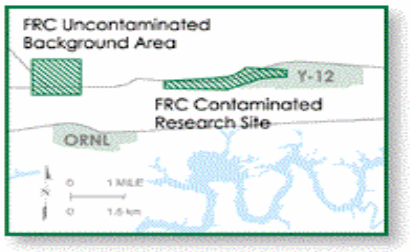
NABIR Field Research Center



Fact Sheet

In situ immobilization of uranium in a fractured, porous subsurface

The NABIR FRC subsurface environment

Remediating below-ground radionuclide contamination at U.S. Department of Energy (DOE) sites is difficult, partly because of the complexity of the subsurface environments, themselves. The area below the soil but above bedrock at the NABIR FRC and other locations in the southeastern United States consists of saprolite. Saprolite is highly weathered rock that, because it has weathered in place, is unconsolidated but filled in by clayey materials, and iron and manganese oxides. Saprolite at the FRC is formed from sedimentary rock like shale, siltstone, or limestone. The weathered bedrock that constitutes saprolite exhibits many of the physical characteristics of its parent bedrock, such as fractures and bedding planes. Groundwater and contaminants can flow through saprolite in complex, not easily predictable ways.

Saprolite in locations like the NABIR FRC is highly porous. Pores within saprolite range in size from large (macropores), to medium (mesopores), to small (micropores). Most of the porosity at the FRC is attributable to micropores. This presence of multiple pore sizes is important for bioremediation efforts for three main reasons:

- Micropores act as a reservoir for contaminants like uranium.
- Materials, like contaminated groundwater, tend to migrate by diffusion from smaller to larger pores—from micropores to mesopores to macropores. This diffusion from small to large pores is one reason why pump-and-treat remediation technologies are problematic—contaminants are removed from larger pores by pumping, but those larger pores then are re-charged with contaminants located in micropores.
- Microorganisms important for bioremediation are too big to fit in micropores, but small enough to live in mesopores and macropores.

Field research to immobilize uranium

A research team is conducting field research that seeks to immobilize uranium in the FRC's highly porous, saprolite subsurface environment. The team is headed by Tim Scheibe (Pacific Northwest National Laboratory, tim.scheibe@pnl.gov), Scott Brooks (Oak Ridge National Laboratory, brookssc@ornl.gov), and Eric Roden (University of Alabama, eroden@biology.as.ua.edu). This interdisciplinary team of scientists has expertise in microbiology, geochemistry, and hydrology, as well as experience in laboratory and field experimentation and quantitative analysis of biogeochemical systems.

NABIR and the NABIR FRC—in brief

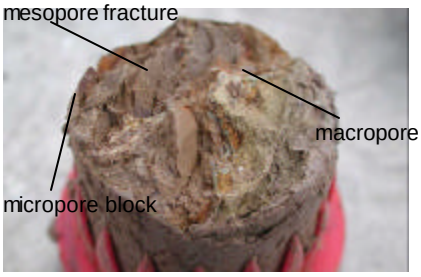
Historic research and production activities at sites owned by the U.S. Department of Energy (DOE) and its predecessor agencies created a legacy of below-ground contamination. Considering only contaminated groundwater, DOE currently is responsible for remediating 1.7 trillion gallons, equivalent to approximately four times the daily U.S. water consumption.

DOE's Natural and Accelerated Bioremediation Research (**NABIR**) Program (www.lbl.gov/NABIR) was created to help address some of the more difficult remediation challenges the agency faces. NABIR provides the scientific foundation for the development of bioremediation strategies for below-ground metal and radionuclide contamination. NABIR supports laboratory, field, and theoretical research in microbiology, ecology, chemistry, geology, and computer science. Research is focused on bioremediation of uranium technetium, plutonium, chromium, lead, and mercury.

The **NABIR FRC** (www.esd.ornl.gov/nabirfrc) provides contaminated and uncontaminated field sites in which program investigators can conduct research and obtain samples useful in exploring how naturally occurring microorganisms can help remediate below-ground metal and radionuclide contamination in place.

Uranium, a major groundwater contaminant at U.S. Department of Energy (DOE) sites exists in different forms. Mobile forms can dissolve in and move with groundwater, while other forms exist as solid minerals that do not dissolve. The mobile form of uranium is of concern because it may migrate to locations where it can be taken up by plants, animals, and humans. Few technically feasible, cost-effective options for remediating groundwater contaminated with uranium currently exist. Scheibe, Brooks, and Roden are involved in a larger effort to investigate a new and promising approach to immobilize uranium by converting it from a mobile form to an immobile form through the use of naturally occurring microorganisms. The team combines laboratory and field experimentation and analysis.

Specifically, the research team is focusing on microorganisms called dissimilatory metal-reducing bacteria (DMRB), which are native to the FRC subsurface environment. The team thinks that, by stimulating these bacteria in place, uranium can be immobilized in subsurface macropore and mesopore regions.



Saprolite core from contaminated site

The team also is addressing the immobilization of uranium in micropores, which represent the vast majority of total subsurface porosity. Previous research indicates the possibility that stimulating DMRB in macropore and mesopore regions effectively will create biologically active boundaries. These boundaries will act as localized, distributed semi-permeable barriers that serve to prevent the movement of mobile uranium VI from the micropores to mesopores and macropores. Blocking this mobile uranium movement, in turn, will reduce contaminant levels in the freely flowing macropore water that poses a contamination risk through discharge to surface waters or movement to deeper aquifers and off-site

Intact core of saprolite collected from the FRC background site for use in controlled laboratory experiments. Relict bedding planes and secondary iron (rust color) and manganese (black) oxides are evident in the saprolite. The white material is paraffin, applied to the outside of the saprolite sample during its collection.

Work on this field project began in 2003. Saprolite collected from the uncontaminated background area is undergoing comprehensive biogeochemical characterization and being used in controlled laboratory experiments. In addition, site characterization and well installation has begun on the contaminated site on which the researchers will conduct field investigations.

For more information about this project, see http://public.ornl.gov/nabirfrc/awards.cfm, or contact

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