Enhancing Range Sustainability Through Innovative Technology Application

Michael F. Warminsky, PE
Technical Director
AMEC Earth and Environmental, Inc.
285 Davidson Avenue, Suite 100, Somerset, New Jersey 08873
Phone: (732) 302-9500, ext. 126, E-Mail: mike.warminsky@amec.com

Coauthor:
Richard Sturm
Regional Manager, AMEC Earth and Environmental, Inc.

Introduction

Live fire training is a critical element in our Nations Homeland Defense Program. At small arms ranges, lead in berm soil can pose a threat to the environment. If left unattended, the lead can migrate as a result of erosion due to wind or heavy rain events. In some select locations, it may also dissolve due to environmental conditions and leach into the ground. Similar concerns exist at artillery test ranges where depleted uranium (DU) rounds are fired.

In both cases, the toxicity of the metal used in the projectiles is a concern. A new product, ENCAPCO Emulsions, have been tested at both small arms and artillery ranges to mitigate the metals migration problem with very positive results. The emulsions are a proprietary blend of tall oil or asphalt pitch, surfactants, and chelating agents. In addition to chemically immobilizing the metals, the emulsions microencapsulate the fine grain particles rendering them physically immobile. If applied as routine maintenance, the threat of toxic metal migration is eliminated, allowing for "environmentally friendly" live fire training.

This paper presents an overview of the technology, as well as a series of case studies with lessons learned presented.

Materials

Tar oil pitch and asphalt-based emulsions have been used extensively in the commercial construction industry to stabilize soils for dust control, thereby minimizing their mechanical migration through wind or water erosion. These same emulsions have been modified (and the modifications patented) to encapsulate heavy metals (such as lead, uranium, arsenic and chromium), rendering them resistant to leaching to groundwater and creating a material that reduces infiltration and is resistant to wind and water erosive forces. Chemical theory indicates the technology would also work on heavy organics (PCBs, DDT, etc.).

In July 2000, USEPA issued a determination that use of encapsulation technologies qualifies as recycling for RCRA characteristic wastes, in that permanent chemical bonding is achieved in a commercially useable end product. Treated soils exhibit increased soil strength and can be used as an asphalt base material. The technology is especially applicable for military ranges (lead and DU contamination), military base reuse sites (where treated soils can be used to construct new roads), and other applications. The emulsions can be mixed into the soil and/or applied topically.

The objective of the technology is to provide permanent encapsulation of contaminated soils, where the resultant treated soil exhibits reduced leachability of the contaminant, reduced permeability of the soil surface, and increased soil strength to withstand wind and water erosion. In most cases, the end product can be used as a non-hazardous construction material, road base, or structural fills. On military firing ranges, the soil can be topically treated or, in the absence of UXO, mixed and compacted. Resultant compacted treated soils typically exhibit high strength and low permeability characteristics.

In addition to lead, laboratory testing for the U.S. Army indicates that the technology is extremely effective at stabilizing depleted uranium from munitions. Treatability study results from several sites are presented in subsequent sections. Additional testing also indicates a high potential for success in stabilizing residual uranium daughter products (cesium) from atomic weapons testing.

This patented technology includes improvements over other stabilization technologies. Most previous stabilization technologies do not exhibit "permanent" treatment and are subject to loss of effectiveness under changing

physical or chemical (pH) conditions. Additionally, most stabilization technologies do not work well on a range of inorganic and organic contaminants.

Under current regulations, waste that is recycled and "used in a manner constituting disposal" is exempt from RCRA regulation if the resulting product is produced for the general public's use, it contains recyclable materials that have undergone a chemical reaction so as to become inseparable by physical means, and the product meets LDR treatment standards. (See 40 CFR 266.20 (b).)

USEPA has recognized a process utilizing asphalt and/or plant-based organic emulsions, modified with proprietary and patented chemical formulations, to enhance the structural characteristics of contaminated soil and to chemically fixate hydrocarbon and metal contaminants found therein. The resulting product meets structural specifications for commercial granular and asphalt road base materials. To be permitted under 40 CFR 266.20(b), the resulting product must satisfy the LDR treatment standards pursuant to the appropriate test procedure. The resulting product has been proven to pass these tests.

Discussion

The use of specially modified organic emulsions has proven effective as permanent treatment on lead-contaminated soils in full-scale implementation and on depleted uranium, arsenic, and chromium in laboratory treatability tests. As part of ongoing range remediation projects, AMEC has tested the efficacy of ENCAPCO emulsions in stabilizing residual lead from small arms firing ranges. In all cases, all particulate lead was removed to #10 mesh. The #10 mesh minus material was then treated with varying ratios of either tall oil pitch or asphalt emulsions. Lime was added to enhance particle binding as required, as both structural integrity and leachability were required parameters. In all cases, the resulting Toxicity Characteristic Leaching Procedure (TCLP) results were less then the required 5.0 mg/L for lead. These results are summarized in Table 1.

Potential applications at SAFR's include treating former berms soils to use as a paving/foundation material for a bullet trap retrofit. In addition, the material can be topically applied to the range floor to minimize erosion and migration of lead dust, or lead bearing colloidal fines. The technology has been used in the field to improve road foundation soils at Ft. Hunter-Liggett and to treat lead-affected soils for a CalTrans highway project in Richmond, Calif. For these projects, once soil-specific emulsion design testing was completed, implementation of this technology in the field was done with normal road construction equipment and crews.

For test and/or bombing ranges where depleted uranium projectiles are used, potential uses of the product include topical application to reduce both wind and water erosion, as well as leachability of DU. Under Contract DAAE 30-00-C-1020, dated December 9, 1999, ENCAPCO conducted testing of organic based emulsions for use in stabilizing DU compounds in soil. Oxidized DU fragments were also collected and used to "spike" certain test samples and to test emulsion effects on corrosion rate. Tests were also conducted on soil samples from a catch box at one of the firing lines.

In order to replicate worst-case soil conditions in a highly variable environment, soil samples were spiked with DU corrosion product (oxidized uranium collected from firing lines at Yuma) to a concentration of 20%. This "baseline" condition therefore allowed the tests to start with a consistent and predictable DU concentration from which reductions in DU solubility could be observed. Soil samples were then treated with both asphalt and tall oil pitch emulsions at three different concentrations representative of normal field application rates (4%, 7% and 10% by weight).

After mixing the emulsion into each of the soil samples, leaching tests were performed. Both Inductively Coupled Plasma Mass Spectrometry (ICP) and Alpha Spectroscopy were used to measure soluble DU. Both methods showed a significant reduction in leachability, with the results summarized in the Table 2.

Biological testing was proposed to verify that field use of these modified emulsions would not cause unanticipated effects on wildlife. A "Hazardous Waste Aquatic Screening Test", according to the method adopted by the California Department of Toxic Substances Control, was conducted on background soils (no DU present) treated with asphalt and tall oil based emulsions. All samples treated with 10% concentrations of asphalt and tall oil pitch passed the aquatic toxicity test. In fact, there was no statistical difference in the fish survival rate of treated or untreated soil samples.

Also performed was testing to determine if the emulsions, after application to the land, might generate unacceptable contaminants in subsequent runoff. A section of land was treated with the product as a dust control agent and allowed to cure normally. Distilled water was allowed to run across the surface to a collection point. Approximately, one quart of the run-off was collected and tested for typical NPDES contaminant parameters. These results indicate only normal background levels of the analytes tested.

References

"Stabilization Of Depleted Uranium Contaminated Soils With Organic Based Emulsions", Prepared by ENCAPCO, Contract DAAE 30-00-C-1020, prepared for US Army TACOM/ARDEC/Picatinny Arsenal, Heavy Metals Office

"Technical and Regulatory Guidance for Remediation of Small Arms Firing Ranges", Draft ITRC Small Arms Range Guidance Document, November 2002, prepared by the Interstate Technology Regulatory Council, Small Arms Range Team.

Table1 **SAFR/Treatability Study Results, TCLP mg/L**

Contaminated Site	COC	Untreated Base Material	Treated with Tall Oil Emulsion	4% Lime Only	Tall Oil w/ 4% Lime	Asphalt Emulsion
Dupont - Delaware	Lead	1300	23	350	ND	
US Army - 29 Palms	Lead	300			ND	
US Army - Ft. Ben Harrison	Lead	23	ND			
USAF - Mather AFB	Lead	15				ND
USAF - McDill AFB	Lead	600			ND	
Speakman Foundry - Del.	Lead	13				ND
Vulture Mine - AZ	Lead	90	ND			
Midvale Slag - UT	Lead	130				0.5
	Cadmium	92				ND

Table 2 **DU Treatability Studies**

Spiked Soil Sample	Saturation Period	Alpha Spectroscopy U233 (pC/L)	Alpha Spectroscopy U235 (pC/L)	Alpha Spectroscopy U238 (pC/L)	Mass Spectroscopy DU (ppm)
	Dry				**(a) 160,000**
Untreated Control Soil	7 Days	2,290	0	16,600	61
	27 Days	2,030	245	12,600	29
	47 Days	774	45	4,100	8
Total Solubilized DU				38,684	98
Soil Treated with Tall Oil Pitch Emulsion	7 Days	130	39	97	<0.05
	27 Days	22	27	45	<0.05
	47 Days	46	0	0	<0.05
Total Solubilized DU				406	0

NOTE: (a) (ppm) measured in dry soil. All other (ppm) measurements reflect DU solubilized in water phase.