Goldschmidt 2021 Abstract
https://doi.org/10.7185/gold2021.7814

Novel Subsurface Reactive Zones Containing Mn-Fe Oxides and Hydrotalcite for In Situ Groundwater Remediation of Multiple Inorganic Contaminants

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Sites contaminated with multiple metals, metalloids and other inorganics with contrasting geochemical fate and transport properties can pose a unique challenge for in situ groundwater remediation in that strategies for effective treatment may require combinations of different removal mechanisms to address the specific mixture of contaminants present. Groundwater contamination beneath coal ash disposal facilities in particular can include combinations of cationic (e.g. Co, Li, Ra) as well as oxyanion (e.g. As, B, Mo, Sb, Se) species, some of which are also redox-reactive. We explored methods to simultaneously synthesize Fe-substituted Mn oxides and hydrotalcite for concurrent removal of cation and anion species, respectively, through laboratory experiments. Mixing of an acidic Mn(II)-Fe(III)-Mg-Cl solution with an alkaline Na-Al-MnO_4 solution was successful as confirmed by bulk chemical analysis and XRD of the precipitates.

Treatment effectiveness was documented in batch tests with groundwater impacted by B (12 mg/L), Li (0.1 mg/L), and Mo (2.5 mg/L). More than 95% of Li and Mo and 60% of B were removed. Additional batch tests focused on further optimizing removal efficiencies by adjusting the reagent solution chemistries to change the relative amounts of Mn-Fe oxide and hydrotalcite precipitates formed.

Successful field implementation for in situ remediation requires delivery of the two solutions to a target area by sequenced injection and mixing to initiate the formation of Mn-Fe oxide and hydrotalcite precipitates that create a subsurface reactive zone to treat groundwater as it flows through. Column tests with injection-treated site soil and groundwater were performed to evaluate the treatment capacity of the reactive zone. Breakthrough of B was observed first, followed by Li and Mo. When column test results were scaled to field conditions, the estimated effective treatment life for a single injection was several years for Li and Mo, and shorter for B, indicating that periodic reinjection may be required at some sites. A pilot test is currently underway and will provide field-scale performance data for the in situ reactive zone application of this treatment approach.