# In Situ Chemical Reduction (ISCR) for Removal of Persistent Pesticides; focus on kepone in tropical soils

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**Background/Objectives.** The global use of organochlorine pesticides (OCPs) such as Lindane, DDT, Dieldrin, Kepone, Chlordane and Toxaphene has resulted in long-term soil impacts at many sites. Given the potential risks to human health and the environment, some OCP-impacted sites require treatment. In certain cases, the "dig-and-dump" approach is not practical due to magnitude of the problem, access issues, and/or resource constraints. Here "bioremediation" can be used to treat the soil on site, often at lower costs, and certainly with lower generation of greenhouse gases. Unfortunately, most OCPs are not amenable to conventional bioremediation technologies hence they persist over time.

**Approach/Activities.** DARAMEND® *in situ* chemical reduction (ISCR) technology uniquely combines controlled-release carbon with a reduced metal such - as zero valent iron (ZVI) or zinc - to yield a highly effective material for stimulating the complete degradation (no accumulation of catabolic intermediates) of persistent organic compounds present in soil, sediment and groundwater. The term ISCR is used to define the combined effects of stimulated biological oxygen consumption (via "fermentation" of complex organic carbon sources), direct chemical reduction with reduced metals, and the corresponding enhanced decomposition reactions that are realized at the lowered redox ($E_h$) conditions. In brief, the ZVI oxidizes to form ferrous iron and releases electrons in the process. The organic carbon is consumed by microorganisms that are indigenous to the soil, resulting in release of additional free electrons. These electrons transferred to the OCPs result in the removal of chlorine from the compound's structure (reductive dechlorination); ultimately, complete destruction of the pesticides occurs. Most soils can be effectively treated in a reasonable time frame (*e.g.*, from 4 to 8 weeks) using standard agricultural machinery at a price typically less than US$20 per tonne of soil treated.

**Results/Lessons Learned.** The presentation will summarize the ISCR theory followed by case studies in the United States, Brazil and Europe. Particular emphasis will be placed on the removal of OCPs from soil at sites in Canada (34 acres impacted by DDT, DDD, and DDE) and the Caribbean (French West Indies, Kepone impacted soils – technology validation tests). For Kepone, bench-scale studies demonstrated rapid (< 2 weeks) and extensive degradation: catabolites with up to 7 Cl removed were identified by GC/MS. Mesocosm (scale-up) studies with tropical soils determined that soil type had a significant impact on process efficacy. Ecotoxicity tests and bioaccumulation studies were also considered in the evaluation of the process. Recognized technology development needs include insight into catabolite environmental fate/affect. Significant advances in the biogeochemistry of OCP degradation are anticipated from basic research on microbiology and genetics of ISCR processes.

**Proposed Session:** Bioremediation Technologies: Lessons Learned; Degradation Pathways

**Platform Requested**

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