Green Remediation of Contaminated Groundwater in Karst Aquifers by Solar Energy Conversion

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Introduction

- Green remediation of contaminants
- Use of solar energy and iron electrodes
- No external chemicals or solutions added
- Practical to implement in karst aquifers

Background: Previous Work

- Zero Valent Iron (ZVI)-single electrode redox system
  - Most commonly used material for treatment of contaminant
  - Uncontrolled reactivity
  - High potential for passivation of iron

Hypothesis

- Electrolysis using two iron electrodes (anodes and cathodes) will induce Fe(II)/H₂ dominated reducing conditions that can be manipulated for the chemical reduction of the contaminants.
- Unlike the ZVI system, the reducing condition of aqueous media can be optimized by controlling the current density and polarity.

Research Tasks

1) Conduct mixed and divided electrolyte batch experiments with inert electrodes and iron electrodes
2) Use sand-packed flow column experiment with varying parameters and different electrode type
3) Conduct mixed electrolyte batch experiment with iron anode to determine TCE degradation rate.

Ongoing/Future Work

- Assess precipitation and porosity reduction due to iron electrolysis
- Modeling of pH and ORP distribution
- Effect of iron electrolysis and polarity reversal on carbonate groundwater chemistry

Current Findings

- Using two iron electrodes system can maintain more reducing electrolyte condition
- The electrolytic reduction zone can be controlled by changing polarity of the electrodes.

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Task 1: Batch Experiment

- Probes
- Sampling Ports
- Membrane
- Iron electrode

Task 2: Sand-packed Flow Column Experiment

- Pump
- Electrodes
- Flow column experiment set up

Task 3: Mixed Electrolyte TCE Spiked Batch Experiment

- Experiment Set-up
- Initial TCE concentration ~60 mg/L
- The current is 30 mA
- Total electrolyte volume is 110 ml
- Electrode surface area is ~ 4 cm²
- Purge and trap method is used to determine the TCE concentration of samples.

Background: Previous Work

- Proposed Pathways for reductive dehalogenation by ZVI

Hypothesis

- pH, ORP, electrical conductivity in aqueous media with varying parameters; electrode material, electrolyte type, current density, polarity reversal.
- Iron and inert (Ti/MMO) electrodes are used
- Total testing duration is 24 hr
- The polarity reversal effect on physicochemical properties of electrolyte is studied.

Current Findings

- The length of column is 82 cm with 6.4 cm inner diameter, electrodes are 24 cm apart.
- Total 8 sampling ports (1 before the first electrode, 3 between the electrodes, 4 after the second electrode)
- The electrolyte is pumped with constant flow rate (1.5, 2 and 2.5 ml/min)
- Experiment duration ~ 3 days
- Sampling rate is 1 ml water sample from each port at every 3 hrs.
- Microelectrodes used to measure pH and ORP.
- The variables are electrolyte type and concentration, electrode material, flow rate and current density.