Department of Chemical and Environmental Engineering

2015—2016 Seminar Series

Friday, January 22, 2016

9:30-10:30am

Winston Chung Hall 205/206

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Role of extracellular electron transfer for contaminant metal reduction in sediment nanopores, and implications for hazardous waste site cleanup

Microbial reduction of metals and radionuclides in the subsurface plays an essential role in the biogeochemical cycling of micronutrients and the remediation of contaminated sediments. While recent advances in the field have improved our ability to understand and predict bioreduction in these environments, the contribution of long-range extracellular electron transfer (EET) by electron shuttling or reduction along conductive pili remains elusive. Long-range EET is implicated in the reduction of radionuclides like uranium that are reversibly sorbed in clay nanopores and exist as persistant sources of contamination. In regions of low hydraulic conductivity, electron shuttles and conductive pili may increase physical mixing beyond what is possible by advection and diffusion, resulting in reduction over a larger area than predicted by current models. We present a novel microfluidic platform that allows us to study long-range EET to the exclusion of other mechanisms, directly observe these phenomena under a controlled environment representative of groundwater conditions, monitor the metabolic activity and redox state of bacteria, and determine the presence of reduced products in-situ. Using Geobacter sulfurreducens as a model metal-reducing bacteria, insoluble manganese dioxide as an electron acceptor, and Escherichia coli K-12 as a reductant and redox buffer, we demonstrate that 1) long-range EET by conductive pili requires the presence of flavins, 2) Reduction by direct contact within 200 nm wide pores only requires the presence of a lowered electric potential, 3) The limit of reduction by conductive pili is on the order of 15-20 microns. The results suggest that microbes can directly reduce metals via conductive pili in soil and sediment micropores as small as 200 nanometers in diameters, up to a depth of 20 microns. We are actively exploring the influence of hydrological conditions on the expression of different mechanisms of long-range EET, and the importance of extracellular cytochromes and pili conductivity on metal reduction.

Biosketch: Charles Werth is a Professor and Bettie Margaret Smith Chair of Environmental Health Engineering in the Department of Civil, Architecture, and Environmental Engineering at the University of Texas at Austin. He joined the UT faculty in August or 2014, after spending 17 years on the faculty at the University of Illinois at Urbana-Champaign. Dr. Werth's research and teaching focus on the fate and transport of pollutants in the environment, the development of innovative catalytic technologies for drinking water treatment, and the mitigation of environmental impacts associated with energy production and generation. He is a chief editor of Journal of Contaminant Hydrology, a member of the USEPA Science Advisory Board, and a Wiley Research Fellow at the DOEs Environmental Molecular Science Laboratory.

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