In situ enhanced bioremediation study of RDX contaminated soil and groundwater at a former military demolition range

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Objective: In situ enhanced bioremediation study of RDX contaminated soil and groundwater, using waste glycerol.

- Waste glycerol (WG) is a by-product of biodiesel production
- Laboratory study with soil columns
- Pilot-scale in situ study, bioremediation of RDX contaminated soil and pore water
- Large scale in situ treatment of suspected RDX hotspots associated with groundwater

Laboratory study with soil columns

- RDX contaminated soil samples collected at the demolition range
- Stainless steel columns (68 cm tall by 20 cm in diameter)
- Control column treated with only water
- Treatment columns received a quantity of WG (low or high concentration)
- Leachates from each column were analyzed for RDX

In situ test plots: soil and pore water

- Experimental design
  - Construction of test plots (3 controls + 3 treatments)
  - Installation of lysimeters in surface (0 - 7.5 cm) and sub-surface (7.5 - 15 cm) soil layers
- Treatment application: 6 times between Aug 13 and Nov 13, 2014
- IWS treatment
- Diluted water for control

- Monitoring program
  - Soil pore water in lysimeters was collected before and after treatment application for analysis
  - Soil samples (simple/plot) collected on 3 occasions in surface (0 - 7.5 cm) and sub-surface (7.5 - 15 cm) soil layers for analysis
  - Analysis included, among others, RDX, TOC, VFA

Study site location: former military demolition range at Garrison Petawawa in Ontario

- Contamination of soil and water with explosives is a widespread problem on military sites

Laboratory study with soil columns

- Significant reduction in mass of RDX in columns amended with WG (99%) or WG + WGH (~ 95%)
- WG offers interesting prospects for treating RDX contamination

Aerobic and anaerobic RDX degradation pathways

RDX (hexogen-1,3,5-trinitro-1,3,5-triazino) - common explosive, found at military sites, with carcinogenic properties

- In situ remediation strategies preferable at military sites due to technical and economic constraints
- RDX biodegradation by biostimulation is more efficient than biodegradation (requires the addition of a carbon source)

In situ test plots: Surface and sub-surface soil layers

- Selected in situ plots and sample with important spatial variations between and within plots
- Slight decrease in [RDX] with depth
- Over time, [RDX] was relatively constant in controls
- RDX was completely removed within 37 days after treatment

In situ test plots: Surface and sub-surface pore water

- Pore water [RDX] remained relatively constant over time
- Slow decreases in [RDX] in control plots contrast with rapid and complete removal within the treatment plots
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- Slow decreases in [RDX] in control plots contrast with rapid and complete removal within the treatment plots

Contamination of soil and water with explosives is a widespread problem on military sites
In situ large scale treatment of suspected RDX hotspots in groundwater: targeting monitoring wells (MW)

- Five monitoring wells (MW) located on gradient of the targeted area
- Targeted wells include MW with a long term history of RDX presence
  - A control MW (GW-8-22) located up-gradient of the targeted area
  - 4 MWs located down gradient of the targeted areas (GW-8-05(a), GW-8-05(b), GW-8-05, and GW-8-43)

In situ large scale treatment of suspected RDX hotspots in groundwater

- Waste glycerol applied 3 times: VFA application
- A control MW (GW-8-22) with no application
- 4 MWs spread out over 3 phases: (GW-8-05(a), GW-8-05(b), GW-8-05, and GW-8-43)

- Groundwater samples collected from MWs in the areas under study
- A sampling campaign spread out over 3 phases (GW-8-05 and GW-8-35)

In situ large scale treatment of suspected RDX hotspots in groundwater

- Monitoring wells (MW) GW-8-05 (s) and (d) are nested
- In situ large scale treatment of suspected RDX hotspots in groundwater
- Collection from MWs in the areas under study
- Reduced conditions appear following VFA application
- ORP values below zero, except in the control MW
- Reducing conditions = anaerobic conditions favorable for RDX bioremediation

In situ large scale treatment of suspected RDX hotspots in groundwater

- MW GW-8-05 (s) and (d) are limited
- MW GW-8-35 is nested
- MW GW-8-43 is limited
- In situ large scale treatment of suspected RDX hotspots in groundwater
- Monitoring Wells
- Monitoring Wells
- Monitoring Wells

In situ large scale treatment of suspected RDX hotspots in groundwater

- RDX concentration remained below detection limit for
- A rebound in MW GW-8-05 (s) in Nov
- A relative long period (~ 12 months)
- The rebound in MW GW-8-05 (s) and (d) are nested
- In situ large scale treatment of suspected RDX hotspots in groundwater

In situ large scale treatment of suspected RDX hotspots in groundwater

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- MW GW-8-35 is nested
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In situ large scale treatment of suspected RDX hotspots in groundwater

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Molecular biological analysis of groundwater samples

- MW GW-8-05 (s) and (d) were nested
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Conclusions

- MW GW-8-05 (s) and (d) were nested
- ORP values below zero, except in the control MW
- Reduced conditions = anaerobic conditions favorable for RDX bioremediation

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