

Bioremediation of Soils Containing Organic Explosive Compounds Using ZVI/Organic Carbon Reagents

John Valkenburg (John.Valkenburg@Evonik.com) and Alan Seech (Evonik Corporation, Parsippany, NJ, USA)

Introduction. The manufacturing and use of organic explosive compounds has resulted in extensive contamination of soil. Over the past 20 years, many of these soils have been successfully remediated using in situ chemical reduction by amending soil with reagents composed of zero valent iron, processed plant fiber, and a food-grade emulsifying agent. The reagents, offered by Evonik under the tradename Daramend[®], promote chemical and biological processes that stimulate reduction of nitro groups on organic explosive compounds. This iron/carbon-based approach to remediation results in destruction of the targeted contaminants, rather than their immobilization, and has enabled reliable attainment of both industrial and residential land use standards. It provides an environmentally sustainable, green alternative to excavation and off-site soil disposal and is now regarded as a thoroughly proven remediation method.

Treatment has been conducted both in situ on surface soil (0 to 24 inches bgs), and ex situ in HDPE-lined treatment cells or soil piles. The ZVI/organic carbon approach has proven broadly effective in treatment of organic explosive compounds including TNT, DNT, amino-nitrotoluenes, RDX, HMX, and tetryl.

Objectives. The presentation will illustrate how changes in soil chemistry and microbiology following addition of the iron/carbon reagents promote destruction of the targeted compounds. Findings from bench-scale testing and full-scale projects will be presented and discussed from the perspectives of performance and cost. Case studies will be used to illustrate attainable removal efficiency as well as limitations to treatment using the ZVI/organic carbon approach. The presentation will include short case studies with performance and cost data from successful large-scale applications of this approach at US Army and US Navy sites.

Performance Data. Representative performance data from full-scale in-situ Daramend[®] treatment of soil at site used for munitions storage in Utah is presented in **Table 1**. Treatment was conducted ex situ indoors in windrows. The project enabled soil TNT and RDX concentrations to be reduced to below site remedial goals, which were protective of local area drinking water resources. Cost analysis indicated that this treatment approach saved over \$4 million relative to conventional composting, which had originally been selected as the preferred remedy. Lessons learned from the work at this site include modification of the reagent application and treatment protocol, enabling reduced labor and equipment input costs, through use of a single larger reagent application and a single soil mixing instead of multiple smaller applications and soil mixing events.

Table 1. Influence of Daramend[®] treatment on soil TNT and RDX concentrations at a military facility in Utah.

Target Compound	Treatment Goal	Initial*	Post Treatment*	One Week Post-Treatment**
	Concentration (mg/kg)			
RDX	31	563	13	6
TNT	86	802	138	7

* Average of six samples

** Average of three samples (re-sample of highest areas)