

Project #1022978

Title: Field-Scale Evaluation of Biological Uranium Reduction and Reoxidation in the Near-Source Zone at the NABIR Field Research Center in Oak Ridge, TN

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Results To Date: We have now added ethanol intermittently for over 700 days. Ethanol has been added weekly with each injection lasting for a few days. We are now observing:

1. Uranium immobilization at 700-2000 mg/kg. Baseline levels before remediation were 30-500 mg/kg.

2. Uranium concentrations in groundwater at the monitoring wells have fallen below the U.S. drinking water standard (30 ppb). This is an important milestone.

3. XANES analyses for day 535 indicate 51% U(IV) at the inner loop injection well, 35% U(IV) at MLS well 101-2, and 28% U(IV) at the extraction well. These numbers indicate that U(IV) reduction is not localized to the injection well, and is spreading through the aquifer.

4. We have had success removing trace levels of oxygen from recirculated water by addition of sulfite and related compounds. These compounds also provide the added benefit that in removing oxygen that themselves are oxidized to sulfate, an important electron acceptor needed for maintenance of our system.

Deliverables: The following papers were published or accepted for publication:

Wu, W., B. Gu, M. W. Fields, M. Gentile, Y-K. Ku, H. Yan, S. Tiquias, T. Yan, J. Nyman, J. Zhou, P. M. Jardine, and C. S. Criddle. 2005. Reduction of uranium(VI) by denitrifying biomass. *Bioremediation Journal* 9(1):1-13.

This paper provides evidence of U(VI) reduction by denitrifying biomass, that also contains sulfate-reducing populations.

Gu, B., W. Wu, M. W. Fields, Matthew V. Ginder, H. Yan, S. Fendorf, C. S. Criddle, and P. M. Jardine, 2005. Bioreduction of uranium in a contaminated soil column. *Environ. Science and Technology* 39:4841-4847.

This paper previewed field operations and demonstrated that the sequence of operations planned for the field could achieve U(VI) reduction.

Luo, J., W-M. Wu, M. N. Fienen, P. M. Jardine, T. L. Melhorn, D. B. Watson, O. A. Cirpka, C. S. Criddle, and P. K. Kitanidis. 2005. Hydraulic analysis of in situ reactors created by extraction-injection wells: a nested cell and its application at Oak Ridge, TN. Accepted for publication in *Groundwater*.

This paper describes the novel nested well recirculation system used at the field site.

Gentile, M., T. Yan, S.M. Tiquia, M.W. Fields, J. Nyman, J. Zhou, and C.S. Criddle. 2005. Stability in a denitrifying fluidized bed reactor. Accepted for publication in *Microbial Ecology*.

This paper describes the resilience of an FBR microbial community in response to operational disturbances.

Nyman, J. L., T. L. Marsh, M. Ginder-Vogel, M. Gentile, S. Fendorf, and C. S. Criddle. 2005. Heterogeneous response to biostimulation for U(VI) reduction in replicated sediment microcosms. *J. Biodegradation* 16:1-14.

This paper describes bench-scale batch studies that previewed field operations and shows that U(VI) reduction was achievable but a heterogeneous response was observed, with 2 of 17 microcosms showing a rebound in U(VI) levels.

Fields, M. W., T. Yan, S.-K. Rhee, S. L. Carroll, P. M. Jardine, D. B. Watson, C. S. Criddle, and J. Zhou. 2005. Impacts on microbial communities and cultivable isolates from groundwater contaminated with high levels of nitric acid-bearing uranium waste. Accepted for publication in *FEMS Microbial Ecology*.

This paper provides background information on the microbial community structure at the FRC prior to site conditioning and biostimulation efforts.

uo, J., O.A. Cirpka, W.-M. Wu, M.N. Fioren, P.M. Jardine, T.L. Mehlhorn, D.B. Watson, C.S. Criddle, P.K. Kitanidis, 2005. Mass-transfer limitations for nitrate removal in a uranium-contaminated aquifer. Accepted for publication in *Environ. Science and Technology*.

This paper describes modeling of a field scale experiment to determine mass transfer rates for nitrate from the immobile zones within the subsurface matrix. The results indicate that the immobilize zones within the solid matrix are a long-term source for nitrate, and that diffusion of nitrate out of the matrix immobile zones would require about one year if bulk nitrate in the mobile zones was removed.

Four more papers are in review.