

Phosphate Recovery from Groundwater Treatment Sludge

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Groundwater treatment produces sludge rich in phosphate (P), a critical resource needed for global agriculture. Nevertheless, this waste stream has been overlooked for its potential for resource recovery due to coexisting toxic components, particularly (As). Our group is developing novel methods to remove toxic As from groundwater treatment sludge by alkali extraction and subsequent selective As reduction, which leaves an alkali solution rich in aqueous P that can be recovered as calcium phosphates (Ca-P). However, the P-rich solution also contains low concentrations of residual aqueous As, posing a potential challenge for P recovery via precipitation as solid Ca-P due to the similar reactivity of P and As(V).

In this study, we dosed calcium chloride (CaCl_2) to P-rich solutions containing low As concentrations to recover as much aqueous P as possible, while minimizing As accumulation in the Ca-P solids. Various experimental conditions were investigated (e.g., solution chemistry, reaction time) and measurements of P recovery were coupled with structural analysis of the formed Ca-P solids. Dissolved inorganic species were measured by ICP-OES, whereas solids were characterized by scanning transmission electron microscopy and pair distribution function (PDF) analysis of high-energy X-ray scattering data (DESY, Hamburg, DE). The results from our study suggest an optimal dosed Ca/P ratio between 1 and 1.6 that can remove a high fraction (>60%) of P from solution, while minimizing As uptake into the solid (Figure 1a). Importantly, nearly complete P recovery can be achieved by dosing Ca/P at a 1.6 ratio but at the cost of disproportionately increased As uptake into the solid. Structural analysis revealed that all solids consisted of hydroxyapatite, though significant differences in crystallite size were observed (Figure 1b). In addition, we found that the final pH of the suspension is a critical parameter that governs P and As uptake. Taken together, these results help improve the design of resource recovery systems for groundwater treatment sludge, which will help shift the paradigm in how this waste stream is managed today.

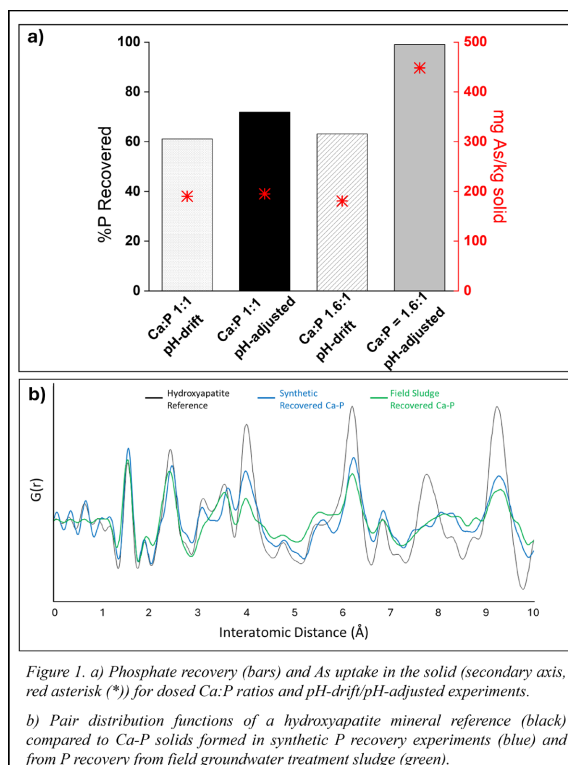


Figure 1. a) Phosphate recovery (bars) and As uptake in the solid (secondary axis, red asterisk (*)) for dosed Ca:P ratios and pH-drift/pH-adjusted experiments. b) Pair distribution functions of a hydroxyapatite mineral reference (black) compared to Ca-P solids formed in synthetic P recovery experiments (blue) and from P recovery from field groundwater treatment sludge (green).