Field-scale evaluation of Biostimulation for Remediation of Uranium-Contaminated Groundwater

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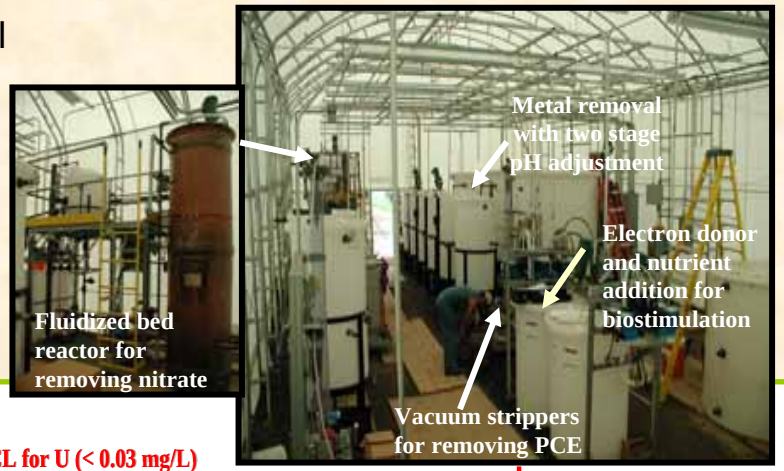
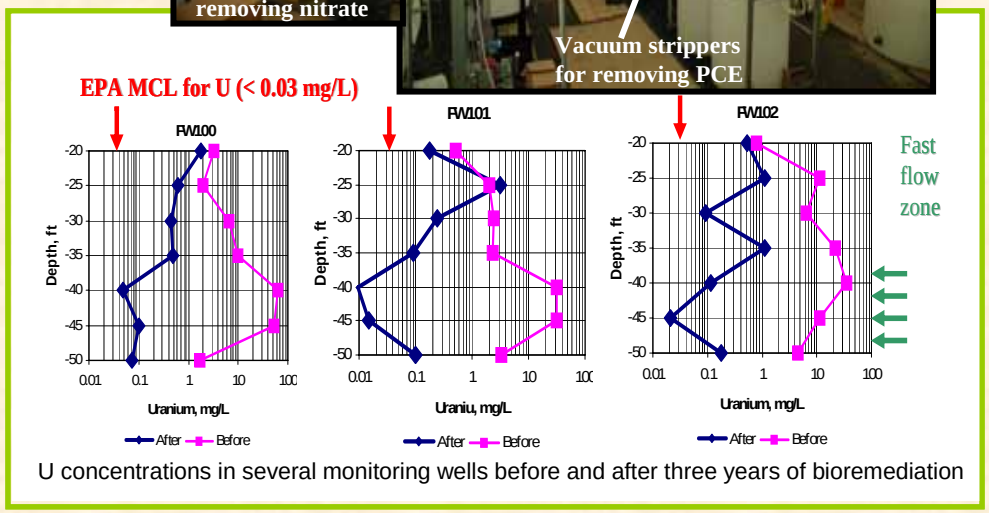
- Project designed to advance the understanding and predictive capability of coupled hydrological, geochemical, and microbiological processes that control the *in situ* transport and bioremediation radionuclides and co-contaminants at the field scale.
- Bioreduction rates are relatively rapid and groundwater U concentrations can be maintained below US EPA maximum contaminant limit (MCL) for drinking water and groundwater, and solid phase U(IV) remains stable under anaerobic conditions.
- The research will have a significant impact on the Oak Ridge Reservation Groundwater Strategy document (DOE 2004), that describes possible groundwater remediation strategies on the Oak Ridge Reservation, by providing new information and predictive tools for implementing successful bioremediation efforts at a variety of sites on the reservation.

Near-source groundwater processing setup





U concentrations in several monitoring wells before and after three years of bioremediation

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This research is motivated by the likelihood that metal and sulfate reducing bacteria can be stimulated in the subsurface to enhance the reduction of redox sensitive metals and radionuclides thereby immobilizing them *in situ*. Low U concentrations, below US EPA maximum contaminant limit (MCL) for drinking water and groundwater (< 0.03 mg/L), could be achieved *in situ* for highly contaminated U and nitrate rich systems by stimulating subsurface microorganisms. An above-ground processing facility assisted with the removal of high concentrations of nitrate, metals, and PCE. In situ bioreduced / immobilized U was stable under anaerobic conditions for 1-2 years and anaerobic re-oxidation was not observed. Both field and laboratory investigations confirmed that metal-reducing *Geobacter spp*., and sulfate reducing *Desulfovibrio spp*. were stimulated by additions of the electron donor ethanol and were most likely significant contributors to the bioreduction of U(VI). X-ray absorption spectroscopy analysis confirmed significant changes in U speciation and chemical environment following biostimulation and the presence of up to 60-to 80% bioreduced U(IV) within bioreduced sediments. The following research will have a significant impact on the Oak Ridge Reservation Groundwater Strategy document (DOE 2004) that describes a watershed-based strategy for making decisions about groundwater remediation on the Oak Ridge Reservation (ORR). The project has over 25 peer-reviewed publications in the open literature.

Wu., W.M., J. Carley, S. Caroll, O. Cirpka, M.W. Fields, M. Fienen, M.E. Gentile, T. Gentry, M.A. Ginder-Vogel, R.F. Hickey, J. Luo, T.L. Mehlhorn, J. Nyman, H. Yan, D.B. Watson, J. Zhou, S.E. Fendorf, P. Kitanidis, P.M. Jardine, and C.S. Criddle. 2006. Pilot-scale in situ bioremediation of uranium in a highly contaminated aquifer II: Reduction of U(VI) and geochemical control of U(VI) bioavailability. Environ. Sci. Technol. 40 (12): 3986-3995.