

In Situ Chemical Reduction for Organic Explosives in Soil



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Presentation Outline

- Project Background
- Technology Overview - DARAMEND®
- Implementation
- Results
- Degradation and Toxicity
- Summary



Project Background

- Tooele Army Depot (TEAD, Near Salt Lake City)
- TNT Washout Facility (SWMU-10)
- 10,000 CY Soil
- TNT and RDX (up to 2500 and 1000 mg/kg)
- Exposure Pathways
- Treatment Goals
- Selected Remedy



Project Background, cont.





Project Background, cont.

- Project bid in 2007 by MWH
- Plexus Scientific award
- Composting cost and time
- Alternate offered, including pilot
- 2007 work



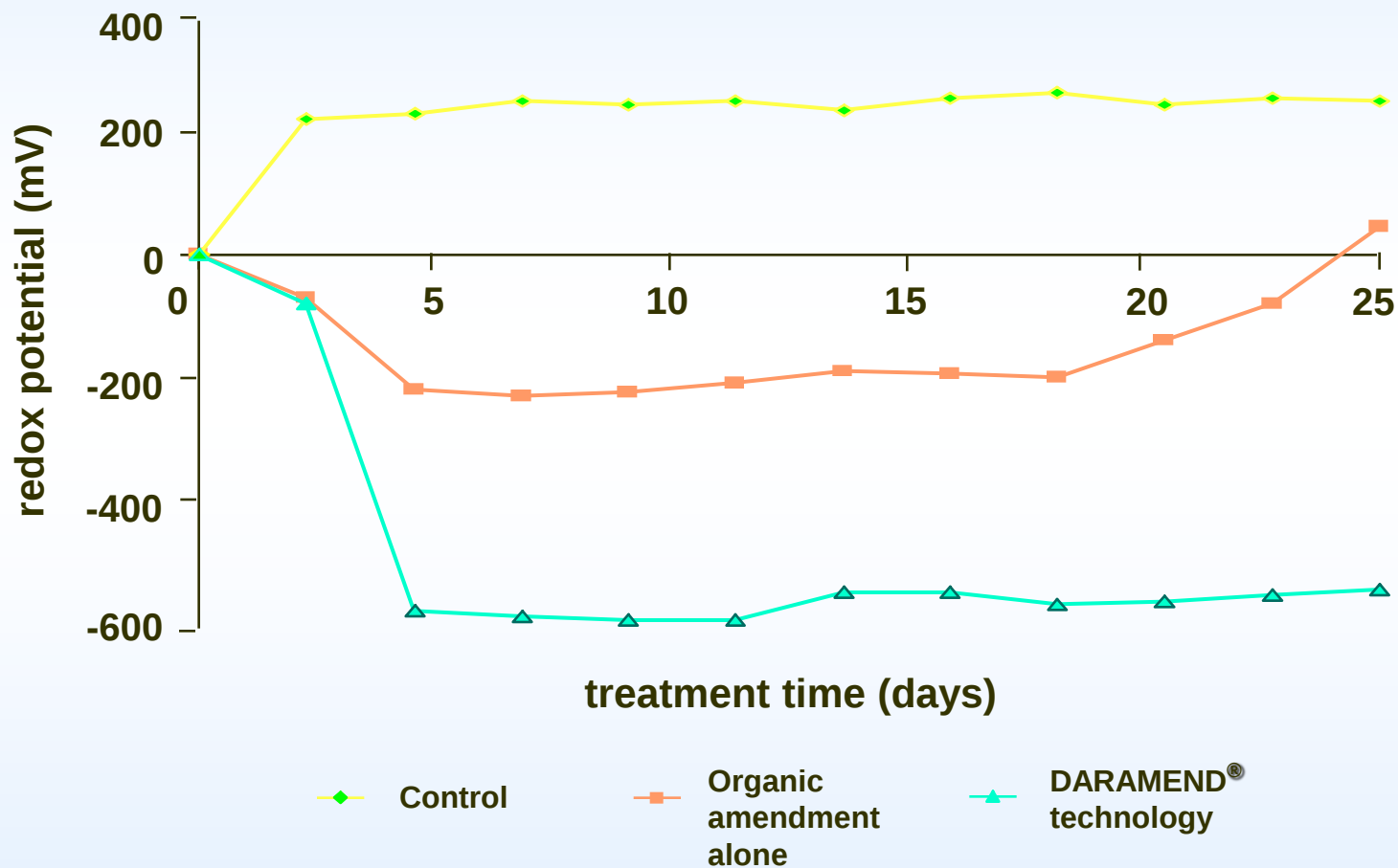
Technology Overview - DARAMEND® Soil Amendment

- Combines solid controlled-release carbon and nutrients (aerobic) or with micro-scale ZVI (anaerobic)
- Stimulates indigenous bacteria by providing carbon and nutrients
- < 5% by weight required to treat most soils
- Treated over 5,000,000 tons of contaminated soils
- Creates ISCR Conditions



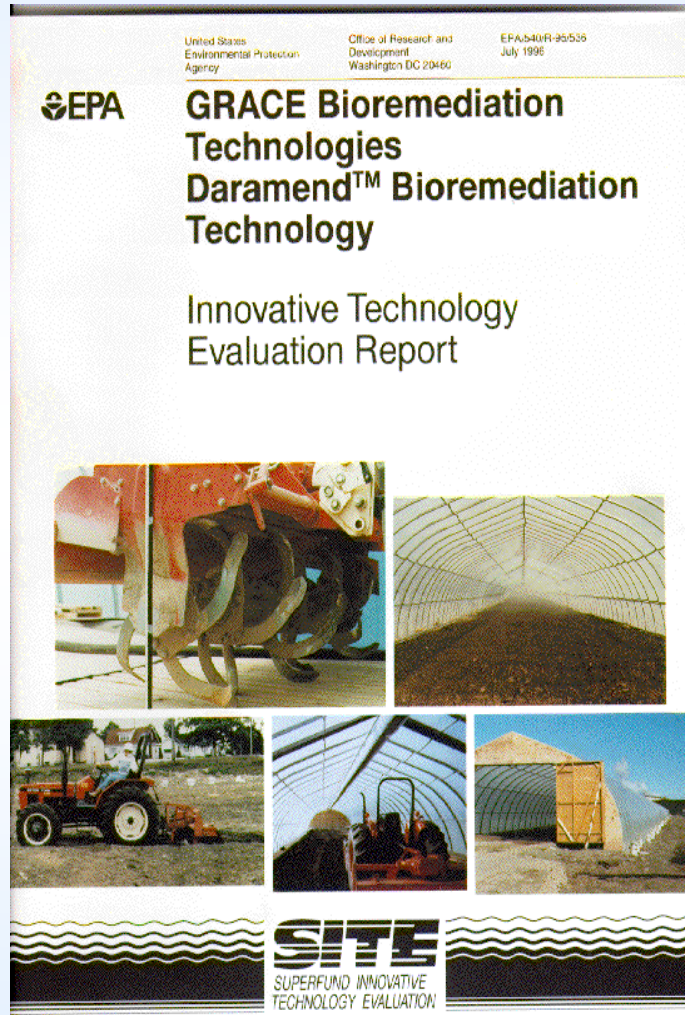


Reductive DARAMEND® Bioremediation





DARAMEND® Evaluation by USEPA



U.S. EPA SITE Report

EPA/540/R-95/536





DARAMEND® Technology Applications

Cycled Anaerobic/Aerobic

- chlorinated pesticides and herbicides
- organic explosives
- chlorinated solvents

Aerobic

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





DARAMEND® - For Explosives

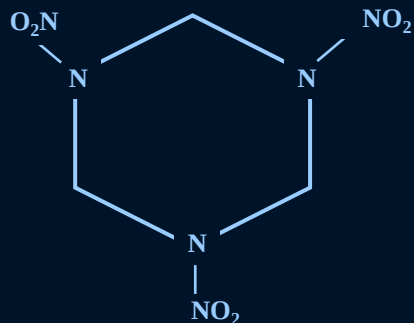
Some Sites Treated

- U.S. Army's Raritan Arsenal - Edison, NJ
- U.S. Naval Weapons Station - Yorktown, VA
- Iowa Army Ammunition Plant - Burlington, IA
- Joliet Army Ammunition Plant - Joliet, IL
- Tooele Army Depot, Tooele, UT



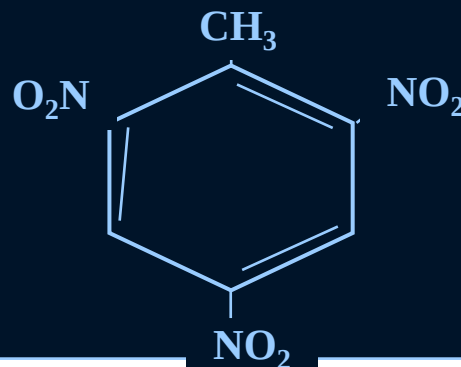
HMX, RDX, Tetryl & TNT Explosives

1,3,5-trinitro-1,3,5-triazacyclohexane



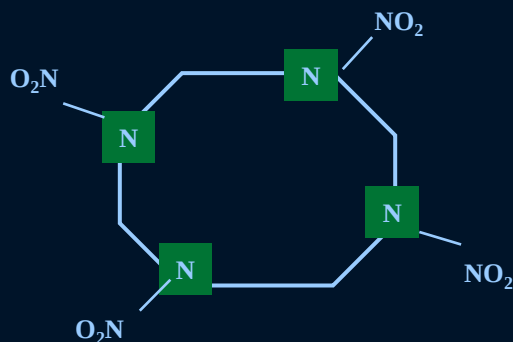
RDX

2,4,6-trinitrotoluene



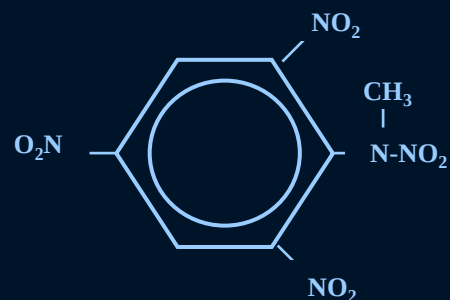
TNT

cyclotetramethylene tetranitramine



HMX

trinitro-2,4,6-phenylmethylnitramine

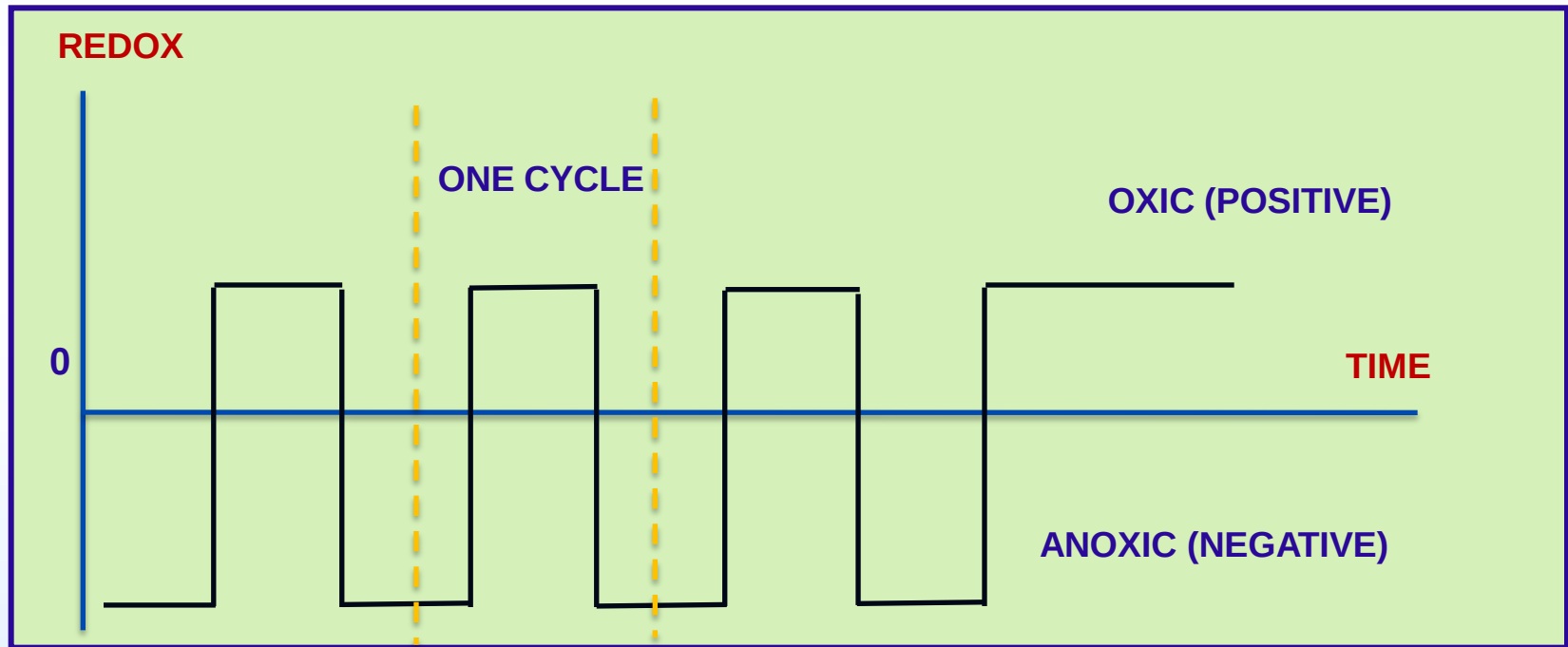


Tetryl



DARAMEND[®] - Treatment Cycles

- Anaerobic/reductive phase
- Aerobic/oxidative phase
- Treatment optimization - site specific





Tooele Army Ammunition Depot





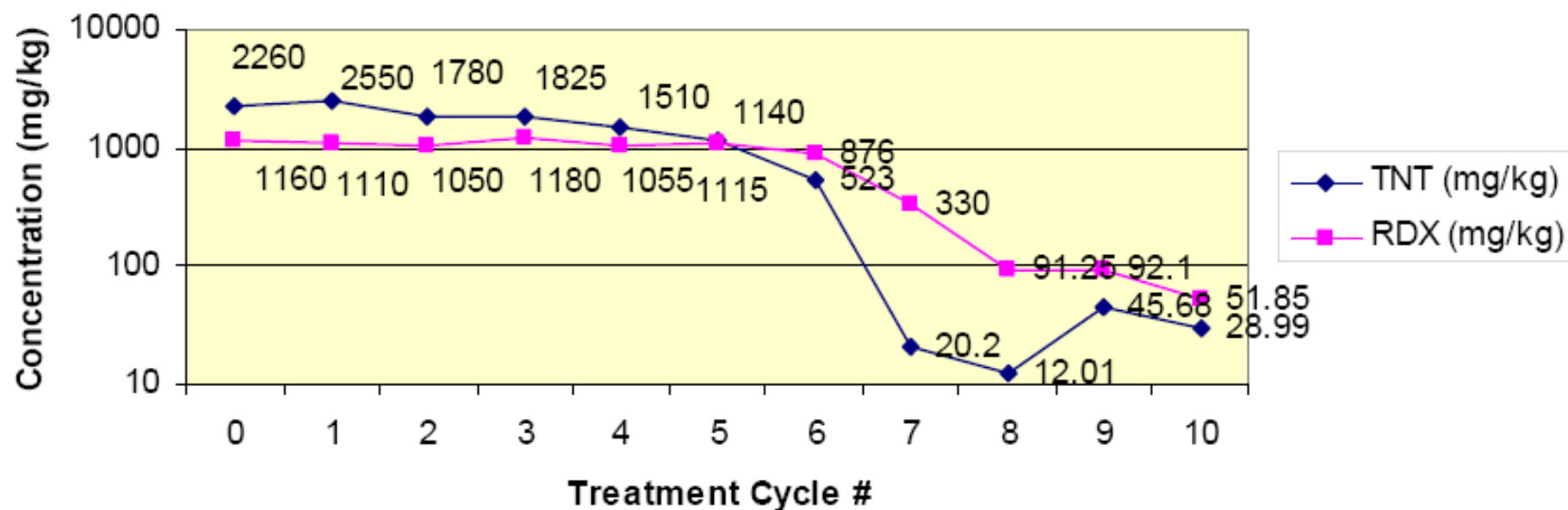
Implementation - Pilot Study

- 7 CY Soil treated in Greenhouse (2007)
- Soils initially cool and soil relatively dry
- Increased moisture (62% -92%) and temps (13-40 C) in later cycles
- ORP from +75 at start to -550 mV at end
- Cycles typically 0.5 to 1 wt% DARAMEND



Pilot Results

**Treatment Influence on TNT and RDX Concentrations
(Averaged)**





Pilot Lessons Learned

Primary - Process Controls:

- Maintain soil temp at 25 C or higher
- Target 90% soil WHC

Secondary - Process Observations:

- ORP
- Odor
- Soil Consistency
- Fungus



Implementation - Full Scale

- Conducted inside building (2008)
- ~3000 CY/batch
- 3.5 wt% DARAMEND/batch
- 8900 CY treated



Implementation Steps

- Excavate Soil
- Place soil in building
- Add DARAMEND
- Till
- Add Water
- Create Piles



Soil Excavation





Soil Placement





DARAMEND Addition





Soil Tilling





Water Addition





Create Piles





Fungus





Full Scale Results

- All Batches Treated with one DARAMEND Addition
- Additional Declines after one cycle
- Little Process Data Collected
- Slow Water Additions (1 week)
- Product Cost \$62/CY
- 8900 CY treated
- \$4.75 million under budget
- Dosage ~5% of Conventional Composting
 - 3.5 wt % DARAMEND
 - 70 wt % Organic Matter for Compost



First Batch Data

	Treatment Goal	Initial*	Post Treatment*	One Week Post-Treatment**
RDX (PPM)	31	563	13	6
TNT (PPM)	86	802	138	7

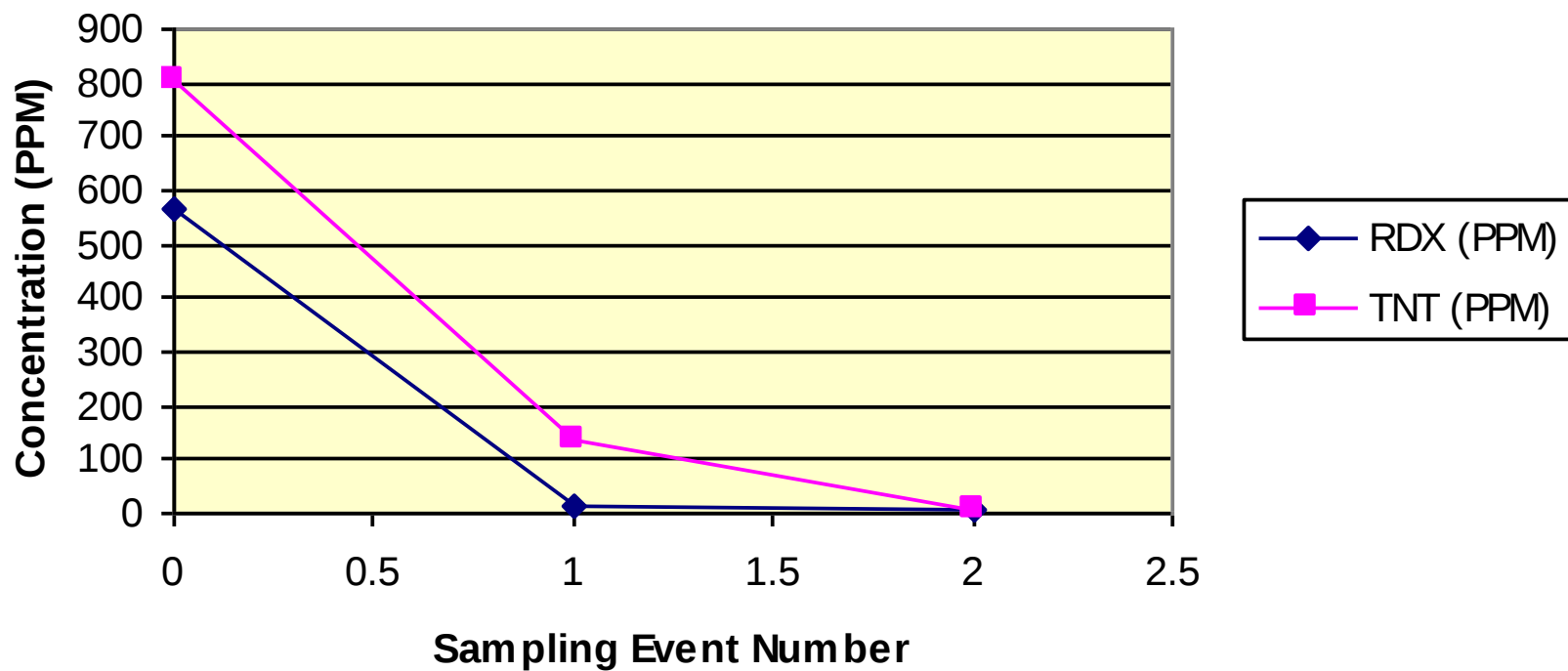
* Average of six samples

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



First Batch Data, cont.

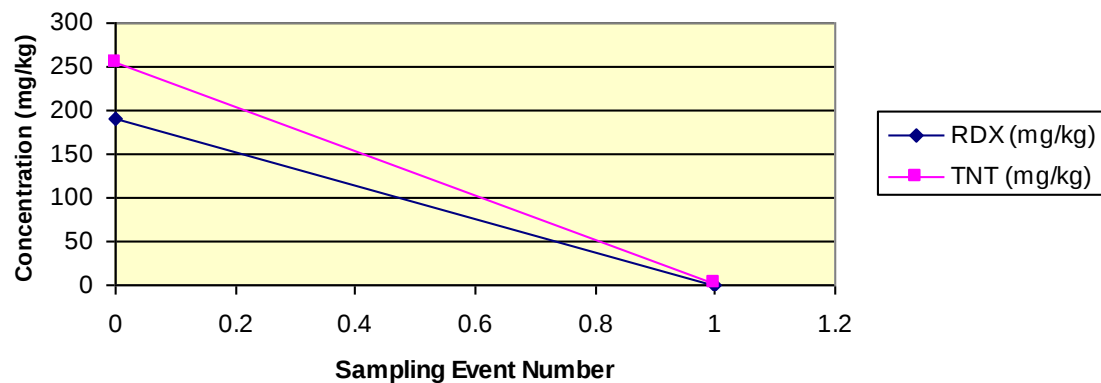
Average TNT and RDX Results



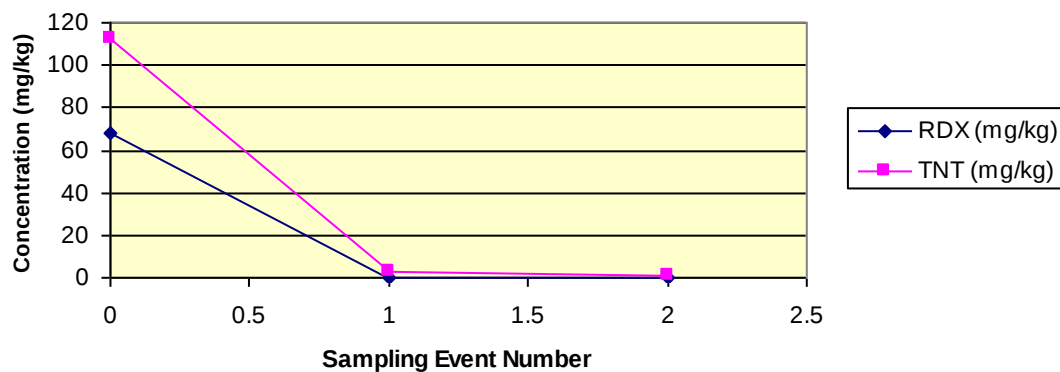


Batch 2 and Batch 3 Results

Batch 2 - Average TNT and RDX Results



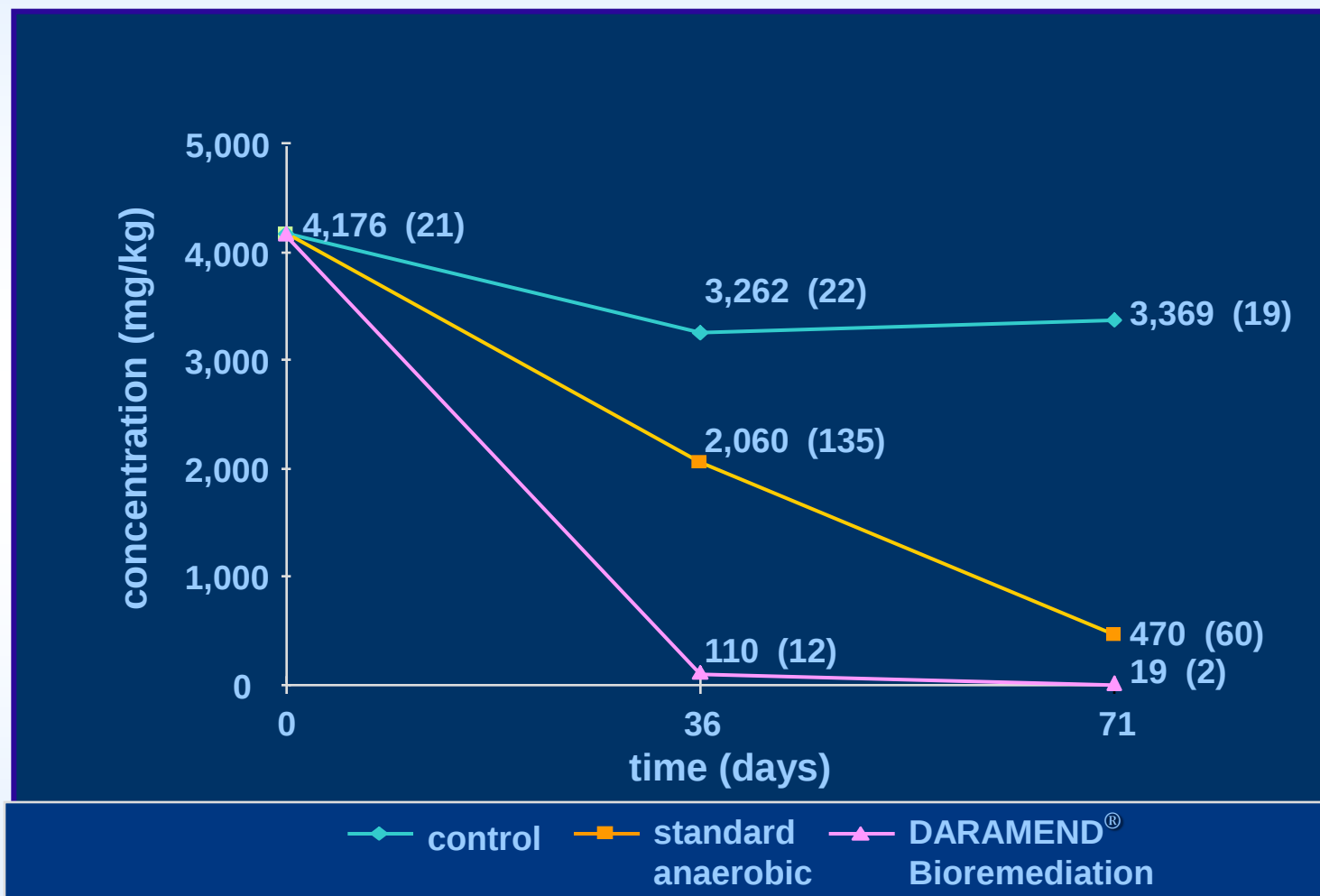
Batch 3 - Average TNT and RDX Results





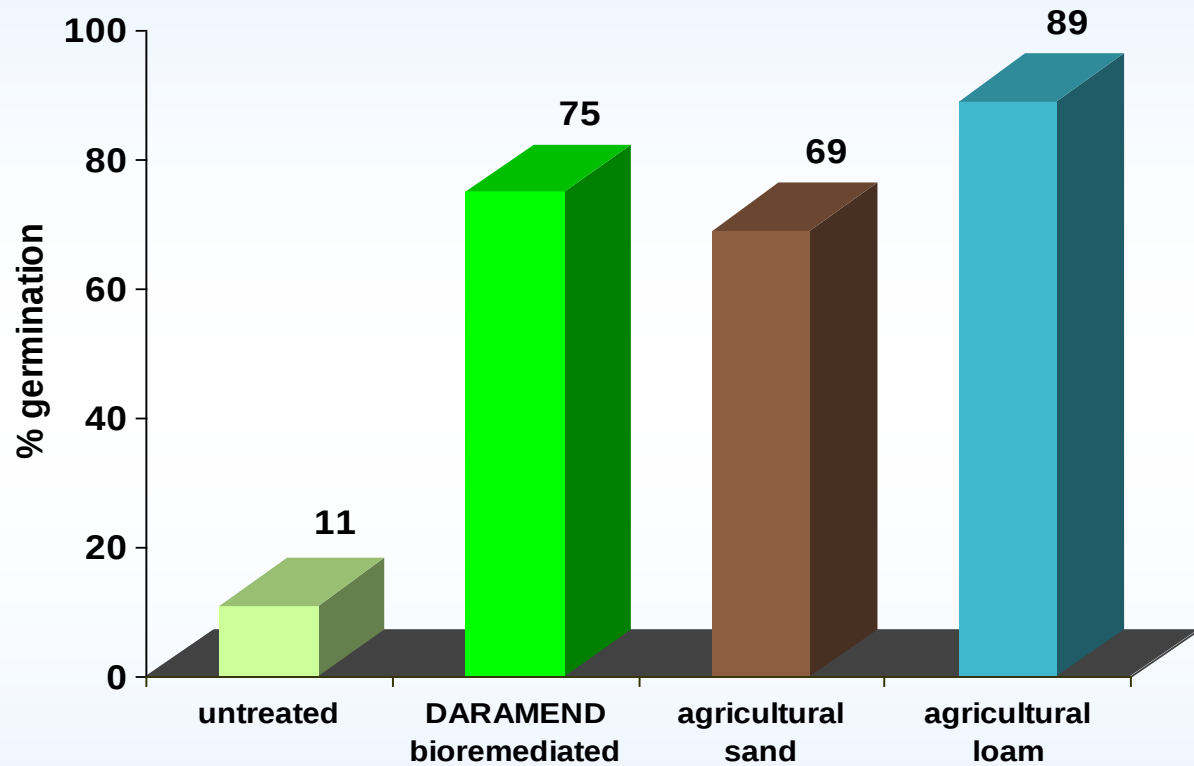
Degradation and Toxicity

TNT and Total Amino Compounds





Degradation and Toxicity - Effect on Tomato Seed Germination in Organic Explosive Contaminated Soil





Summary

- DARAMEND outperformed composting
- Remedial goals attained within reasonable timeframes
- Can be effectively utilized *Ex* or *In Situ*
- Material cost was \$62/CY treated
- Total project cost \$4.75 million under budget



Special Thanks

The US Army Corps of Engineers

Tooele Army Depot

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Adventus

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Matt Fedowitz at Plexus