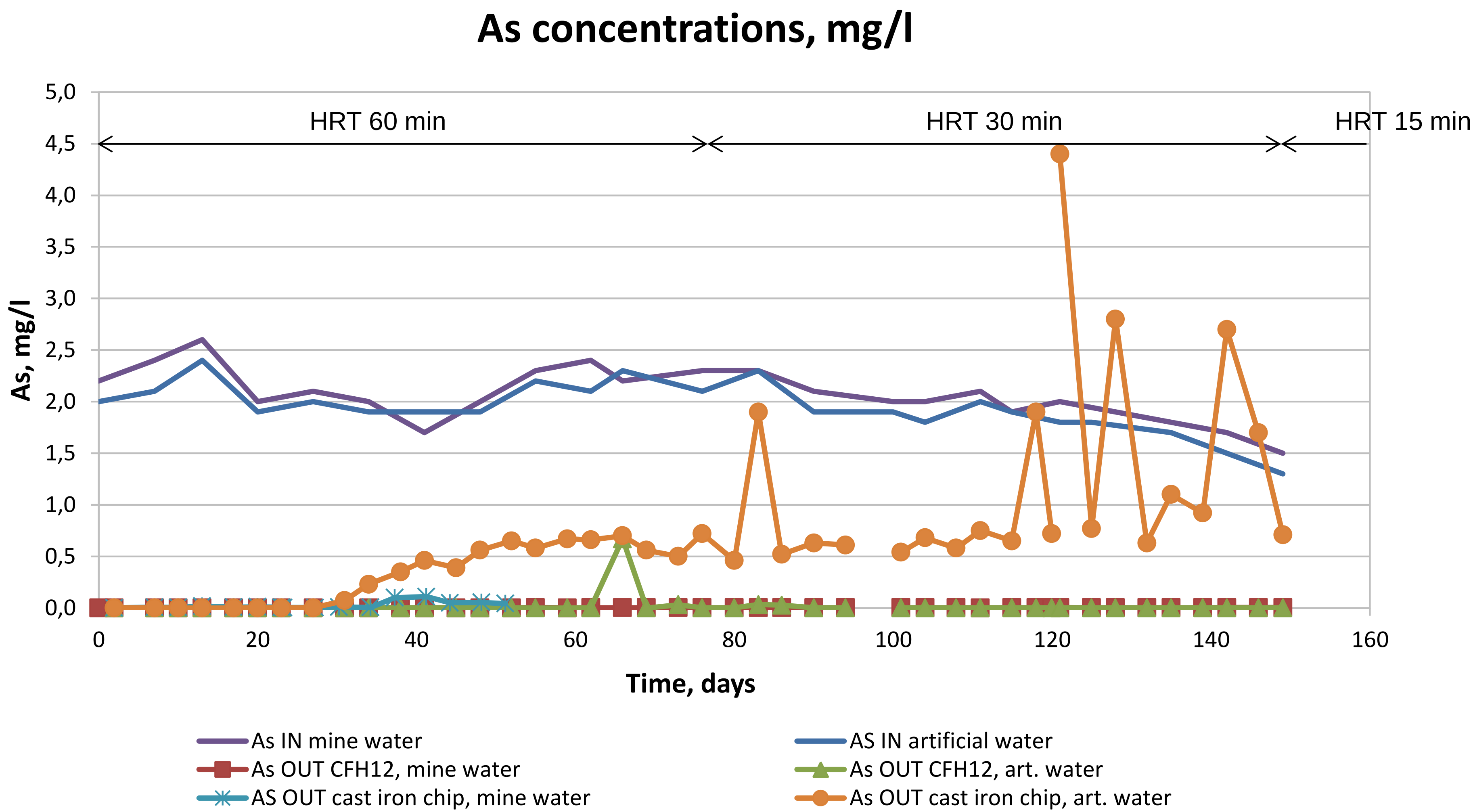




Column tests for As-removal

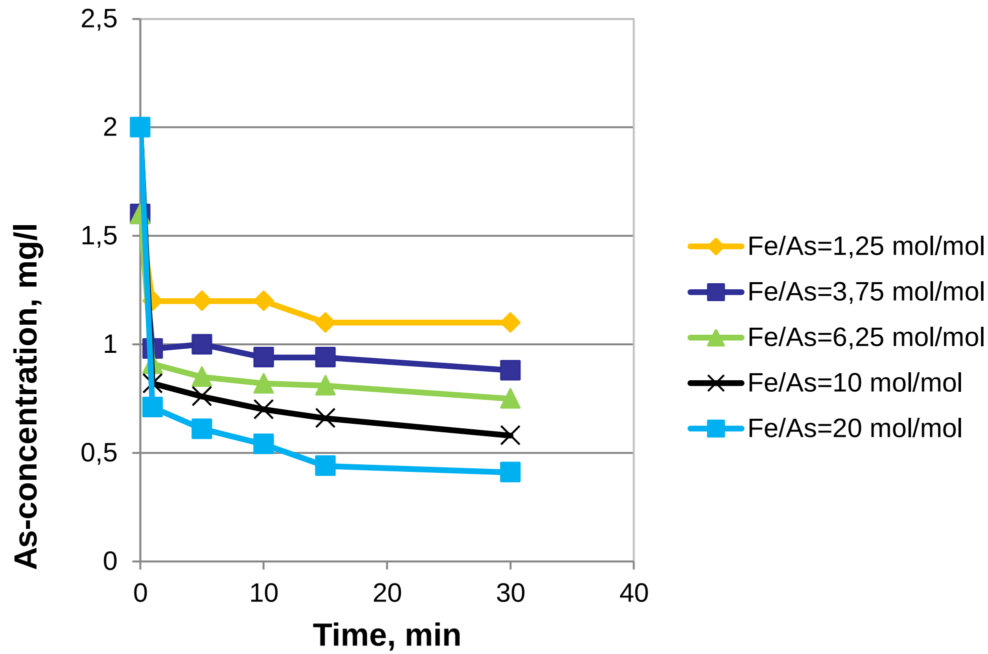
- Mine water with As concentration of 2 mg/l fed to two columns (initial 0,8 mg/l, spiked with As^{5+})
- Artificial water spiked with As^{5+} (2 mg/l) fed to two columns
- Tests started with retention time (effective) of 60 minutes -> 30 min. -> 15 min.
- As-concentrations determined two times per week, wider analytics once/month
- Started in March 2013

Column tests for As removal



Precipitation tests for As-removal

- Mine water with As^{5+} -conc. 2 mg/l (same water than in the column tests)
- Ferric sulphate (Kemira PIX-105) used as coagulant with varying Fe/As –ratios
- Batch tests with 30 minutes of mixing followed by filtration
- Intermediate samples were taken during tests to assess kinetics
- Data used in comparisons with sorption based As-removal



Scaling up the preliminary results – rough estimates

- Mine water with 2 mg/l As concentration, 1 million m^3 per year: Annual As load of 2 000 kg

Sorption based As-removal:

- Approximately 5 mg As removed per 1 gram of garnulated ferric oxohydroxide (CFH12) so far
- 400 tons of CFH12 needed annually (and waste to be disposed of)

Precipitation with ferric sulfate:

- In this case 20 times molar amount of Fe^{3+} needed to reduce As level below 0,5 mg/l
- Approximately 30 tons of Fe^{3+} needed (10 m-% Fe^{3+} in chemical PIX-105)
- 300 tons of liquid ferric sulfate needed annually
- 123 tons of sludge created

Conclusions

- Industrial by-product material (cast iron chips) showed promising As-removal potential in batch tests
- Technical problems faced in column testing (reactions with mine water caused clogging, under investigation)
- Commercial sorption material Kemira CFH12 shows good behaviour in column tests
- Rough calculations show relatively big material consumption and chemical consumption for sorption based and precipitation treatment, respectively

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