A Technology Platform to Harness Speed and Certainty in Groundwater Remediation

Ashley Cedzo, Northwest District Technical Manager

REGENESIS
Technology-Based Solutions for the Environment
Biodegradation Principles

Bacteria live on surfaces – biofilms
- Think slime not Pac-Man

They have to wait for their growth substrate (food) to come to them
- They must therefore either sit on / in the food source (rotting vegetables)
- Or wait for it to dissolve and come to them in solution (groundwater bioremediation)

As the plume is progressively cleaned up, the contaminant concentration drops
- The rate that substrate comes to the bacteria reduces
- The rate that bacteria can therefore degrade it reduces

Below a certain concentration, the rate can slow dramatically

"The first 95% is easy, it's the last 5% we always worry about"

Question to our R&D group: “How do we increase microbial efficiency rates.”
R&D Efforts and Findings

2007: Began to focus on use of particulate sorbents and dissolved contaminants *in situ*.

Activated carbon and other sorbent particulates do not disperse in the aquifer waters and requires fracturing (grain displacement).

- **Granular Activated Carbon particles**: > 1000 µm
- **Powdered Activated Carbon particles**:
  - 40 to 100 micrometers diameter
  - Agglomerate to >1000 µm in water

**Soil Pore Throat Diameter**
- Silts/Sands: Est. Range: 3-30 µm
Challenge to REGENESIS

Development of:

- Flow-able and dispersible sorbent
- Stimulates rapid sorption of contaminants
- Permanently biodegrades contaminants
PlumeStop® is a Technology Platform

PlumeStop BioMatrix (PlumeStop) was specifically designed to eliminate rebound, mitigate matrix back diffusion and meet stringent groundwater standards.

PlumeStop provides the first ever colloidal biomatrix for contaminated sites that rapidly reduces contaminant concentrations while enhancing bioremediation of a wide range of contaminants.

PlumeStop reduces risk by being the first wide-area distribution, high-volume, sorptive media to be applied directly into groundwater.
PlumeStop Coating on Soil Particle
What it Treats

- CVOCs including ethenes and ethanes
- Petroleum Hydrocarbons (TPH, BTEX, etc.)
- MTBE, pesticides, and more
Primary Methods of Contaminant Destruction

Aerobic Treatment
  • Electron Acceptor Addition, Sparging…

Anaerobic Treatment
  • Slow release electron donors
  • Lactate, recirculation systems

Monitored Natural Attenuation/Intrinsic Remediation

Contaminants Sorbed, Now What?
PlumeStop Mode of Action

- Sorption sites become available for additional contaminant
- Contaminant sorbs to sites available on PlumeStop particle
- Microbes biodegrade sorbed contaminants
When/Where to Use

1. When time is critical
2. As a long-term barrier
3. To achieve stringent cleanup standards
4. To address matrix back diffusion
Pitfalls – Things to Avoid

High mass/high concentration zones
• NAPL – too much to sorb, too much to bio

Low resolution sites
• Design Verification – “Infeasability Testing”
Injecting granular or powder activated carbon requires fracturing of aquifer formation (grain displacement) due to large particle size and agglomeration.

Results in:

- Inefficient placement
- Only partial treatment of subsurface
- Can compromise monitoring wells
Fracturing Carbon: Only Partial Treatment of Subsurface

Most of vertical thickness untreated

Fracturing Carbon: Compromises Monitoring Wells
Fracturing Carbon: Can Effect Monitoring Wells

NET RESULT:

Subsurface still highly contaminated
Post-Fracture Monitoring Requires New Well

New well shows true results of treatment: Contamination still exists in zone.
Effective Distribution

To get more details on this topic read **Technical Bulletin 1.1 Distribution through a Permeable Medium**

Long Column Study

- 16 foot length (5m) (ID 2”; 5 cm)
- Fine to medium silica sand (210 – 420 µm)
- 20% porosity (est.) (pore volume 0.5 gal; 2 L)
Front progresses through dispersive flow

Post-flush residual coating visibly apparent
Total mass retained within column ca. 0.1% of pore volume

1-2 µm coating on sand particles
PlumeStop Flows into Subsurface

Monitoring Well

Contaminated Groundwater
PlumeStop Flows into Subsurface
Low Pressure Injection - Flows into Subsurface
Low Pressure Injection Does Not Compromise Monitoring Wells
Evidence of Dispersive Flow (low pressure application)

- Distribution of PlumeStop through target zone visually apparent
- Even dispersion evident through permeable strata
Field Performance

How fast does it work?
How long does it last?
Is biodegradation occurring?
Immediate 14,000 – 16,000 µg/l to ND

Exceeds sorption capacity at 58 days

Countered by bio-regeneration of sorption sites
Midwest Chlorinated VOC Site

- Former electronics facility
- Contaminants: TCA, TCE, etc.
  - TCE 1,390 µg/L
  - TCA 3,550 µg/L
- Treatment Area
  - Plume area only, no NAPL
  - PlumeStop: 10-pt low pressure injection grid around MW-6
  - HRC electron donor applied up gradient
Corresponding proliferation of solvent-degrading microbial species and functional genes

10 x reduction
100 x reduction
1000 x reduction
non-detect
Northwestern PlumeStop sites:

1) Mixed plume site in Seattle
   - Former dry cleaner and service station

2) Active gas station in southwestern Washington
Figure 1 – Injection Locations Map

Prepared By: CIL

Date Prepared: December 2014

*Not to Scale*
Soil Settling Tube Tests (aka Field Hydrometers)
Performance

• Chlorinated solvents
• Post-sorption degradation
• Lines of evidence
California Site

‘Dune Sand’ formation
10 m/year groundwater flow
High redox conditions (aerobic)
No attenuation evident
PCE 550 µg/L
No daughter products
PlumeStop
Electron donor and bacteria
### Historic Data

#### MW-3 (ppb)

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- Steadily increasing PCE
- No daughter products
- (aerobic conditions)
Redox ‘sweet spot’ establishes Competing TEA’s decline

Application

(note zero on 2° axis)
Contaminant and Dechlorination Microbial Assay Trends

Application

PCE immediately ↓ to ND (<5µg/L)
Micro parameters increase post-app then decrease after ~two months

676%

541%

3,000 x

(init. ND)

(no methanogenesis)
How fast does it work?:
Generally > 90% reduction within 30 to 60 days.

How long does it last?
Indefinitely if electron donor/acceptors present.

Is biodegradation occurring?
Multiple lines of evidence indicate complete biodegradation.
PlumeStop – When To Use?

When time is critical
For control of migrating contamination
To secure stringent clean-up targets
As a long–term means of addressing matrix back-diffusion
When remediation performance is flat-lining
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REGENESIS
Technology-Based Solutions for the Environment
RESOURCES FOR YOUR BENEFIT

- Dedicated, Highly-Qualified, Technical Services Support
- Complimentary Remediation Design and Cost Estimates
- Extensive Library of Contaminant-Specific Information, Case Studies and Application Instructions
- www.regenesis.com
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- Social Media (Blog, Twitter, Facebook, LinkedIn)
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