Sulfur Modified Iron: A Versatile Media for *Ex Situ* Water Treatment

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Sulfur Modified Iron (SMI®III)

• Industrially prepared granular media
  – 92-98% Iron, 2-8% Sulfur
  – Particle size: 20 - 80 mesh
  – Bulk density: 2.5 g/cm³ (135 lbs/ft³)
• NSF Standard 61 Certified (for use with drinking water)
• US Patents 5,575,919; 5,866,014; 6,093,328; other patents pending
Contaminants Removed

• Inorganic contaminants
  – Arsenic (III), Arsenic (V)
  – Copper
  – Hexavalent chromium
  – Nitrate

• Organic compounds—chlorinated solvents (e.g. TCE)
Removal Mechanism—Adsorption

- Arsenic, copper, other metals removed via adsorption
  - Arsenic sorption capacity: 2-4 mg As/g SMI®III
  - Copper sorption capacity: > 2 mg Cu/g SMI®III
- Adsorption may be chemical and/or physical
- Mode of adsorption may vary with metal
Removal Mechanism—Chemical Transformation

• Nitrate removed via chemical reduction
  – Nitrate products include ammonia/ ammonium, possibly nitrogen gas
  – Nitrite not observed

\[ \text{NO}_3^- \xrightarrow{\text{SMI}} \text{NH}_4^+ / \text{NH}_3 + \text{other products} \]

• Chlorinated solvents removed via reduction—products most likely ethene, ethane, lesser chlorinated compounds
Removal Mechanism—Chemical Transformation (cont’d)

• Factors affecting chemical transformation
  – EBCT (longer EBCT yields greater removal)
  – SMI particle size (smaller particles yield faster rates)
  – Influent contaminant concentration
  – Influent water quality
SMI Column Design (I)

Column Design (I):
Diameter: 1 inch
Bed Height, 2-4 inches
Flow: upflow
50-100 g SMI III
EBCT: 5 min Arsenic
20-30 min Nitrate
SMI Column Design (II)

Column Design (II):
Diameter: 2 inches
Bed Height: 24 inches
Flow: Upflow
3 kg SMI III
Max EBCT: 120 min

Influent (Port #1)
Sampling Ports
Effluent (Port #5)

To influent reservoir
Arsenic Removal (Lab)

Influent ~ 1,200 µg/L As(III) + 1,200 µg/L As(V)
Detection limit = 5 µg/L
EBCT = 10 minutes

~ 12 days
(1,600 bed volumes)
2 mg As/g SMI
As Removal—Field Pilot Test

- Field Test, East Niles, CA—groundwater
  - Column parameters
    - 12” diameter column, 30” bed depth
    - 2.5 GPM
    - Empty Bed Contact Time (EBCT) ~ 6 minutes
    - Backwash every 1000 gallons of production
  - About 200,000 gal (13,300 bed volumes) put through
  - Influent As: 18 µg/L
  - Effluent As: < 2 µg/L
Influent: Nevada Site Groundwater

- Nitrate = 36 mg/L as NO₃⁻
- Silica = 61 mg/L as SiO₂

EBCT = 30 minutes
Nitrogen Mass Balance

Influent = Groundwater from Salinas, California
Nitrate Removal—Field Pilot

Influent = site groundwater; EBCT = 23 minutes; flowrate = 1.5 gpm

Concentration, mg/L as N

Graph showing concentrations of Influent NO3, Effluent NO3, Effluent NH3, and Total Effluent N vs. Number of Bed Volumes.
Other Contaminants Removed by SMI

• Copper
  – Influent = DI water spiked with 10 mg/L Cu
  – EBCT = 5 minutes
  – Effluent Cu < 0.1 mg/L
  – Capacity > 2 mg Cu/g SMI

• Hexavalent Chromium
  – DI water spiked with 0.9 mg/L Cr(VI)
  – EBCT = 6 minutes
  – Effluent Cr(VI) < 0.02 mg/L
Other Contaminants (cont’d)

- TCE
  - Influent = site water containing 8 µg/L TCE
  - EBCT = 28 minutes
  - Effluent TCE < 1 µg/L
SMI III Longevity

• For removal via *Adsorption*, column life depends upon
  – capacity of SMI for given contaminant
  – initial contaminant concentration
  – desired effluent concentration

• For removal via *Chemical Transformation*
  – column life probably controlled by hydraulic or mechanical factors
  – column life expected to be much longer than for removal by adsorption
Status of SMI Development

• Laboratory
  – Intensive lab testing in progress to systematically evaluate effect of influent water quality on removal of arsenic
  – Testing to evaluate removal of inorganic and organic contaminants

• Field pilot tests
  – Several in place to evaluate arsenic, nitrate, and copper removal
Conclusions

• SMI is a versatile new media for *ex situ* water treatment
  – Groundwater
  – Industrial wastestreams

• Shown effective at removing
  – As(III), As(V), Cu, Cr(VI), nitrate, TCE
  – Probably also effective for other metals and reducible compounds such as chlorinated pesticides

• Several field pilot studies underway
Contact Information

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