Emulsified Zero-Valent Iron (EZVI): A Combination ISCR Technology for Source Zone Remediation

Presented by:
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Scientists at NASA (KSC) and UCF invented EZVI to address TCE DNAPL contamination at the Kennedy Space Center.

The EZVI technology has been commercially available since 2005. RemQuest has provided EZVI for remediation projects in over 20 states, as well as, Canada and Australia.
BACKGROUND – What is EZVI?

- Nano/micrometer sized zero-valent iron particles emplaced within a **surfactant-stabilized, biodegradable, water-in-oil emulsion.**
- EZVI is a remediation DNAPL.
- Highly effective for *in-situ* treatment of DNAPL due to matching physical chemistry and combination remedial technology (abiotic & biotic processes).
EZVI – Combination Technology

STRUCTURE – What makes EZVI Unique?

- Hydrophobic exterior membrane mimics DNAPL physical chemistry characteristics and enables sequestration of contaminant
- Utilizes both ABIOTIC and BIOTIC anaerobic remediation processes
- EZVI is MISCIBLE with phase or residual DNAPLs in-situ

Brooks, 2000

Miscible with DNAPL
MECHANISMS – How does it work?

1. Sequestration (phase partitioning of COC into veg. oil membrane)
2. Dissolution (COC diffuses into water/ZVI interior of micelle)
3. Reductive Dehalogenation (abiotic & biotic)
MECHANISMS – How does it work?

- **Biotic Processes:**
  - Vegetable Oil associated with EZVI is fermented and ultimately provides H2 for biologically mediated reductive dechlorination reactions.

- **Abiotic Process:**
  - Zero Valence Iron (ZVI) associated with EZVI is emplaced as an aqueous suspension in the interior of the emulsion. Contaminants contact the ZVI via a concentration gradient from the lipophilic membrane into the interior of the micelles.
Engineered as an in-situ source treatment technology
Delivered into subsurface soil/groundwater zones that are contaminated with source material(s) (DNAPL)
Is effective in vadose soils, as well as saline and aerobic saturated environments
Has been implemented at highly active military and commercial manufacturing sites

Pilot Scale
EZVI staged for field implementation

Full Scale
EZVI Delivery

- EZVI injections performed using:
  - Fracturing methods
  - Pneumatic Enhanced IDS
  - KAPSDIDS (or Badger System)
  - Soil Mixing (LDA method)

- Injection pattern typically “outside-in” and “bottom-up” in highly permeable soils to minimize the potential for DNAPL mobilization.
Implementations

Pneumatic Enhanced Injection

Hydraulic Fracturing/Injection & Direct Push Injection

Hybrid Direct Push Injection

Hydraulic Fracturing/Injection
Case Study #1 - Pilot Scale

Private Client in Central Florida

- Trichloroethylene (TCE), cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride

- 3,000 gallons of 10% EZVI was injected in a 40 ft. radius around a former UST/sump location.

- Injections targeted a 10-ft. thick subsurface zone.

- Electron donor material was injected above the area treated with EZVI and down gradient of the former source area to stimulate naturally-occurring biodegradation of the dissolved phase plume.
Results of Case Study #1

- Source area results: TCE groundwater concentrations from 417 mg/L (baseline results) to 6.88 mg/L after six months and non-detect within twelve months.

- Dissolved TCE concentrations adjacent to and above the EZVI injection zone decreased from 3.25 mg/L (baseline results) to <0.002 mg/L.

- Source Area [TCE] remained at non-detect levels for ~3 years post EZVI injection.
Case Study #2 - Pilot Scale

Private Client in Western U.S.

- PCE/CT source area beneath a tank farm in an active chemical facility, with a depth of contamination to 85ft bgs

- **MIP survey** conducted to identify location/depths of injection points

- 30,000 gallons of 10% EZVI were injected using the **KAPSDIDS technology**

- Injection design and monitoring program limited due to active tank farm
Results of Case Study #2

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**Source Area Residual DNAPL**

- MW-637 B
- MW-638 B
- EZVI Implementation
- CT, PCE

**Concentration (umol/L)**

- Date Sampled:
  - 12/2/2010
  - 1/2/2011
  - 2/2/2011
  - 3/2/2011
  - 4/2/2011
  - 5/2/2011
  - 6/2/2011
  - 7/2/2011
  - 8/2/2011
  - 9/2/2011
  - 10/2/2011
  - 11/2/2011
  - 12/2/2011
  - 1/2/2012
  - 2/2/2012
  - 3/2/2012
Case Study #3 - Full Scale

Federal Client in Central Florida

- TCE source area was 75 feet wide and 150 feet long with a depth of contamination to 45 feet.
- 20 acre dissolved plume
- 62,000 gallons of 10% EZVI were injected using pneumatic fracturing technology
- Vegetable oil and KB-1 were also injected in the downgradient plume areas.

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Case Study #3

- Baseline samples from TCE source zone up to **350 ppm** in groundwater samples
- One EZVI injection event
- ~90% destruction of source area TCE within one year
- >99% destruction of source area TCE to date
- **Prior to EZVI injection** - Estimated to take ~**200 yrs.** to remediate site via MNA
- **Post EZVI injection** - Estimated to attain remediation goals within **50 yrs.**
Federal Client in Central Florida

- TCE source area “A” was ~ 50 ft. wide and 100 ft. long; while source area “B” was ~ 20 ft. wide and 60 ft. long; both with a depth of contamination to 40 feet.

- 37,500 gallons of 10% EZVI were injected into the two source areas using the KAPSDIDS technology.
SOURCE AREA Results
Case Study #4

Source Area A

Source Area B

Baseline

10 ppm TCE

100 ppm TCE

200 ppm TCE

1 yr post EZVI Injection

1 ppm TCE

10 ppm TCE

100 ppm TCE

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EZVI Performance Highlights

- **Contaminant Reduction**
  - Typical source area VOC concentration reduction of 80 - 95% within <1 year

- **Timeframe of Reactivity**
  - EZVI has been shown to be effective in the subsurface for periods exceeding 2.5 years

- **Source Area Effects**
  - Directly destroys source material

- **Plume Effects**
  - *Adjacent to source area:* Fermentation reactions provide hydrogen for biotic transformations or “polishing” adjacent to injection area
  - *Downgradient:* Eliminates on-going source for downgradient areas
FAQ’s

- How much EZVI will I need at my site?
- How is EZVI packaged for site delivery?
- How much do you dilute the product for injection delivery?
- Can you inject EZVI through wells?
- What are typical reduction results?
- How long is EZVI reactive?
- How much does EZVI cost?
- What is the difference between EZVI and any of the other ZVI and carbon products that are available?
Contact Information

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