“Bioremediation of chromate in alkaline sediment-water systems “

Robert Whittleston

Background

3 year BSc in Earth Systems Science at the University of Leeds, 2005-2008.

Covering aspects from both the Earth and Environmental science schools.

Undergraduate dissertation: *“Chromium Contamination: Processes Affecting Subsurface Contaminant Mobility”*

Overview

Chromium is considered thermodynamically stable in the environment in two oxidation states, Cr(III) and Cr(VI).

Cr(VI): *Carcenogenic, mutagenic and toxic.*

Highly soluble.

Cr(III): Considered relatively immobile in aqueous systems

100-1000 times less toxic.

Essential trace nutrient.

Source

“High lime” method

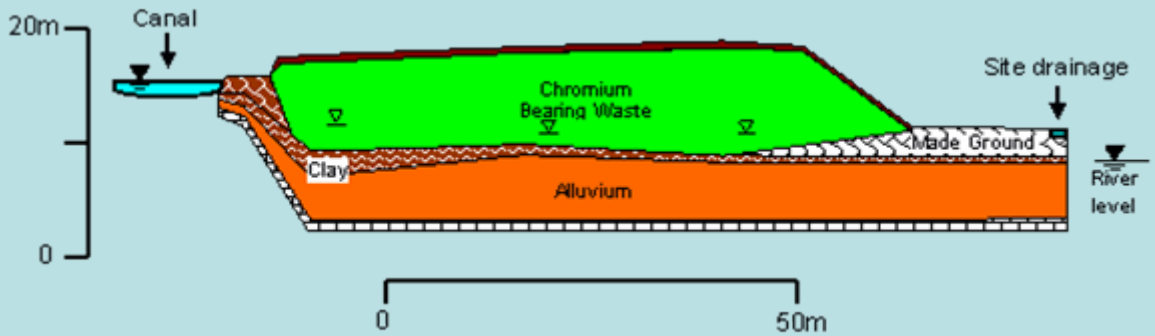
Chromite ore roasted in the presence of an alkaline carbonate, oxidising Cr(III) to Cr(VI) to enable extraction with water:

$$4FeCr_2O_4 + 8Na_2CO_3 + 7O_2 \rightarrow 8Na_2CrO_4 + 2Fe_2O_3 + 8CO_2$$

Chromite ore

The problem

Chromate ore processing residue (COPR)



Example of COPR disposal. (Dr D. Stewart in Whittleston et al., 2007)

Large volume of waste (4:1 waste to product ratio).

Highly alkaline wastes (pH 9-12)

Residual chromium concentrations 2-6 (w/w)% of which as much as 30% can be Cr(VI).

The high solubility of Cr(VI) means the potential for leaching is also high.

(Deakin et al., 2003; Geelhoel et al., 2003; Stewart et al., 2007)

The environment

Geochemical interactions

Cr(III) stongly retained in the solid phase (adsorbtion)

Cr(VI) stong oxidant so will be reduced to Cr(III) in the presence of Fe(II), S(II), and organic matter:

$$Cr(VI) + 3Fe(II) \rightarrow Cr(III) + 3Fe(III)$$

$$6H^{+} + 2HCrO_4^{-} + 3HSO_3^{-} \rightarrow 2Cr(III) + 2SO_4^{2-} + S_2O_6^{2-} + 5H_2O$$

$$2Cr_2O_7^{2-} + 3C^{0} + 16H^{+} \rightarrow 4Cr^{3+} + 3CO_2 + 8H_2O$$

Reduction desirable as Cr(III) less toxic and less mobile/bioavaliable!!

The environment

Microbial interactions

Able to couple the oxidation of organic matter to the reduction of a trace metal (electron acceptor)

Iron(III) (with glucose):

$$C_6H_{12}O_6 + 24Fe(III) + 12H_2O \rightarrow 6HCO_3^- + 24Fe(II) + 30H^+$$

Cr(VI) (with acetate):

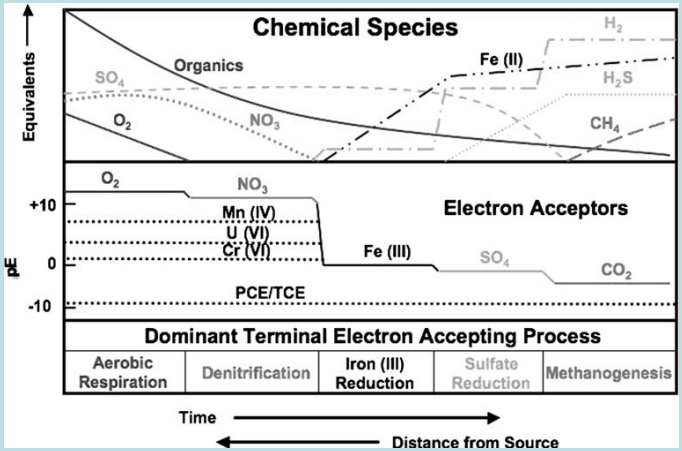
$$3CH_3COO^- + 8CrO_4^{2-} + 17H_2O \rightarrow 8Cr(OH)_{3(s)} + 6HCO^{3-} + 13OH^-$$

Current research

Microcosms used to observe Cr(VI) reduction over time in a variety of conditions.

Ion chromatography used to illustrate the cascade in reduced species

Cascade consumption of competing electron acceptors (Hazen and Tabak, 2005).



Soil DNA extraction from microcosms, for RISA analysis.

"Hopefully" any change will correlate to ion chromatography results