

## Optimizing Bioremediation of Recalcitrant Soil Contaminants in Canada's Cold Climate

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**Background/Objectives.** Many large-scale enhanced bioremediation projects with nutrients and bacterial preparations have been completed in Canada, over the past 25 years. Contaminants treated using this approach include petroleum hydrocarbons, PAHs, phthalates, chlorinated phenols, and chlorinated herbicides. Challenges that must be overcome over the cold climate include low solubility and high acute toxicity of some contaminants as well as stringent remedial standards. Treatment has been conducted both in situ without excavation, on-site following soil excavation, and off-site at permitted soil treatment centers. This approach to soil remediation provides a more economical and environmentally sustainable alternative to excavation, thermal treatment, or off-site soil disposal by landfilling. The presentation will illustrate how specific type of amendments selected based on soil/contaminant type can increase contaminant destruction rates versus traditional biostimulation techniques.

**Approach/Activities.** The use of various soil additives including specialized bacteria, surfactants, nutrients, and organic amendments can be evaluated at bench- or pilot-scale level to promote more rapid and complete destruction of the targeted contaminants either using aerobic or anaerobic pathway. Completion of properly designed bench- or pilot-scale testing increases the probability of effective full-scale treatment and attainment of the remedial objectives. Proper design parameters and post-application monitoring will be discussed as these are the critical key factors for successful management of ex situ or in situ bio-stimulation. The soil amendments are typically applied at low dosages and result in very little or no increase in soil volume following treatment. Over the last 25 years, bioremediation in Canada has been used successfully for in situ and ex situ treatment of soils contaminated with a broad range of chlorinated and non-chlorinated recalcitrant compounds despite limitations imposed by Canada's cold climate.

**Results/Lessons Learned.** Detailed results from representative bench-scale testing and completed full-scale projects in Quebec, Ontario, and Alberta will be presented. Contaminants treated include chlorinated pesticides (DDT, Dieldrin) and herbicides (bromacil), pentachlorophenol, and PAHs. Performance and cost information will be reviewed. The full-scale project results will be used to illustrate attainable removal efficiencies as well as recognized limitations to this type of soil remediation.