Integrated systems for treating groundwater contaminated with chromium.

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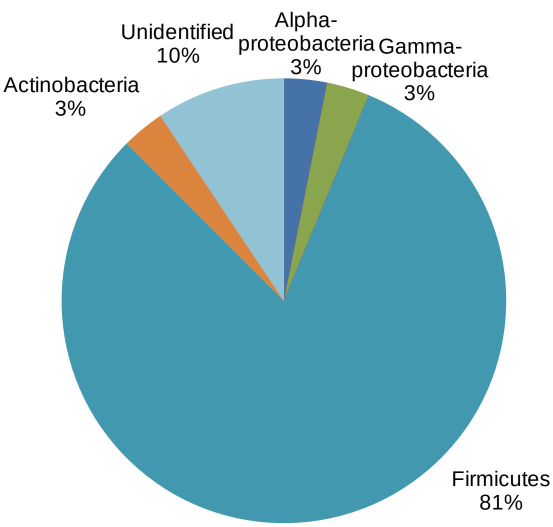
Aim: To develop and evaluate effective and sustainable engineering treatments for chromate contaminated groundwater.

Environmental protection is currently an important issue at the local, national and international level. Thus, it is vitally important to correctly manage and treat industry polluted sites for the benefit of society. This project is focused on the environmental impacts of chromium containing wastes, which is a globally significant industrial legacy. Leaching of toxic and carcinogenic Cr(VI) from the waste, and accidental release of this wastewater damages the environment and has a severe detrimental impact of any groundwater resources. This project will seek sustainable solutions to treating Cr(VI) contaminated waste leachate and groundwater. The overall objective will be to develop a beneficial integrated system for treating Cr(VI) containing water in-situ, and to identify both its optimum operating conditions and its limitations.


Precipitate that forms where alkaline leachate emerges from chromium ore processing residue



Microbial community of a soil sample from immediately under a chromium ore précising waste pile (based on phylogenetic affiliation of the 16S rRNA gene sequences)

The release of chromium from industrial wastes causes major changes in the groundwater chemistry. There are two main types of chromium contamination problems; alkali-generating waste from chromium ore processing, and acid-generating wastes from chrome plating and similar industrial applications. These contrasting conditions require the investigation of two different treatment options. In both cases, the most effective way of removing Cr(VI) from groundwater is to reduce it to insoluble Cr(III). Several ways of reducing chromium in the ground have been attempted. For example a chemical reducing agent can be introduced into a permeable treatment zone created in a natural aquifer (a "permeable reactive barrier"), or natural metal reducing bacteria can be stimulated by injection of a suitable organic substance ("bio-stimulation"). This project will employ laboratory batch and column tests to understand which of these treatments, or the optimal combinations of treatments, is most suitable for the two study conditions, and then take a process engineering approach to treatment efficiency and optimisation. Numerical modelling techniques, such as equilibrium geochemical modelling of batch reactors and one-dimensional reactive transport modelling of columns, will be used as appropriate to interpret experimental data. The project will attempt to understand the key underlying mechanisms of chromium reduction and mineralisation by using advanced geochemical methods such as electron microscopy, X-ray photoelectron spectroscopy and X-ray absorption spectroscopy to analyse the surface speciation of chromium precipitates formed during treatment (the chemical form of the chromium after treatment will


Run-off from a chromium ore processing residue site entering near-by stream

determine whether it can be easily remobilised if there is a change in the groundwater chemistry). The project will also evaluate the ecological impact of treatment on the microbial community in aquifer materials by extracting microbial DNA from soil specimens and undertaking 16S rRNA gene sequencing to evaluate changes in microbial community resulting from treatment.

Having determined the most effective and ecologically sound treatment combinations in the first stage of the project, these will then be tested using materials from fully characterised industrial sites in the UK. The anticipated outcome of the project is a better understanding of the most appropriate treatments to use at real industrial legacy sites.

The Applicant: This project will suit either an engineer willing to acquire skills in geochemistry and microbiology, or an environmental geochemist wishing to tackle applied environmental problems. The successful applicant will join an interdisciplinary team with expertise in all the necessary areas, so training and support will be readily available.

Recent Publications:

D.I. Stewart, I.T. Burke. D.V. Hughes-Berry and R.A. Whittleston (2009). Microbially mediated chromate reduction in soil contaminated by highly alkaline leachate from chromium containing waste. Ecological Engineering, doi:10.1016/j.ecoleng.2008.12.028.

D.I. Stewart, I.T. Burke and R.J.G. Mortimer (2007). Stimulation of microbially-mediated chromate reduction in alkaline soil-water systems. Geomicrobiology Journal, 24 (7-8), 655-669.