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Stabilizing As Polluted Soil using Ochreous Sludge from Waterworks

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Ochreous sludge

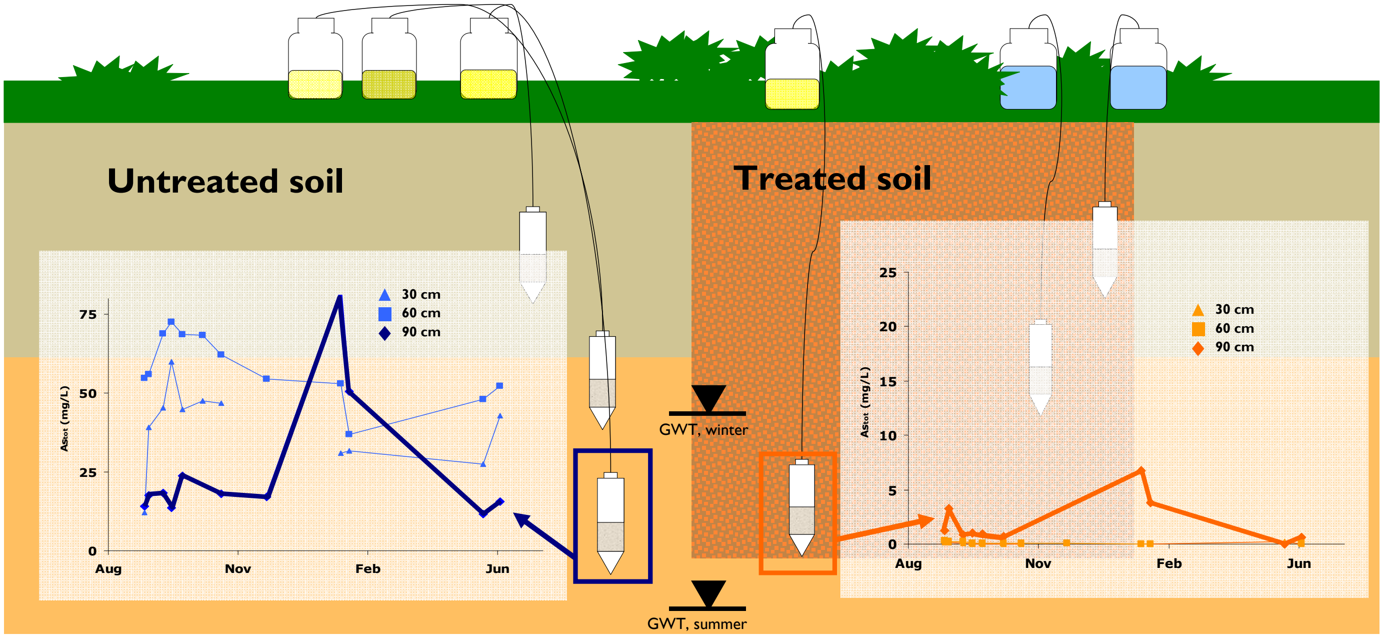
- Waste product from the production of drinking water
- Forms by aeration of groundwater and is removed by settling in a sand filter
- The same substance is formed in springs and streams that are recipients of anaerobic groundwater

- Dry matter contains 80% iron oxide, a mixture of green rust and ferrihydrite
- Sorbs up to 0.2 g As per g ferrihydrite[1]

Field site and experimental work

The field site is the former Collstrup Wood Impegnation Plant in Hillerød, DK. The site is heavily polluted with As, Cr and Cu. Arsenic is mobile and detected in the downstream swamp and ditch system. A typical As soil concentration at the site is 1000 mg/kg.

- The polluted soil was mixed with 3 % ochreous sludge in a 1 m^2 area
- Sampling from the presumably unsaturated zone was made with PrenArt suction cups
- Arsenic was measured by GAAS



Reductive transformation of iron oxides

Ferrihydrite
200 mg As/g [1]

Goethite and Lepidocrocite
4-20 mgAs/g [3]

Anoxic conditions

Green Rust
20 mgAs/g [2]

Iron reducing conditions

Reductive dissolution

$$CH_2O + 4\,FeOOH + 7\,H^+ \rightarrow Fe^{2+} + HCO_3^- + 6\,H_2O$$

Causes complete arsenic release

Conclusions

- During winter arsenic concentrations increase in the deepest samplers. The increase is presumeably caused by the rising water table and following anaerobic conditions
- Despite this seasonal release, the leaching of arsenic is more than **10 times smaller in the treated soil** at all times
- Consequently the stabilization by ochreous sludge is **proposed as a method to minimize the leaching of arsenic from soils**
- Further research is required to determine whether recrystallisation or dissolution controls the arsenic mobility

References: R. Cornell og U. Schwertmann (2003): *The Iron Oxides – Structure, Properties, Reactions, Occurences and Uses.* [1] K. Raven, A. jain og R. Loeppert (1998): Arsenite and arsenate adsorption on ferrihydrite Kinetics, equilibrium and adsorption envelopes. Env. Sci. Techn. 32: 344-349 [2] J. Jönsson og D. Sherman (2008): Sorption of As(III) and As(V) to siderite, green rust and magnetitet: Implications for arsenic release to groundwaters. Chemical Geology 255 173-188 [3] B. Manning, S. Fendorf og S. Goldberg (1998): Surface structures and stability of As(III) on goethite: spectroscopic evidence for inner-sphere complexes. Env. Sci. Techn. 34 2383-2388

Green rust (GR)

A layered double-hydroxide containing both Fe(II) and Fe(III). Forms under anoxic conditions. Very unstable and is oxidized within minutes to goethite and ferrihydrite.

Lepidocrocite

Usually formed from goethite in contact with Fe(II). Often found as plate-like micro crystals.

Goethite

A common iron oxide, naturally occuring in temperate climate soils. One of the most stable iron oxides.

Ferrihydrite

Forms under rapid oxidation of Fe(II) e.g. in a spring. Thermodynamically unstable. Small crystals result in large surface area and high reactivity.