

Fate and Behaviour of Vanadium During the Aerobic Neutralisation of Alkaline Steel Slag Leachate

ANDREW J. HOBSON¹, DOUGLAS I. STEWART²,
ANDREW W. BRAY¹, WILLIAM M. MAYES³,
ALEX L. RILEY³ AND IAN T. BURKE¹

¹School of Earth and Environment and ²School of Civil Engineering, University of Leeds, Leeds, LS2 9JT, UK. Email for correspondence: i.t.burke@leeds.ac.uk

³Centre for Environmental and Marine Sciences, University of Hull, Scarborough, YO11 3AZ, UK

Steel slags are the primary by product of steel making and increased demand for the product in recent decades has led to large increases in the volume of slag produced. Although slag has viable afteruses in construction and water treatment, production outstrips demand, and most slags is stockpiled in land based repositories. Long term leaching of CaO and Ca silicate phases in the slags by rain water produces a highly alkaline (pH 12+) Ca(OH)₂ dominated leachate, and, several toxic trace metals such as V, Al and Pb have been reported to be mobilised from the slag into the leachate. At sites where steel slag leachates enter surface drainage, in gassing of atmospheric CO₂ produces large volumes of secondary carbonate precipitation and neutralises the alkalinity present. The concentration of trace metals (e.g. V and Al) are also reduced during this process. This study reports findings from a combined field and laboratory investigation of the fate and behaviour of V in leachates from the Consett steel slag repository, Co Durham, UK, during aerobic neutralisation.

Field investigation showed that aqueous vanadium concentrations are reduced downstream of the point where leachate enters surface streams concurrent with significant reductions of water pH and Ca concentrations. In laboratory experiments only modest removal (<20%) of V occurred in neutralisation experiments where calcite or kaolinite clay were the only sorption surface present. However, when iron oxide (goethite) was present the degree of removal increased substantially (>50% removal). XANES analysis of the V speciation in solids recovered after neutralisation revealed only V(V) was present, most likely in surface sorption bonding environments. EXAFS analysis on selected samples revealed that V formed strong inner sphere complexes with goethite surfaces during neutralisation, accounting for the increased degree of V removal observed. These results showed that pH dependant sorption processes ultimately control the behaviour of V in surface waters affected by steel slag leachates and that interaction of V with iron oxides can be expected to limit V mobility in affected environments.