Getting to the Root of Contamination

By Ms. Marie C. Darling

Researchers with the Engineer Research and Development Center (ERDC), Cold Regions Research and Engineer Laboratory (CRREL), have been treating petroleum-contaminated soils in remote, cold areas by using root-microbial processes. According to a fact sheet released by the Alaska Department of Environmental Conservation, Spill Prevention, and Response Division, petroleum is the most common contaminant in Alaska.

The Department of Defense (DOD) has used a wide variety of petroleum products—including gasoline, diesel fuel, heating oil, jet fuel, lubricating oil, bunker oil, and tar—all of which are refined from crude oil. Many petroleum products contain benzene and poly-nuclear aromatics, known carcinogens to people and animals.

Most petroleum contamination in Alaska comes from leaking storage tanks, containers, and pipes (with undetected leaks underground); leaking equipment; transportation accidents; and improper handling and disposal practices. Many DOD sites are so remote that transport and operation of traditional cleanup systems are impractical or too costly. Some sites are underlain by permafrost and are vulnerable to environmental damage.

Natural attenuation, the most cost-effective treatment for remote contaminated sites, is often inhibited by a lack of nutrients, a lack of mixing, highly dynamic moisture and temperature conditions, and a short treatment season. One recommendation is to identify a means to enhance natural attenuation processes and effectively monitor the enhancement to cost effectively treat hundreds of petroleum-contaminated sites in remote, cold regions.

Modifying soil conditions by introducing plants with diffuse root systems exploits the rhizosphere effect. The rhizosphere is a zone of enhanced microbial activity in soil near plant roots. Using the rhizosphere effect takes advantage of a host of natural cycles and processes. For example, plant roots exude excess carbon, which stimulates microbial activity and biodegradation near the roots. As roots explore the soil, microbial activity is enhanced for increasing percentages of soil and results in "pseudo-mixing" without the need to physically till the soil.

In early laboratory experiments at CRREL and field studies in Fairbanks, Alaska, successful plant germination, plant growth, and root intrusion in both crude oil- and diesel-contaminated soil were successful. Cold-tolerant grasses, especially annual ryegrass and Alpine bluegrass, appeared to germinate and grow in petroleum-contaminated soils. There were greater numbers of bacteria in the rhizosphere soil compared to unvegetated bulk soil and an increase in the percentage of soil microorganisms that can degrade model organic contaminants. And most significantly, the vegetated soil treated with nutrients increased remediation rates and reached a lower endpoint concentration than unvegetated or untreated soils.

For the past five years, researchers have further investigated earlier findings by conducting field studies of rhizosphere-enhanced treatment at three geographically diverse sites in Alaska—Barrow (north slope), Galena (interior), and Annette Island (southern)—and two sites in Korea. Results show a significant beneficial plant effect, and the effect is more pronounced for recalcitrant compounds. Surprisingly, the data show that nutrient additions alone can slow or inhibit biodegradation of recalcitrant compounds relative to either the vegetated or control treatments.

The Army Environmental Quality Technology Program, the Strategic Environmental Research and Development Program, and the Environmental Security Technology Certification Program supported this research. The findings have implications for live-fire range sustainability and understanding the persistence and fate of chemical-biological agents, both involving microbially driven surface-soil phenomena. By providing a science basis for low-cost treatment at remote sites, results of this research will benefit DOD and residents of Alaska.

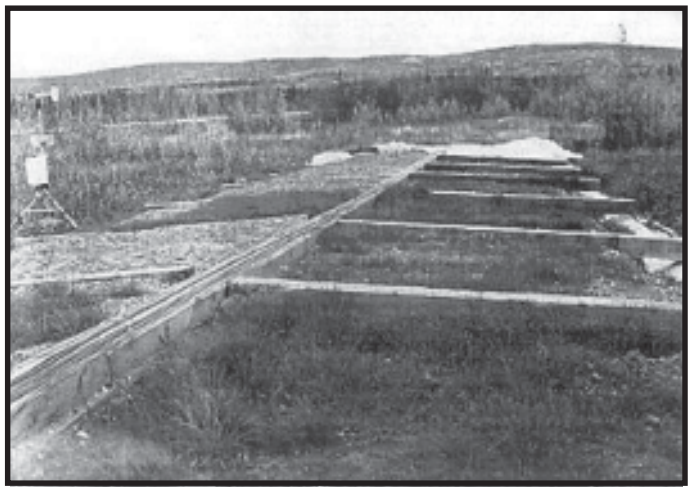

Photo courtesy C.M. Reynolds, ERDC CRREL

These plants in a contaminated soil landfarm in Fairbanks, Alaska, provide a field study to evaluate the rhizosphere effect.

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