**Generation of In Situ Biodegradation-Sorption Barriers for Munitions Constituents**

Stewart R. Farling; Jongho Won; Robert C. Borden, PhD, PE (North Carolina State University, Raleigh, NC)

Bilgen Yuncu, PhD (Solutions-IES, Inc., Raleigh, NC)

**Problem**
- High Explosive (HE) residue accumulates in soils at detonation and open burn areas.
- Can be transported into groundwater.
- Limited in soils with high organic content.
- Aerobic conditions not conducive to HE degradation.
- Anaerobic conditions lead to rapid degradation.
- Trinitrotoluene (TNT), Research Demolition Explosive (RDX), and High-Melting Explosive (HMX) sorb to organic material.

**Destruction of column to measure soil TOC**
- Initial column saturation from surface water application.
- Well water applied to surface.
- Initially 1 cm/week.
- Increased to 1.5 cm/1.5 weeks.
- Final increase to 2 cm/2 weeks.
- Treatment added with 5 cm water.

**Increased moisture**
- Final increase to 2 cm/2 weeks.
- Effluent tested for Total Organic Carbon (TOC).

**Proposed Treatment**
- Apply soluble humic matter and organic soluble substrate (SS) to surface.
- Non-toxic/NO fire hazard.
- Create long lasting anaerobic conditions at a depth in soil profile.
- Retraactive and proactive treatment options.
- Sites unaffected.
- Safe and easy application methods.

**Treatment Goals**
- Humic Material Selection (NC State University)
- Preliminary Lab Study: “Proof of Concept” (NCSU)
- Field Site Identification & Characterization (SIES)
- Field Demonstration & Data Analysis (SIES)

**Laboratory Column Studies**
- 4 columns per treatment.
- 2 with TNT/RDX, 2 without.
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- Well water applied to surface.
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**40 cm contaminated**
- 60 cm uncontaminated
- 25 cm Drainage Layer

**Laboratory Column Results**
- TOC concentration increases as soluble glycerin is transported through column; decreases after being flushed out.
- TNT reduction corresponding to TOC Leaching at ~day 120.
- No effect on RDX initially. Difference emerges after ~270 days.
- Perchlorate leached out prior to contact with treatment.
- 2,6-DNT production corresponds to TNT reduction.
- MNX production increases around day 270.

**Laboratory Column Results (continued)**

**Field Demonstration**
- Hand grenade range (RG40) at Ft. Bragg, NC.
- Has been in active use for over twenty years.
- Suction and bucket lysimeters to collect pore water samples, moisture sensors and redox probes were installed at 3, 4 and 5 ft below the soil surface at two grenade bays.
- During the installation, soil samples were collected and analyzed for explosives, perchlorate, TOC, pH, cations, metals and particle size distribution.
- First grenade bay - treated with the humic material/SS amendment.
- Second grenade bay - untreated control.
- HE leaching and attenuation data will be collected 3 months before amendment application and over at least 58 months after application to evaluate field performance and estimate costs for large scale application.
- Collected pore water will be analyzed for explosives, perchlorate, pH, cations, anions, TOC, and metals.

**Acknowledgements**
- The Environmental Security Technology Certification Program (ESTCP) for funding this project.
- Fort Bragg Installation and Ft. Bragg Range Control Officer Wolf W. Amacker for their support.

**Field Site Identification**
- Grenade Bay Trench
- Sampling equipment installation
- Test plots for longevity evaluation.

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**Glycerin**
- Indulin + Glycerin
- Ultrazine + Glycerin
- Indulin
- Ultrazine
- Control

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