DARAMEND® technology for in situ bioremediation of soil containing organochlorine pesticides

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Introduction

DARAMEND® is an innovative technology for bioremediation of soils and sediments contaminated with a variety of organic pollutants. DARAMEND® was originally developed to provide a low-cost, highly effective means of remediating polycyclic aromatic hydrocarbon and pentachlorophenol (PAH/PCP) contaminated soil at the large number of wood-preserving sites that exist in Canada. Developmental work was initiated in 1988 and completed in 1992. Since that time, DARAMEND® technology has been modified to enable effective treatment of soils containing chlorinated and nitroaromatic compounds. DARAMEND® has been demonstrated to be an effective treatment approach for soil containing organochlorine pesticides and herbicides and chlorinated phenols (including pentachlorophenol - PCP) and benzenes (including hexachlorobenzene - HCB). DARAMEND® technology has been successfully implemented at industrial sites in the United States and Canada. Recently, several leading remediation contractors have entered into license agreements with Grace that enable them to use DARAMEND® bioremediation for treatment of soils at sites in the United States and Canada, and other regions worldwide.

The technology

DARAMEND® technology is unique in that soil-specific, solid-phase organic amendments are used to increase the activity and survival rate of indigenous contaminant-degrading microorganisms. DARAMEND® bioremediation can be applied to higher contaminant concentrations and will result in greater contaminant destruction at a lower cost than competing technologies. The initial development of DARAMEND® technology, for treatment of PAH/PCP contaminated soils, involved aerobic application of DARAMEND® amendments to soil. For treatment of organochlorine pesticides, a second generation technology was developed, based on imposition of sequential (cycled) oxic and anoxic conditions enhanced by proprietary non-hazardous soil amendments. Strong reducing (anoxic) conditions are created through addition of DARAMEND® amendments in combination with inorganic amendments (multivalent metals) and water. DARAMEND® amendments stimulate the biological depletion of oxygen within the soil matrix. Oxygen depletion is assisted by oxygen scavenging by the metals, and diffusion of replacement oxygen is prevented by near saturation of soil pores with water. The resulting very low redox potential (as low as -800mV) promotes dechlorination of organochlorine compounds. Intermediary metabolites of degradation are removed during subsequent aerobic (oxic) cycles, introduced by the passive air-drying of the soil and tillage to promote aeration.

Application of DARAMEND® technology

Laboratory feasibility studies using soils containing Metolachlor®, 2,4-D and 2,4,5-T and chlorinated pesticides (including DDT, DDD, DDE, Dieldrin, Lindane, Toxaphene® and Chlordane®) have been successfully completed. Several large field demonstration projects have also been completed.

Results of a laboratory feasibility study using soil from a former Lindane production site in Kentucky, USA are shown in Figure 1. The initial total concentration of hexachlorocyclohexane (HCH) isomers was 4,122 mg/kg. The Lindane concentration in the soil was 95 mg/kg. Lindane concentrations in the soil were reduced to 5 mg/kg during 251 days (15 cycles) of treatment, a reduction of 95%. Analysis for other isomers of hexachlorocyclohexane revealed 92% removal of all isomers during the same time period (data not shown).

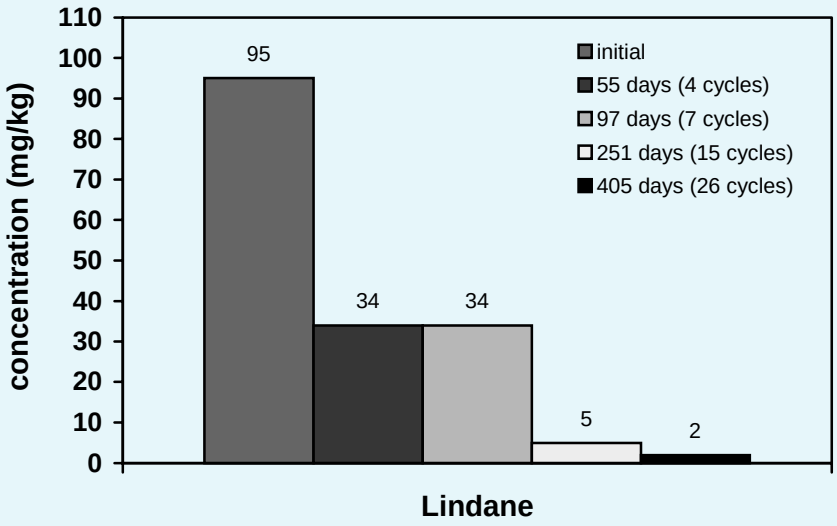

Figure 1. Lindane removal during bench scale treatment of soil containing HCHs from Kentucky, USA

In another laboratory feasibility study using soil from Michigan containing hexachlorobenzene (HCB), over 76% removal of HCB was achieved during 70 days (10 cycles) of treatment (Figure 2). The HCB concentration was reduced from 27 mg/kg to 6 mg/kg.

Successful completion of several field scale projects for treatment of chlorinated herbicides and pesticides has established the effectiveness of DARAMEND® technology. In two separate field demonstrations in Ontario, Canada, DARAMEND® bioremediation was applied for remediation of sites containing herbicides (Figure 3). Concentrations of 2,4-D, 2,4,5-T and Metolachlor® were reduced by 98%, 89% and 97%, respectively, resulting in residual concentrations of 5 mg/kg or lower.

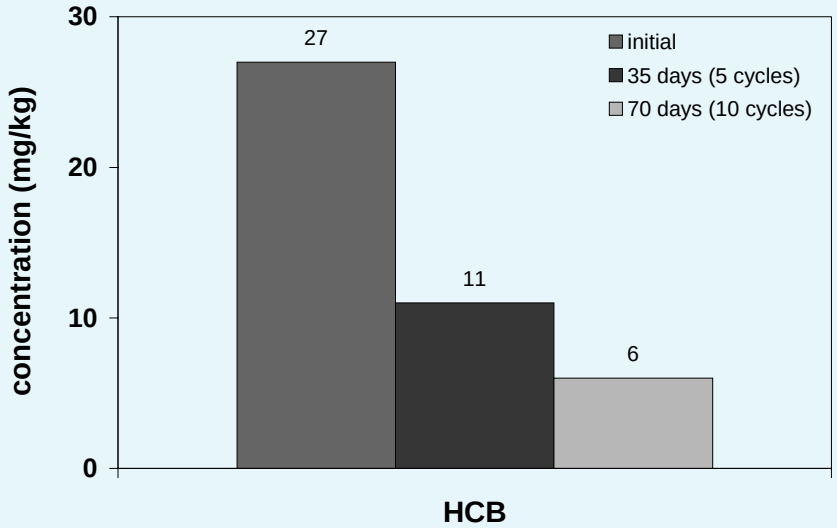

Figure 2. HCB removal during bench scale treatment of soil from Michigan, USA

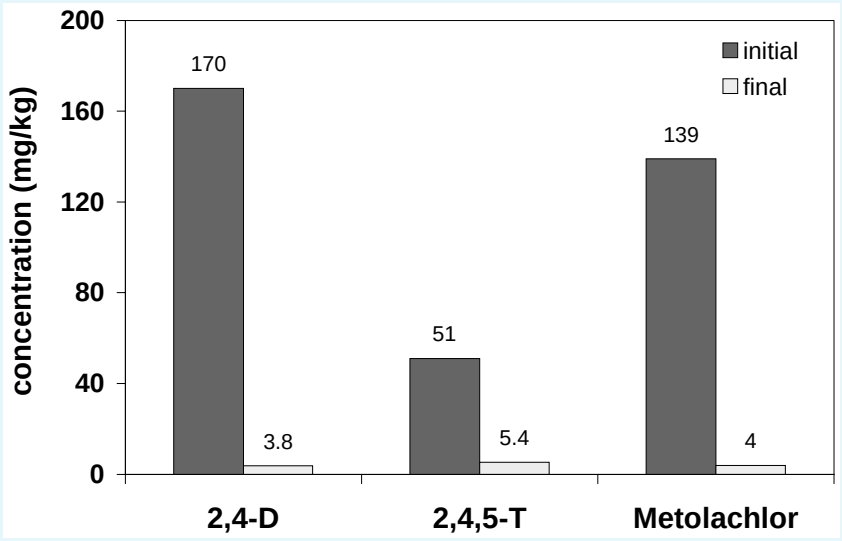

Figure 3. Herbicide removal during field scale treatment of soil from Ontario, Canada

Two highly successful field scale projects for the treatment of soil containing Toxaphene® and DDT have been completed in the Southeastern USA (South Carolina and Alabama). In the first, 98% removal of Toxaphene® was observed, resulting in a final concentration of 5 mg/kg after 8 cycles of treatment (Figure 4). DDT was reduced by 82% to a final concentration of 16 mg/kg during the same period of treatment. In the second field scale project, Toxaphene® and DDT concentrations were reduced by 96% and 89%, respectively, after 12 cycles of treatment (Figure 5). DDT concentrations were reduced from 164 mg/kg to 18 mg/kg with nearly no accumulation of DDD and/or DDE.

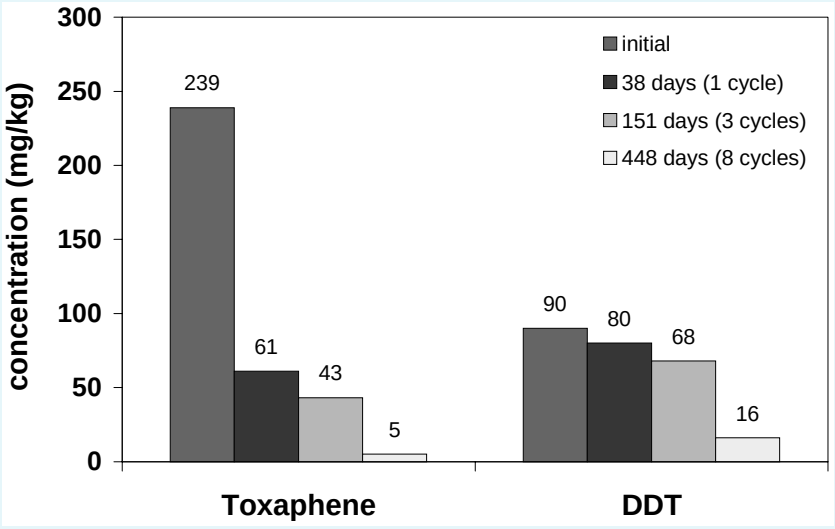

Figure 4. Toxaphene and DDT removal during field scale treatment of soil from South Carolina, USA

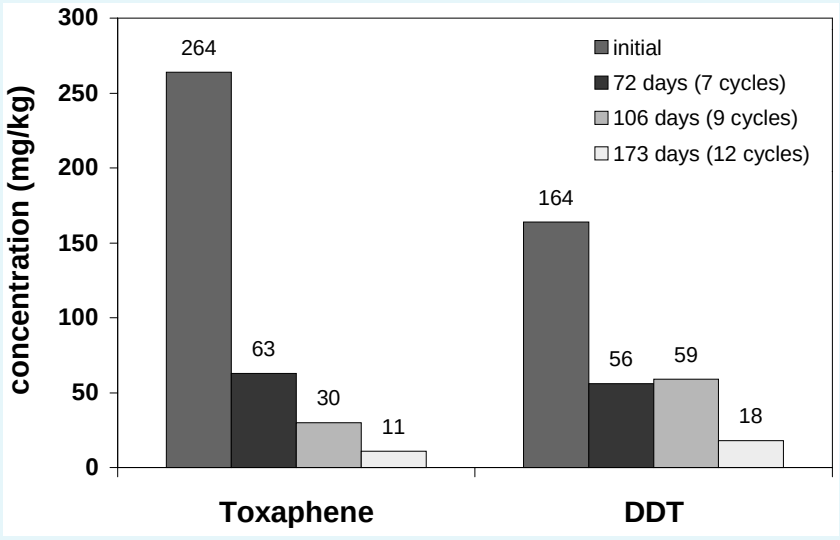

Figure 5. Toxaphene and DDT removal during field scale treatment of soil from Alabama, USA

Summary

DARAMEND® technology has been proven effective for solid-phase *in situ* or *ex situ* removal of chlorinated organic compounds from soil.

Compounds effectively removed during soil bioremediation feasilbility studies and field scale demonstrations include organochlorine herbicides (2,4-D, 2,4,5-T, Metolachlor®) and pesticides (Lindane, HCB, DDT, Toxaphene®).

Grace has recently entered into license agreements with several leading remediation contractors and is seeking new partners in countries where inexpensive, effective remediation technologies are being sought.