

Design and Application Strategies for Klozur® Activated Persulfate:



Field Application Basics

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It can work!!



But it's not a SILVER BULLET!



Field Application Basics

Agenda



Key Factors in a Successful ISCO Application

- Establishing Contact
 - Site specific geology / hydrogeology
 - Contaminant mass distribution + remedial goal
 - Injection strategies
 - Other design basics
- Monitoring Progress / Success
 - Monitoring objectives
 - Expectations and Remedial Goals
 - Soils vs. groundwater sampling
 - Soil Sampling strategies

Establishing Contact: Overview



After it is known that the contaminant can be degraded by activated persulfate the *key is to establish contact between a sufficient mass of oxidant with the contamination for a sufficient duration of time*

Oxidant Mass \geq Contaminant Demand + SOD/NOD
+ Autodecomposition



Establishing Contact: Geology / Hydrogeology



- Activated persulfate has been applied successfully in a variety of geologies
- Potential limitations:
 - Non-target oxidant demand
 - Geochemical interferences
 - Complex / heterogeneous subsurface
 - Limited hydraulic conductivities/flow rates
 - Groundwater flow
- Degree of limitations reflected in a site specific design

Establishing Contact: Contaminant Mass and Distribution



- Activated Persulfate can be and has been used to treat a variety of contaminants of varying mass and distribution
- Important factors:
 - Contaminant mass
 - Contaminant distribution
 - Phase (aqueous, soil or NAPL)
 - Architecture-specifics of phases and distribution
 - Pore filled NAPL?
 - Contaminant concentration/contaminant density
- Sufficient mass of oxidant for the mass of contaminant in a given volume of soil.

Establishing Contact: Additional Design Issues



- Injection Volume vs. Pore Volume
 - Lesser percent pore volume injected
 - Will primarily treat preferential pathways or limited radius from injection point
 - More dependent upon diffusion and groundwater transport
 - Higher percent pore volume injected
 - Greater distribution via advective flow
 - Less dependent upon diffusion and groundwater transport
- Fluid Density
 - Injected fluids are typically denser than water so need to understand potential for vertical migration of the reagents
- Injection Concentration
 - Higher concentrations help ensure contact with sufficient oxidant

Establishing Contact: Injection Strategies

- Purpose
 - Establish contact
- Options
 - Direct injection
 - Flow down
 - Recirculation
 - Push - Pull
- Strategy may change over treatment period



Establishing Contact: Direct Injection vs. Recirculation

Direct Injection

- **What it is:**
 - Injection of reagents through DPT or fixed points into the subsurface
- **What it does:**
 - Displaces pore water and contacts stationary contamination (soils or NAPL) with some mixing with groundwater
- **Best suited for:**
 - Stationary contamination (soils or NAPL)
 - Higher concentrations with higher remedial goals

Recirculation

- **What it is:**
 - Extraction of groundwater from a set of extraction wells, addition of reagents and reinjection of amended reagents into a separate series of injection wells
- **What it does:**
 - Assures contact with extracted groundwater while treating soil
- **Best suited for:**
 - contamination in the aqueous phase is a concern
 - Enhanced contact time
 - Access is limited

Direct Push Temporary Injection Point



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Solutions for a cleaner earth.



Recirculation System



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Pull – Push vs. Flow Down

Pull - Push

- **What it is:**
 - Extraction of a set volume of groundwater, addition of reagents, and reinjection of the groundwater into the sample location from which it was extracted
- **What it does:**
 - Assures contact with extracted groundwater while treating soil
 - Minimizes aqueous contamination displacement
- **Best suited for:**
 - Small sites and where mass of contamination in the aqueous phase is a concern

Flow Down

- **What it is:**
 - Injection of reagents into lines of injection wells within or upgradient of impacted source and allow reagents to flow down to contact the source
- **What it does:**
 - Allows for lesser numbers of injection points
 - Treatment of inaccessible areas
- **Best suited for:**
 - Sites with rapidly moving groundwater
 - Access is limited

Establishing Contact: Other Design Basics



- Design parameters that can be adjusted to help ensure better distribution and contact with the contamination include:
 - IW spacing/expected ROI from IWs
 - Vertical injection interval
 - Injection volume
 - Reagent concentration

Monitoring Progress / Success



- Monitoring Objectives
- Expectations and Remedial Goals
- Soil vs. Groundwater Sampling
- Soil Sampling Strategies

Monitoring Progress/Success: Monitoring Objectives



- Implementation Process
 - Distribution of reagents
 - Lateral and vertical
 - Indicators (e.g. conductivity) vs. oxidant
 - Oxidant persistence
 - Implementation/geologic issues
 - Flow rates
 - Injection pressures
- Performance
 - Progress toward remedial goals
 - Impact/success of application
 - Geochemical impacts



Monitoring Progress/Success: Expectations/Remedial Goals



- Difficult to achieve
 - Stringent / low numerical standards for soils
 - MCL's in groundwater
 - Remedial goals at every monitoring point
- More reasonable goals
 - Contaminant mass reduction
 - Reduction in groundwater concentrations (can see increases)
 - Groundwater mass flux reduction
 - Visible NAPL reduction / reduce NAPL migration
 - Achieving remedial goals at a percentage or average number of monitoring points

Monitoring Progress/Success: Soil vs. Groundwater Sampling



- Monitor contaminant phase that contributes to the intended remedial goal:
 - Mass reduction on soils or NAPL: Monitor soils
 - High concentrations in GW: Monitor soils and GW
 - Low concentrations in GW: Monitor GW
- Soils mass balance
 - Spatially weighted mass averages (Thiessen Polygons)

Monitoring Progress/Success: Soil Sampling Strategies



Grab Samples

- **What it is:**
 - Discrete sample selected from cores based on visual or screening tool
- **What it does:**
 - Meet regulatory requirements in many states
 - Can provide negative or positive bias on performance based on sample selection approach

Composite Samples

- **What it is:**
 - Mixing soils from core or visually similar section to obtain a composite sample for analysis
- **What it does:**
 - Provides a more comparable analysis for mass determination and treatment effectiveness
 - May not meet regulatory requirements in many states

Summary



- Establishing Contact between sufficient oxidant for the contamination
 - Critical element of activated persulfate design
 - Dependent upon several factors including contaminant phase, distribution, architecture, and subsurface conditions
 - Variety of ISCO design elements can be used to help ensure adequate contact
- Monitoring Progress/Success
 - Critical to identifying the success of activated persulfate application
 - Monitoring program needs to be designed for each site

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Achieving cost-effective site closures through sound decisions & strategic remediation

Strategic. Environmental. Solutions.



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