Stabilizing Arsenic and Chromium Polluted Soils with Ochreous Sludge from Waterworks

Sanne S. Nielsen, Peter Kjeldsen and Rasmus Jakobsen, DTU Environment

DTU Miljø
Institut for Vand og Miljøteknologi

The Idea

Arsenic is leaching from old wood impregnation sites

The sites are expensive to remediate

Iron oxides are good sorbents of anions

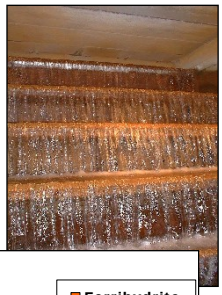
Ochreous is a waste product consisting of 85% iron oxides

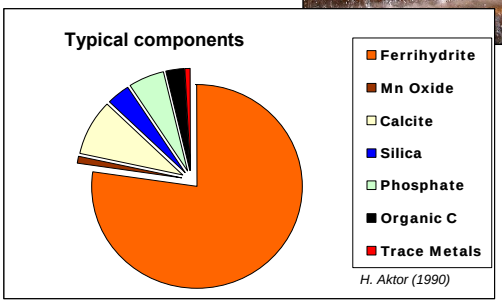
Why not try to mix soil and sludge to minimize leaching?

DTU Miljø
Institut for Vand og Miljøteknologi

What is Ochreous Sludge?

- Waste product from drinking water treatment
- Usually landfilled or incinerated
- Contains unwanted trace elements





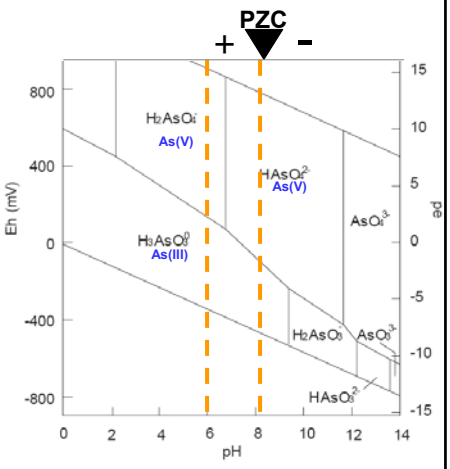
DTU Miljø
Institut for Vand og Miljøteknologi

Iron Oxides as Sorbents

Mimicking a natural process
-Iron oxides are abundant in soil

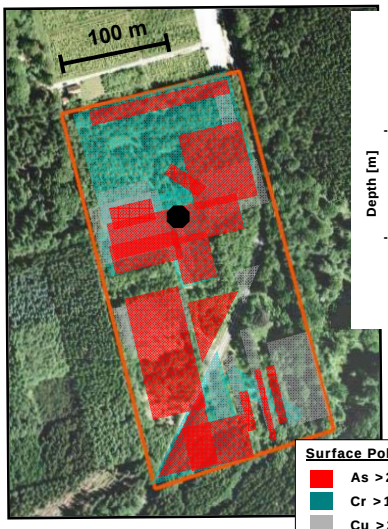
Ferrihydrite and goethite
-High surface area (80-300 m^2/g)
-A lot of sorption sites

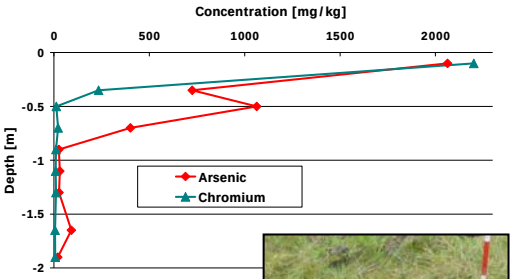
Surface charge depend on pH
-$PZC_{ferrihydrit}$ =8,5
-Sorbs anions (CrO_4^{2-} og $HAsO_4^{2-}$)



DTU Miljø
Institut for Vand og Miljøteknologi

Fieldsite: Wood Impregnation Plant





Surface Pollution

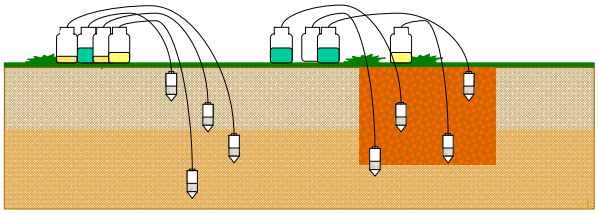
- As >250 mg/kg
- Cr >100 mg/kg
- Cu >250 mg/kg

Samfundsteknik (1989b)

DTU Miljø
Institut for Vand og Miljøteknologi

The Field Experiment

Monitoring As and Cr in soil pore water



Estimating mobility

$$K_d = \frac{C_{Soil}}{C_{pore\ water}}$$

DTU Miljø
Institut for Vand og Miljøteknologi

The Field Experiment

Arsenic pore water concentrations

Treated soil: **20-100 µg /L**

Untreated soil: **5-70 mg/L**

Mobilty

K_d [L/kg]	As	Cr
Untreated soil	10 (1-60)	200 (70-400)
Treated soil	1.000-50.000	>5.000

DTU Miljø
Institut for Vand og Miljøteknologi

Stability of Ochreous Sludge

Ferrihydrite is transformed to other iron oxides

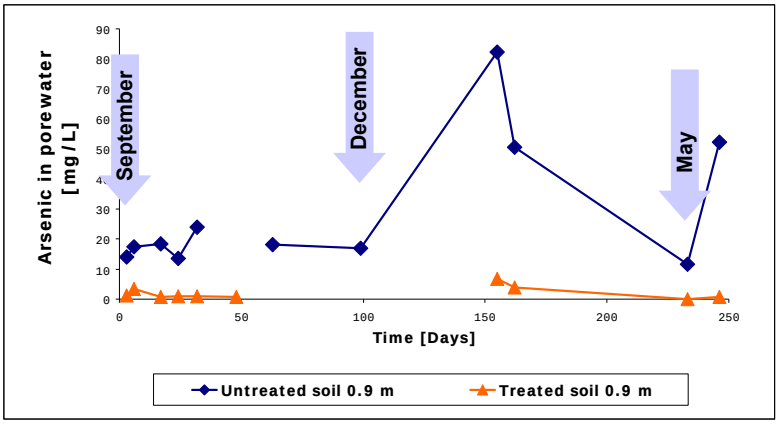
- **Direct recrystallisation: Ferrihydrite → Goethite or Hematite**
- **Redox-induced recrystallisation (like above, faster)**
- **Reduktiv dissolution:** $CH_2O + 4\ Fe(OH)_{3(s)} + 14\ H^+ \leftrightarrow 4\ Fe^{2+} + HCO_3^- + 13\ H_2O$

The transformation entails

- **Lower surface area (Goethite 20-80 m^2/g)**
- **Fewer sorption sites**
- **But maybe As can be trapped in the new structure?**

DTU Miljø
Institut for Vand og Miljøteknologi

Field experiment - Iron reduction?



DTU Miljø
Institut for Vand og Miljøteknologi

Results Summary

Mobility decreased

- **K_d increased x1000 for As and >25 for Cr**
- **A significant reduction in leaching**

Less sensitive to iron reduction than expected

- **Survived first winter**

DTU Miljø
Institut for Vand og Miljøteknologi

Conclusive Remarks

Ochreous sludge minimize leaching of As and Cr

- **and it seems to be more stable than expected**

Problems compared to traditional remediation

- **Iron oxides lose sorption capacity**
- **Soil is still polluted**
- **Not fulfilling groundwater criteria (10 µg/L)**

DTU Miljø
Institut for Vand og Miljøteknologi

References

Aktor, H. (1990): Okkerslam – Karakterisering af vandværksokkerslam og vurdering af betydningen af naturgivne forhold og fysisk-kemiske processer. Phd.-afhandling. Institut for Teknisk Geologi, DTH og Erhvervsforskerudvalget, ATV. December 1990

Cornell, R. M. and U. Schwertmann (2001): The Iron Oxides – Structure, Properties, Reactions,Occurrence and Uses. VHC Publishers, Weinheim.

Samfundsteknik (1989): Kemikalieaffaldsdepot 219-3 Stenholtvang. Forureningsundersøgelse Fase 2. Skov og Naturstyrelsen, december 1989.

DTU Miljø
Institut for Vand og Miljøteknologi