

Leaching from pyritic waste slags under alternating flow conditions: Control of primary and secondary mineral dynamics on the reactive transport of arsenic and heavy metals in a carbonate-buffered aquifer

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Pyrite cinders have been used in the Netherlands during the 70's to fill clay pits that had been dug for brick production. To date, the leaching of these waste slags continues to contaminate the underlying groundwater with arsenic and heavy metals. Due to the dynamics in river stages near these sites, an oscillating pattern of drainage and infiltration conditions is encountered. In consequence, this results in oscillating water saturations and redox conditions, both at the cinders and near the river. Geochemical modeling using PHREEQC corroborated that the oxidation of pyrite with oxygen and subsequent pH-buffering by carbonate dissolution can describe the overall geochemical processes, although analysis of the waste slags suggests that the waste slags are largely oxidized, with hematite as the dominant mineral in XRD analysis. Calculated CO₂ pressures for the groundwater that range over 10% point to carbonate-buffering that, at least in part occurs, under closed, i.e. saturated conditions. Partly this is due to the alkaline groundwater periodically entering the pyrite slags under infiltration conditions, and by the pH-buffering that occurs when carbonate minerals

react with the (remaining) acidity in the leachate. In part however, pH-buffering capacity by carbonate is depleted, as elevated potassium and barium concentrations indicate that acid buffering by K-feldspar is occurring at the site. Using a 2-D reactive transport model (PHT3D-Modflow), the developed conceptual site model is tested to anticipate the future development of contaminant levels at the site, as well as evaluation of remedial options. Using various scenarios in a sensitivity analysis, the extent to which nickel, zinc will be transported off-site is shown to depend in particular on the depletion of the acid-buffering capacity by sedimentary carbonates. In addition the adsorption capacity for nickel and zinc in the sediment is influenced by the accumulation of iron hydroxides due to the precipitation that occurs near the waste slags and to a lesser extent near the river. The surface complexation that these iron hydroxide precipitates provide are the main controlling factor for the arsenic transport.

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