

## ***In situ* immobilization of uranium in oxic groundwater via phosphate reprecipitation**

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Groundwater uranium (U) contamination occurs at sites associated with uranium mining and milling, nuclear fuel and energy production, nuclear waste storage and depleted uranium munitions manufacture. Oxidized U(VI) is relatively mobile in groundwater due to the formation of uranyl carbonate complexes that partition weakly to mineral surfaces; however, U(VI) in the presence of phosphate is known to form sparingly soluble phosphate minerals such as autunite. *in situ* remediation of groundwater U contamination through uranyl phosphate precipitation is a promising, passive remedial approach in aerobic aquifer systems which requires no redox manipulation. We present the results of a proof-of-concept study to demonstrate the efficacy of *in situ* U sequestration using Apatite II™ (PIMS NW, Inc.) a fish bone-derived form of poorly crystalline and highly porous apatite ( $\text{Ca}_{10-x}\text{Na}_x(\text{PO}_4)_{6-x}(\text{CO}_3)_x(\text{OH}_2)$ ).

Columns packed with sand-sized particles of Apatite II™ were deployed at a facility where U is present in groundwater at up to 3 mg/L. One set of media canisters constructed of stainless steel mesh was deployed in the screened interval of pre-existing monitoring wells to investigate U sequestration under passive gradients. Uranium uptake under higher mass loading was evaluated using columns constructed of solid PVC installed in wellhead sheds. Groundwater was pumped through these active columns with frequent sampling of the groundwater influent and column effluent.

Apatite II solids within the columns underwent pre- and post-experiment characterization including sequential extraction, TEM and SEM imaging, and bulk XRF and XRD. Initial results suggest that Apatite II is highly effective at U sequestration with greater than 99% removal in the active columns. Media dissolution was observed in the active experiments, creating conditions favorable for the precipitation of insoluble uranyl phosphate mineral phases. Spatially resolved imaging and spectroscopy of the active column media will be used to evaluate transitions in U retention mechanisms with degree of loading.