Hello, this is Kevin O'Donovan, and I'd like to welcome you to the National Institute of Environmental Health Sciences Superfund Research Program monthly Research Brief podcast.

This month we're tackling an innovative method to accelerate pump-and-treat remediation at Superfund sites.

The research brief, Number 194, was released on February 2, 2011, and was written by SRP contractor Maureen Avakian in conjunction with SRP-supported researcher Dr. Danny Reible from the University of Texas.

Covering submerged contaminated sediments with layers of sand, gravel, rock, or synthetic materials (i.e., *in situ* sediment capping) stabilizes the sediment and prevents mobilization of contaminants into the water column. Capping strategies can reduce long-term ecological and human health risks at sites where dredging is cost-prohibitive and monitored natural attenuation is not a suitable remediation option.

"Amended capping" incorporates adsorbents such as activated carbon or apatite in the cap material to sequester contaminants. Recently-developed "reactive caps" integrate engineered components to stimulate abiotic or biotic degradation of contaminants. For example, iron/palladium nanoparticles can adsorb and dechlorinate the PCB 2-chlorobiphenyl, and reactive caps have been designed to promote microbial growth and biodegradation of contaminants. However, even in reactive caps, biodegradation processes are limited by the availability of electron donors or electron acceptors.

With funding from the SRP, Dr. Danny Reible's research group is exploring the concept of combining *in situ* capping with another contaminant-remediation strategy: electrode-based remediation. When electrodes are placed in contaminated groundwater or sediment, redox gradients can be established to sequester heavy metals at the electrode, collect contaminants for further treatment, or stimulate microbial growth to enhance biodegradation. However, standard electrode-based systems are costly as they require high voltage and/or a large number of electrodes.

Dr. Reible, in cooperation with co-investigators Kelvin Gregory and Greg Lowry at Carnegie Mellon University, developed an approach to place geotextiles with polarized carbon electrodes in a sediment cap. He hypothesized that, by controlling the voltage through the electrodes, he could establish and control oxidation and reduction zones within the cap. Hydrogen (H_2) and oxygen produced by water electrolysis at the electrode surfaces can serve as electron acceptors and electron donors to stimulate microbial growth and create an "electrode biobarrier" that accelerates contaminant degradation. The magnitude and thickness of an electrode-stimulated biobarrier and the redox gradient could be engineered to address specific contaminants of concern on a site-by-site basis.

The researchers evaluated the potential for carbon electrodes to create and control a redox gradient in a sand cap using T-cell reactors containing sediment from the Anacostia River (Washington, DC). They placed carbon electrodes in a sand sediment cap and continuously applied a 4V electrical current. Within 3 days, the system established oxidizing conditions at the anode and reducing conditions at the cathode, as well as a gradient between the electrodes.

The researchers examined carbon electrode-stimulated degradation of tetrachlorobenzene (TeCB) in Anacostia River sediments and found that an external potential of 4V resulted in ~90% removal of TeCB over 21 days. Similar removal was not observed in the absence of electrodes or when only 3V was applied to the system.

Additional studies demonstrated that electrochemical and geochemical factors (pH, dissolved organic carbon, and ionic composition) do not greatly affect the rate of H_2 production. Moreover, the same electrode material was used for over 6 months in this study without a decrease in the rate of H_2 production. These findings suggest the technology would function in the long term, under a variety of field conditions.

To minimize capital costs for materials and remote power, electrochemical-capping strategy could be applied in combination with a "funnel-and-gate" treatment configuration. In this configuration (also developed by Dr. Reible with SRP funding), the majority of the sediment area is covered by a low-permeability cap, and the contaminants are funneled by hydraulic control to a relatively small area or "gate," where an electrochemical cap is installed for contaminant degradation.

The critical advance in this research is the application of low voltage and low current to large area electrodes to enhance and control appropriate microbial activity in a thin horizontal layer within a cap.

Dr. Reible's results show that simple carbon electrodes can be used to engineer a redox gradient in a sediment cap, produce microbial electron donors, and stimulate contaminant degradation. Electrode-based capping with biobarriers may provide a novel and effective mechanism to remediate contaminants (e.g., PCBs, TCE, and mixtures) that require sequential reduction and oxidation, which may not develop under natural conditions.

If you'd like to learn more about this research, visit the Superfund Research Program website at www.niehs.nih.gov/srp. From there, click on "Who We Fund," "Individual Research Grants," and "Currently Funded"; then look for the University of Texas link. If you have any questions or comments about this month's podcast, or if you have ideas for future podcasts, contact Maureen Avakian at avakian@niehs.nih.gov.

Join us next month as we discuss an SRP-funded article that appeared in *Science* a few weeks ago.