

Green Technology Bioremediation of Pesticides in Soil at Large Scale

Biodégradation de DDT and d'Autres Pesticides en Sol à Grande Échelle

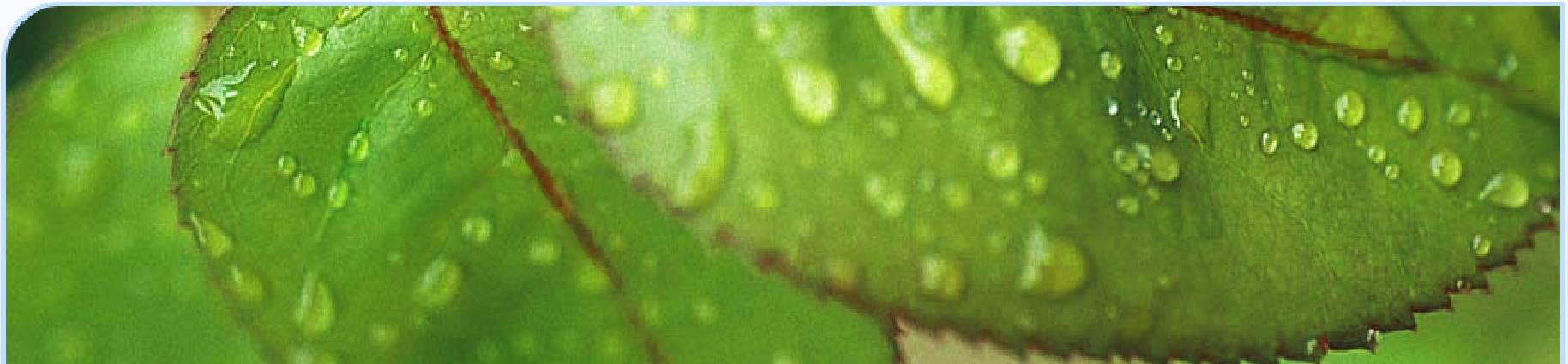
INTERSOL 2009

Paris, France

March 24, 2009

Alan Seech, Michael Mueller, and David Hill
(Dr. James Mueller presenting)

Adventus Europe





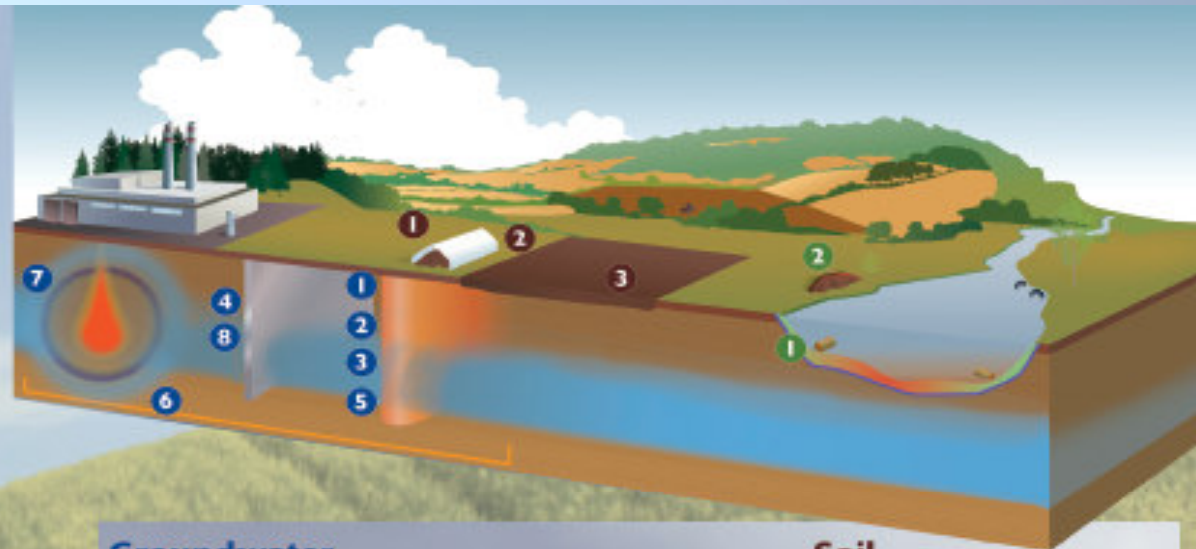
Overview

- ❖ DARAMEND[®] and ISCR technology concepts
- ❖ Key steps toward implementation
- ❖ Case studies, including performance and treatment costs
- ❖ Conclusions
- ❖ Next steps



Adventus' Remedial Technologies Portfolio

The Adventus Group provides the environmental remediation industry with a portfolio of innovative proprietary Soil, Sediment, and Groundwater remediation solutions and other technologies shown here. Contact us today to arrange a complementary Technology Transfer Session, or Site Evaluation.



Groundwater

In Situ Chemical Reduction (ISCR) Technologies

- ① EHC® injectable controlled release carbon plus ZVI
- ② EHC®-A injectable aqueous treatment of chlorinated compounds
- ③ EHC®-M injectable immobilization of heavy metals
- ④ ZVI PRBs patent holding innovators

Other Groundwater Solutions

- ⑤ EHC-O™ injectable controlled release oxygen compound with nutrients
- ⑥ mGCW™ reactive groundwater circulation wells
- ⑦ ISGS™ *In Situ* Geochemical Stabilization for sources zones / flux reduction
- ⑧ ZVI-Clay *In Situ* treatment of DNAPL source zones

- A-SOX™ anaerobic biodegradation in ground water wells
- O-SOX™ aerobic biodegradation in ground water wells
- HolePlug+™ reactive sealant
- Modeling Services for optimization of remedial designs and strategies

Soil

In Situ, Ex Situ, Land Farming and Soil Vapor Pathway Technologies

- ① DARAMEND®
- ② DARAMEND®-M
- ③ TERRAMEND®

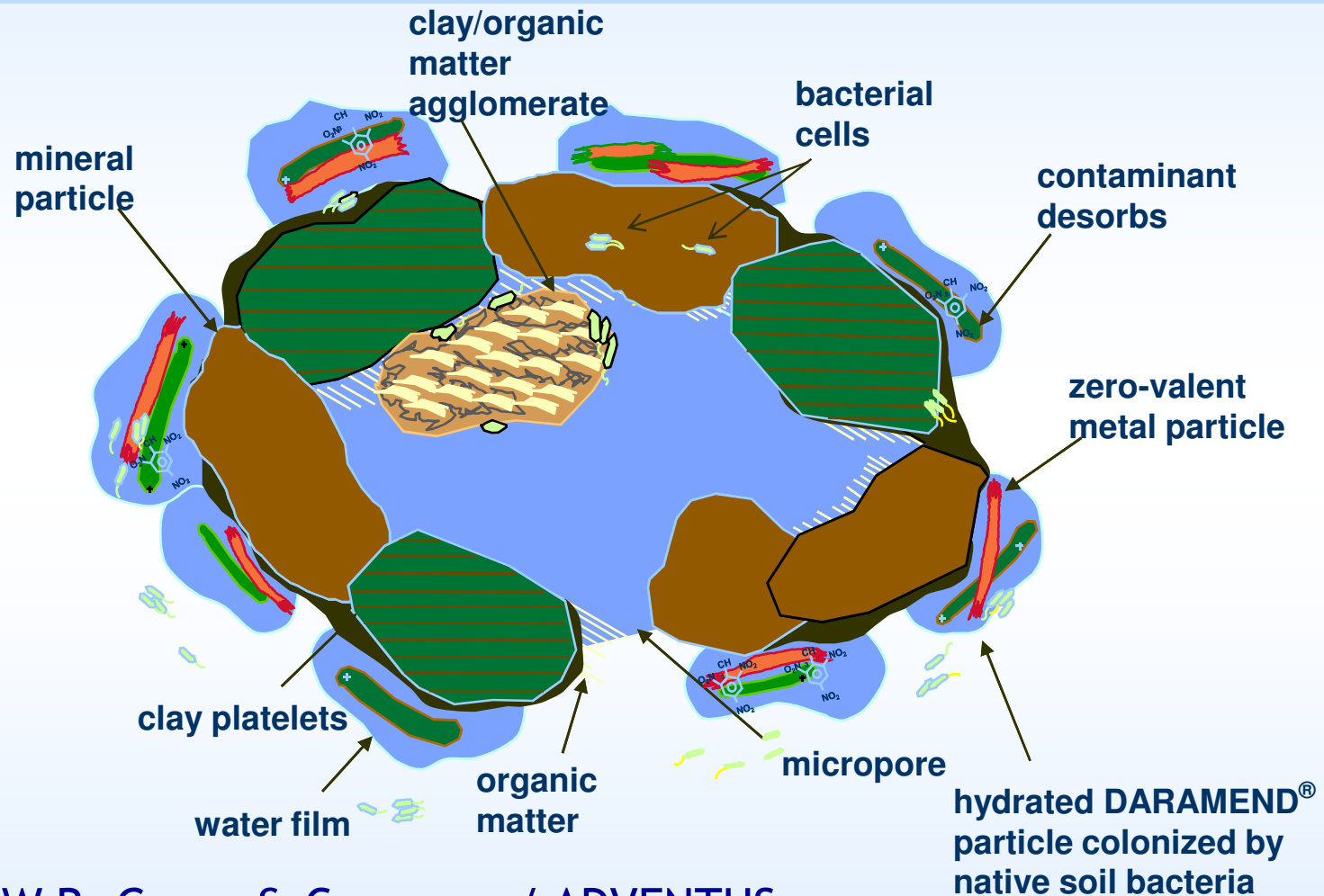
Sediment

In Situ Capping and Treatment Technologies

- ① AquaBlok+™
- ② DARAMEND®



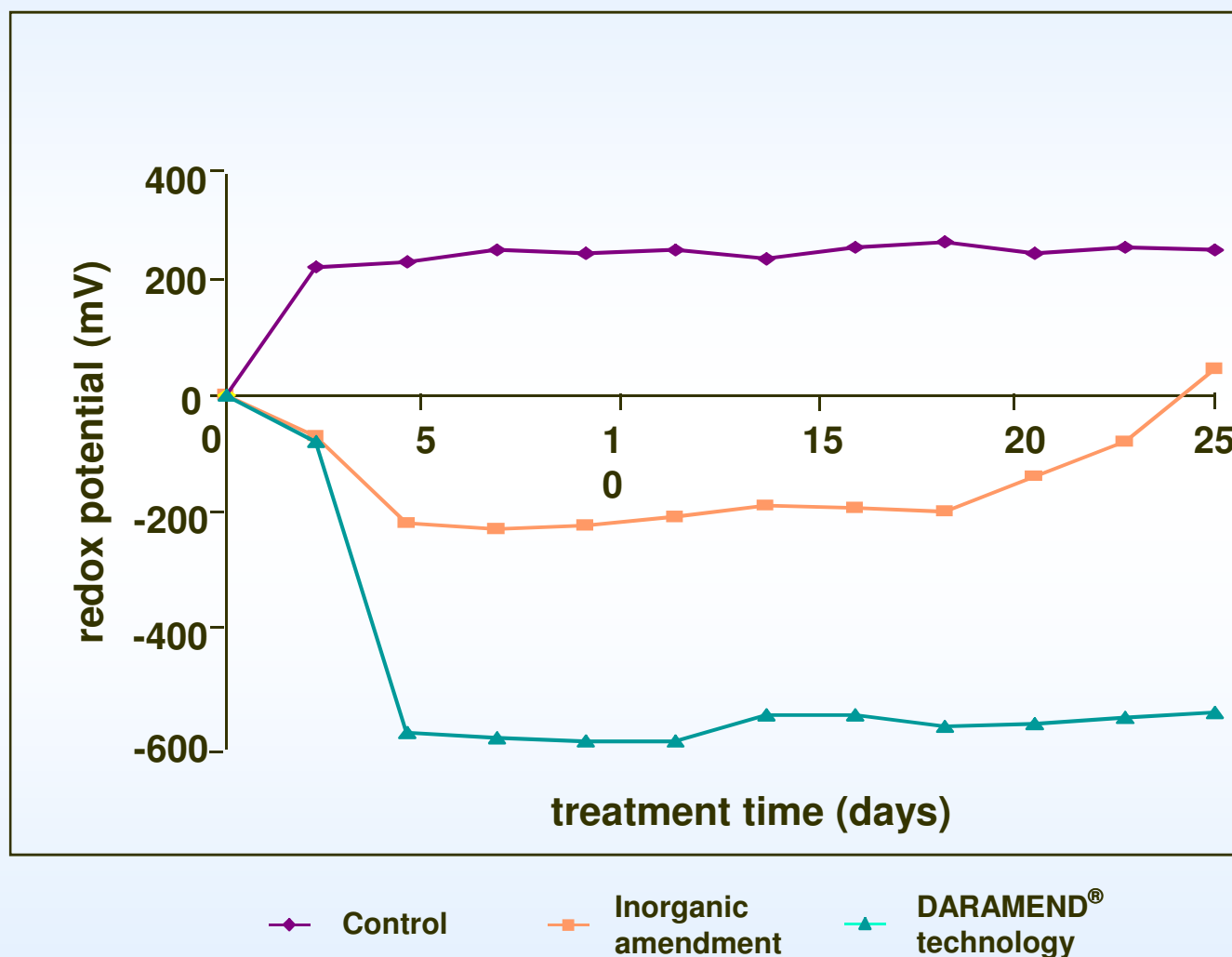
Reductive DARAMEND[®] Bioremediation



US Patents W.R. Grace & Company / ADVENTUS



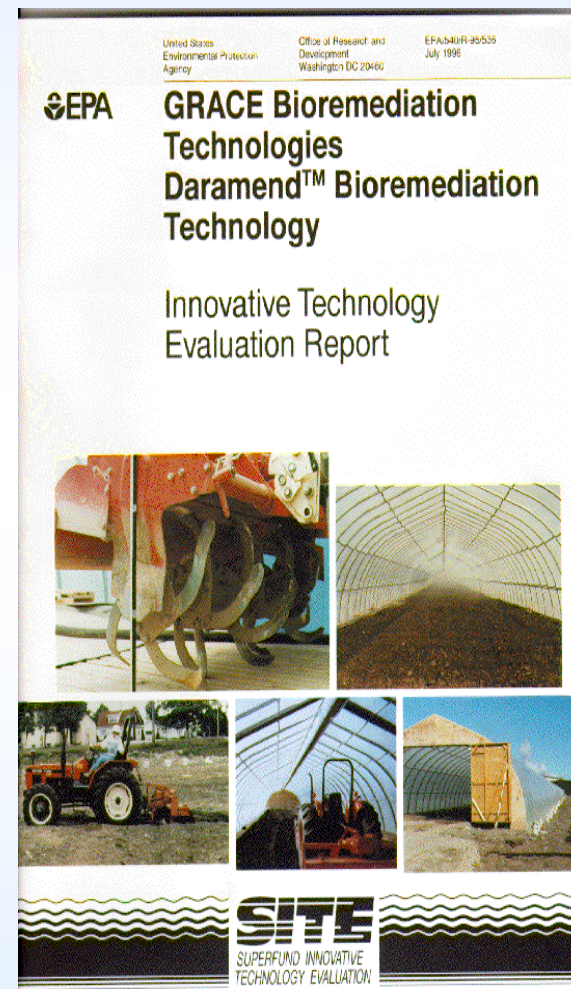
Influence of DARAMEND® Technology on Redox Potential in Soil during Reductive Phase





DARAMEND® Soil Amendment

- ❖ Particles combining solid controlled-release carbon and nutrients (aerobic) or also with micro-scale ZVI (anaerobic)
- ❖ Organic carbon often by-product of other processes
- ❖ ZVI often a clean, recycled material
- ❖ Stimulates indigenous bacteria by providing carbon and nutrients
- ❖ < 5% by volume required to treat most soils
- ❖ Has been used to treat 5,000,000 metric tonnes of contaminated soils





Principles of Reductive DARAMEND® Bioremediation

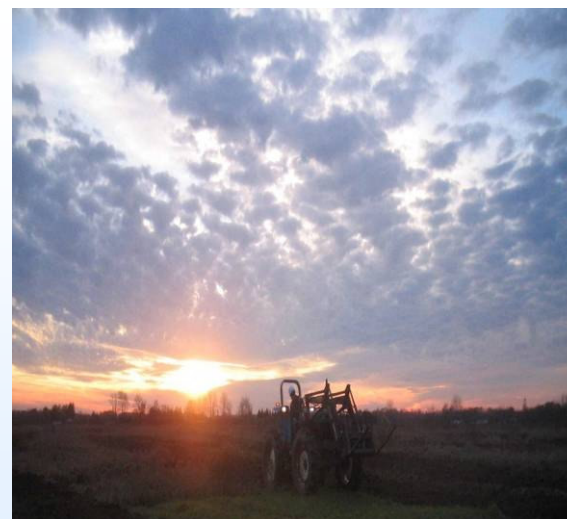
- ❖ Chlorinated organic pesticides are not amenable to aerobic treatment.
- ❖ Cycled treatment involving generation of repeated and sequential anaerobic/aerobic conditions developed.
- ❖ Strong reducing conditions generated during anaerobic phase through application of:
 - DARAMEND organic amendments,
 - Combined with zero-valent iron (ZVI)





DARAMEND Treatment of Pesticides in Soil: Origin of ISCR

- ❖ Need to remediate brownfields and greenfields for community development purposes
- ❖ Agricultural land often impacted specifically with organochlorine pesticides such as DDT, DDE, DDD, Dieldrin, Toxaphene etc.
- ❖ Recalcitrant compounds persistent in the environment





DARAMEND Technology Applications

Aerobic

- ❖ wood treatment chemicals (PAHs & PCP)
- ❖ manufactured gas plant PAHs
- ❖ phthalates

Cycled Anaerobic/Aerobic

- ❖ chlorinated pesticides and herbicides
- ❖ organic explosives
- ❖ chlorinated solvents





Case Study 1 - Pesticides Treatment, Ontario, Canada (2007)





Case Study 1 - Site Overview

Case Description

Location

Ontario , Canada

Type of Site

Future Residential Development Site

Description of Impacts

Dieldrin, DDT and DDE residual concentrations above residential standards .

Objective and Approach

DARAMEND implementation for treatment of organochlorine pesticides via ISCR



Site Overview

- ❖ A total of approximately 14 hectares of land exceeded the standards on this 100-hectare site.
- ❖ Pilot study using DARAMEND was completed on a one-hectare plot in 2006.
- ❖ Full-scale remediation of an additional 13 hectares of soil in completed in September 2007.





Key Steps for pesticides treatment using DARAMEND (ISCR)

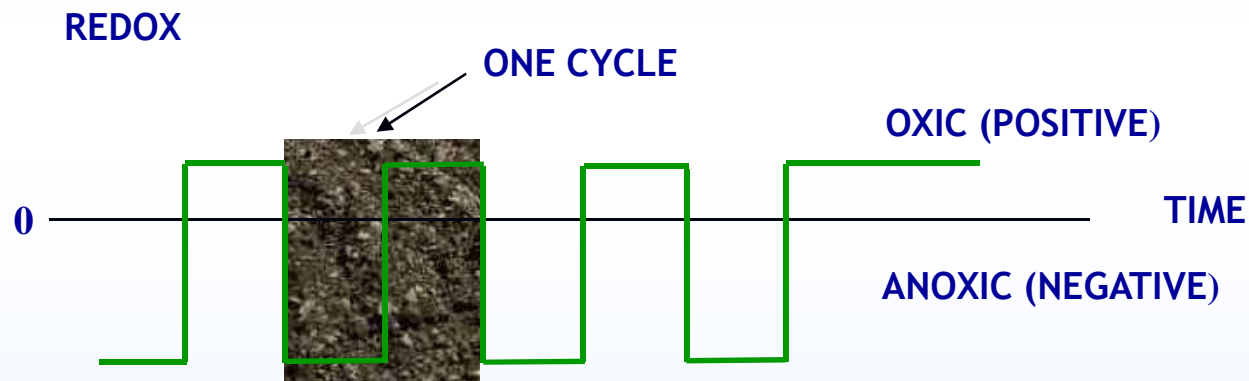
1. DARAMEND is spread evenly onto the soil.
2. Soil tilled using specialized rotary tiller to mix amendment thoroughly, and break up cohesive soil.
3. Water is added to reach 90% of the soil's water holding capacity to drive the ORP strongly negative.
4. After a period of at least five days, soil is tilled to create aerobic (oxidizing) conditions.
5. Process is repeated as necessary until treatment target achieved.





ORP Cycling

- ❖ Cycling between reductive and oxidative phases
- ❖ Amendment composition and dosage are site specific





ISCR Treatment of Pesticides in Soil - Step 1





ISCR Treatment of Pesticides in Soil - Step 2





ISCR Treatment of Pesticides in Soil - Step 3





Average Data for Areas Treated after One Treatment Cycle

Constituent	Initial Concentration (mg/kg)	Concentration After 1st Cycle (mg/kg)	Final % Removal
DDT	1.90	0.98	49%
DDE	2.38	1.11	53%
Dieldrin	0.064	0.040	38%



Average Data for Areas Treated after Two Treatment Cycles

Constituent	Initial Concentration (mg/kg)	Concentration After 1 st Cycle (mg/kg)	Concentration After 2 nd Cycle (mg/kg)	Final % Removal
DDT	2.05	2	0.66	68%
DDE	2.37	1.98	0.8	66%
Dieldrin	0.11	0.08	0.028	65%



Performance and treatment costs

- ❖ The remedial standards were met for 100% of the plots after two cycles, within a period of four months.
- ❖ The guaranteed fixed-price cost of this turn-key project was less than US\$87,000 per hectare (less than \$24 per tonne).
- ❖ Significant cost savings when compared to theoretical cost of dig and dump of \$110/tonne.
- ❖ Estimated 93% lower carbon footprint compared to “dig, dump, haul, back-fill” option.



Case Study 2- Site Overview

Case Description

Location	Jupiter , Florida
Type of Site	Future Residential Development Site
Description of Impacts	Dieldrin and chlordane residual concentrations above residential standards in 2,400 tonnes of soil
Objective and Approach	Daramend implementation for treatment of organochlorine pesticides via ISCR



Treatment Protocol

- ❖ Applied and incorporated 0.5% (w/w) DARAMEND amendments per cycle.
- ❖ Irrigate amended soil to 90% of soil water holding capacity (approx. 30% moisture on a dry weight basis).
- ❖ Allow to stand undisturbed for about 7 days (variable dependent on weather).
- ❖ Aerate by tilling for 2 or 3 days.
- ❖ Repeated for 2 cycles.





DARAMEND Treatment of Pesticide Impacted Soil





DARAMEND Treatment of Pesticide Impacted Soil





DARAMEND Treatment of Pesticide Impacted Soil





DARAMEND Treatment of Pesticide Impacted Soil





Results (North Plot)

Compound	Concentration ($\mu\text{g/kg}$)		RDE (%) ¹
	Initial	Final	
<i>Dieldrin</i>	43.4	18.7	57
<i>α-Chlordane</i>	7.3	3.9	49
<i>γ-Chlordane</i>	13.3	2.7	80
Total COC ²	64.0	25.3	60

¹ Removal and Destruction Efficiency

² Contaminants of Concern



Results (South Plot)

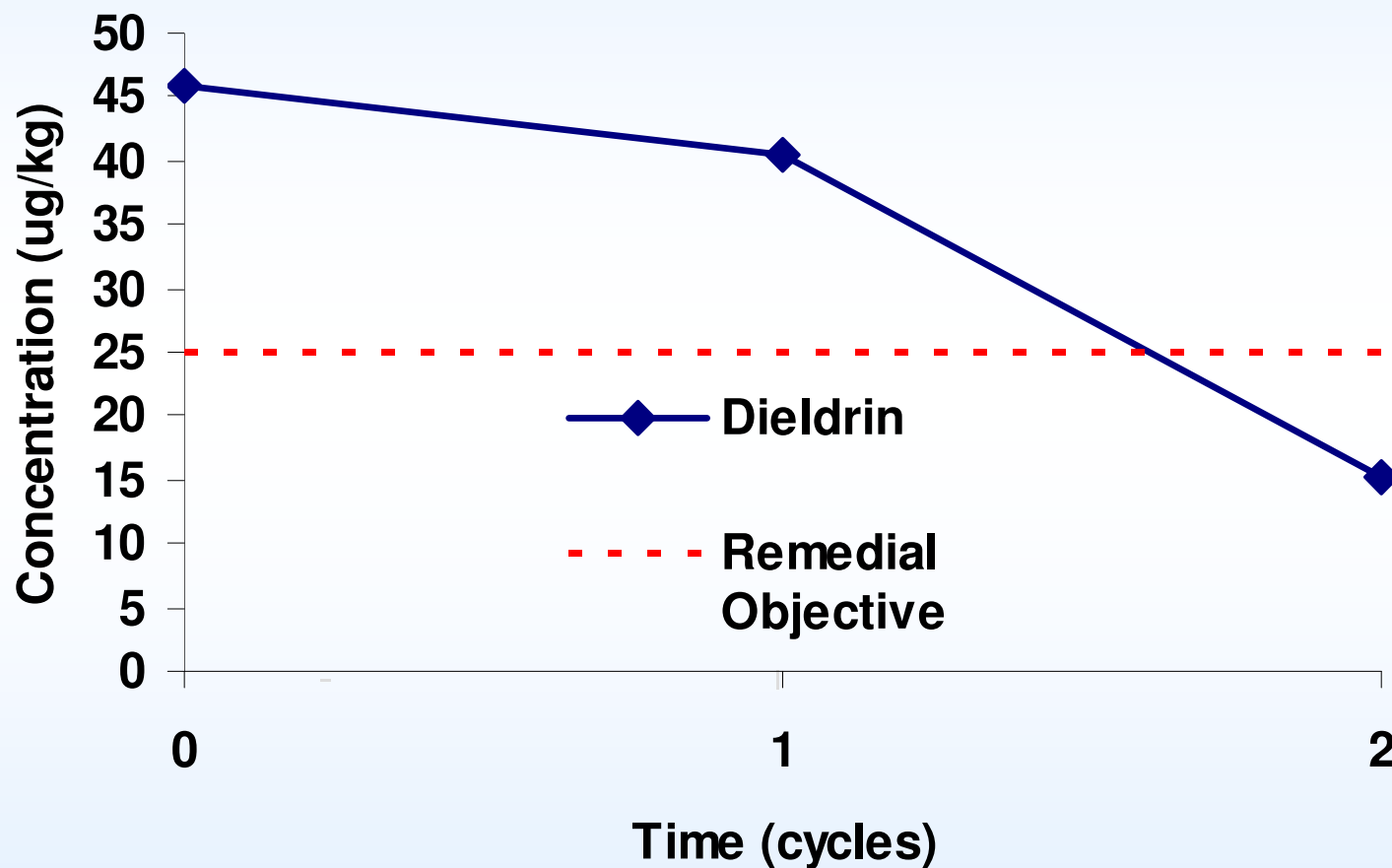
Compound	Concentration (µg/kg)		RDE (%) ¹
	Initial	Final	
<i>Dieldrin</i>	48.4	11.6	76
<i>α-Chlordane</i>	8.5	4.1	51
<i>γ-Chlordane</i>	13.9	4.1	71
Total COC ²	70.8	19.8	72

¹ Removal and Destruction Efficiency

² Contaminants of Concern



Results for Dieldrin - Average of both plots





Conclusions

- ❖ DARAMEND successfully reduced the concentrations of all target compounds to less than the performance standards
- ❖ Treatment was completed within a reasonable timeframe (2-3 weeks)
- ❖ Treatment cost was approximately \$16.50 per cubic meter, or \$10.50 per ton
- ❖ Significantly lower carbon footprint and fertile top-soil remained on-site
- ❖ SOIL IS A RESOURCE TO CONSERVE



Advantages of ISCR

- ❖ Unique physical , chemical and biological processes for enhanced reduction of pesticides.
- ❖ The ISCR approach resulted in significant cost savings compared to the dig and dump estimate.
- ❖ Treated over 5,000,000 metric tonnes to date, globally.
- ❖ Technology is applied widely to a variety of contaminants including pesticides, herbicides, explosives , PCPs and PAHs.
- ❖ Treatment method is environmentally sound in terms of treatment space used, energy consumed and resources utilized.





Risk Sharing

ADVENTUS offers performance-based contracts, to help Project Managers achieve their clean-up goals.

Our risk-sharing with you comes in two primary forms:

1. Soil Remediation “Performance Guarantees”:

- DARAMEND® and TERRAMEND® have been used to successfully treat over 5,000,000 metric tons of soils, sediments and sludge.

2. Groundwater Remediation “Performance Warranties”:

- EHC®, EHC® -M and EHC-O® have been used to successfully treat millions of gallons of impacted groundwater globally.





Consider us for a free Conceptual Design Forms at: www.adventusgroup.com/site_eval.shtml

The screenshot shows the Adventus website interface. At the top, there is a navigation bar with links: home | contact us | media center | international. Below this is the Adventus logo and a Google Custom Search bar. A dark green navigation menu contains links: Home, About Us, Solutions, Products, Projects, Library, ISCR Blog, Contractors, and Contact Us. The main content area is titled 'resources : site evaluation forms' and features a section 'Request a Site Evaluation'. This section contains a paragraph about Adventus's expertise in soil, sediment, and groundwater remediation. Below this is a 'Desired Remedial Approach' section with a paragraph asking users to select a scenario. A bulleted list follows, detailing various remediation technologies such as mGCW™, EHC-O®, O-Sox™, EHC®, EHC-A®, Granular Iron PRBs, ZVI-Clay, EHC-M®, AquaBlok+™, TERRAMEND®, DARAMEND®, and ISGS™. At the bottom of the form area, a note states: 'If you have any general questions or are not sure which template to use, please [contact Adventus](#) for assistance.'

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resources : site evaluation forms

Request a Site Evaluation

Adventus soil, sediment and groundwater remediation experts stand ready to offer you unbiased technical advice, and proposal preparation. Please take a moment to supply us with the appropriate site information via the form(s) below, and an experienced team of engineers, geologists, chemists and scientists will provide a complimentary Conceptual Design. With more than 100 years of combined practical experience, our team of qualified professionals is eager to help you solve your remediation challenges.

Desired Remedial Approach

Please select the general scenario that best suits your situation, and choose one of these options to input the basic site information we need to provide an initial evaluation. Once your information is received, an Adventus representative will quickly be in touch to serve as a point of contact, and answer any initial questions you may have.

- [Impacted Groundwater](#): Circulation Well treatment (mGCW™)
- [Impacted Groundwater](#): Aerobic Bioremediation (EHC-O®, O-Sox™)
- [Impacted Groundwater](#): ISCR Anaerobic Bioremediation (EHC®, EHC-A®)
- [Impacted Groundwater](#): Granular Iron PRBs for VOCs
- [Impacted Groundwater](#): ZVI-Clay treatment of VOCs and DNAPL source zones
- [Heavy Metals Impacted Groundwater](#): Anaerobic Bioremediation (EHC-M®)
- [Impacted Sediments](#): Anaerobic horizontal PRB Bioremediation (AquaBlok+™)
- [Impacted Soils](#): Aerobic and ISCR Anaerobic Bioremediation (TERRAMEND® & DARAMEND®)
- [Organic Fertilizer](#): Elimination of chemical residues in soils
- [NAPL Stabilization](#): *In Situ* Geochemical Stabilization (ISGS™)

If you have any general questions or are not sure which template to use, please [contact Adventus](#) for assistance.



Questions Are Always Welcomed ...

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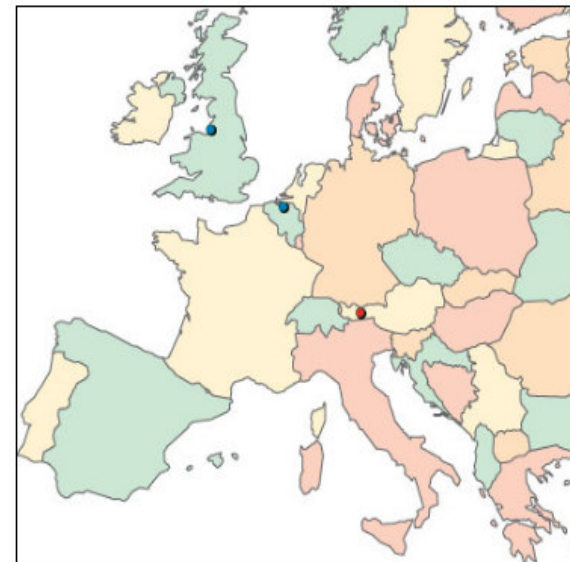
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