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

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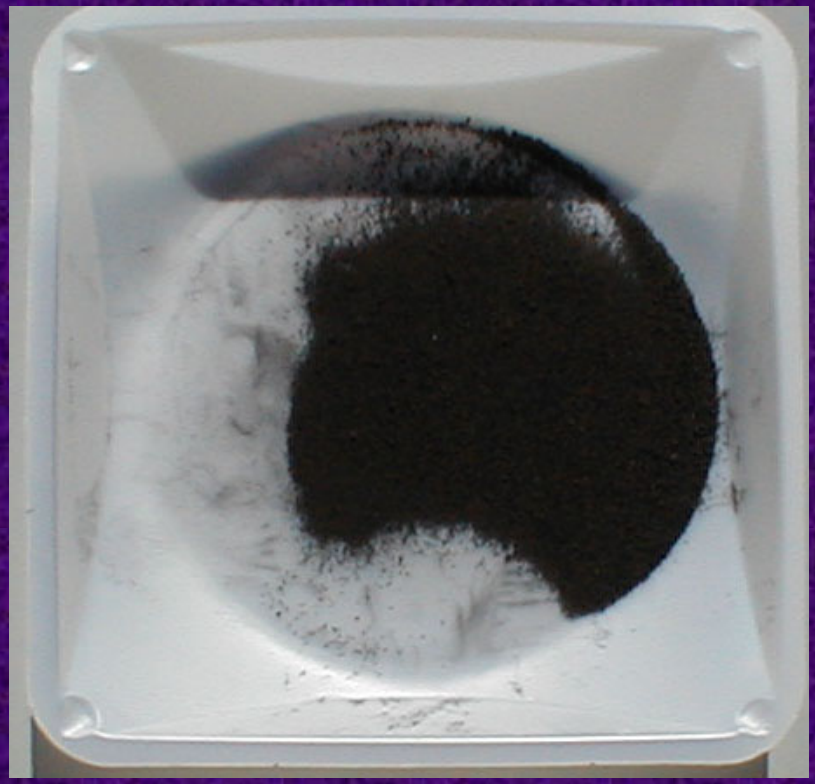
Sulfur Modified Iron (SMI®III)

- **Industrially prepared granular media**
  - **92-98% Iron, 2-8% Sulfur**
  - **Particle size: 20 - 80 mesh**
  - **Bulk density: 2.5 g/cm^3 (135 lbs/ft^3)**
- **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**

$$NO_3^- \xrightarrow{SMI} NH_4^+/NH_3 + \text{other products}$$

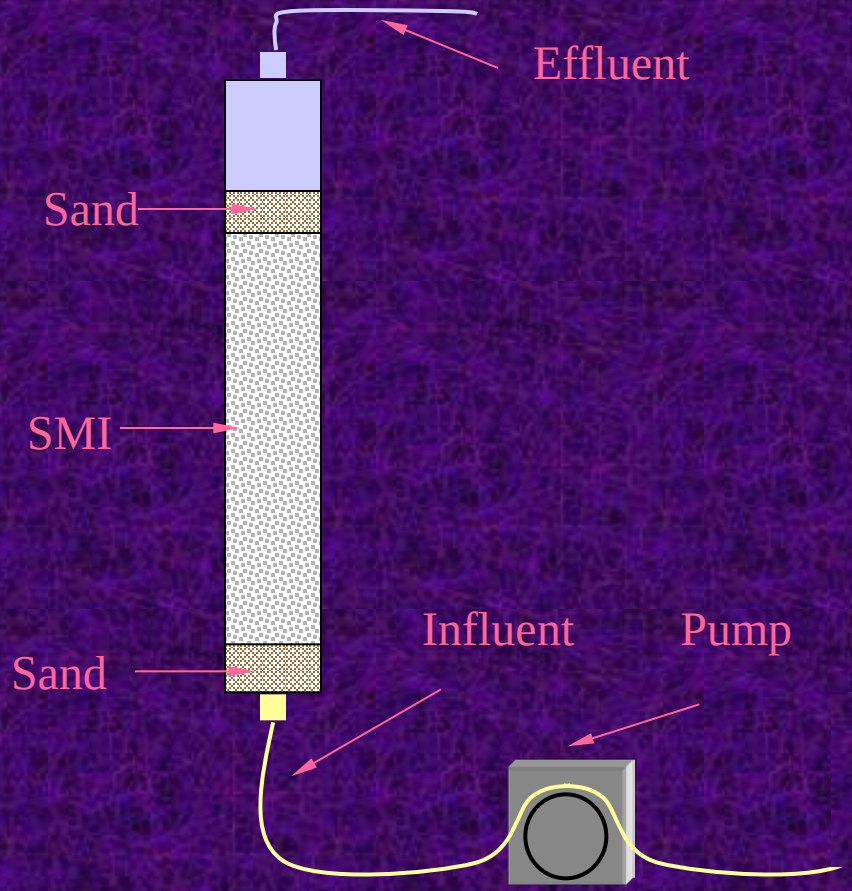
- **Chlorinated solvents removed via reduction—products most likely ethene, ethane, lesser chlorinated compounds**

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**

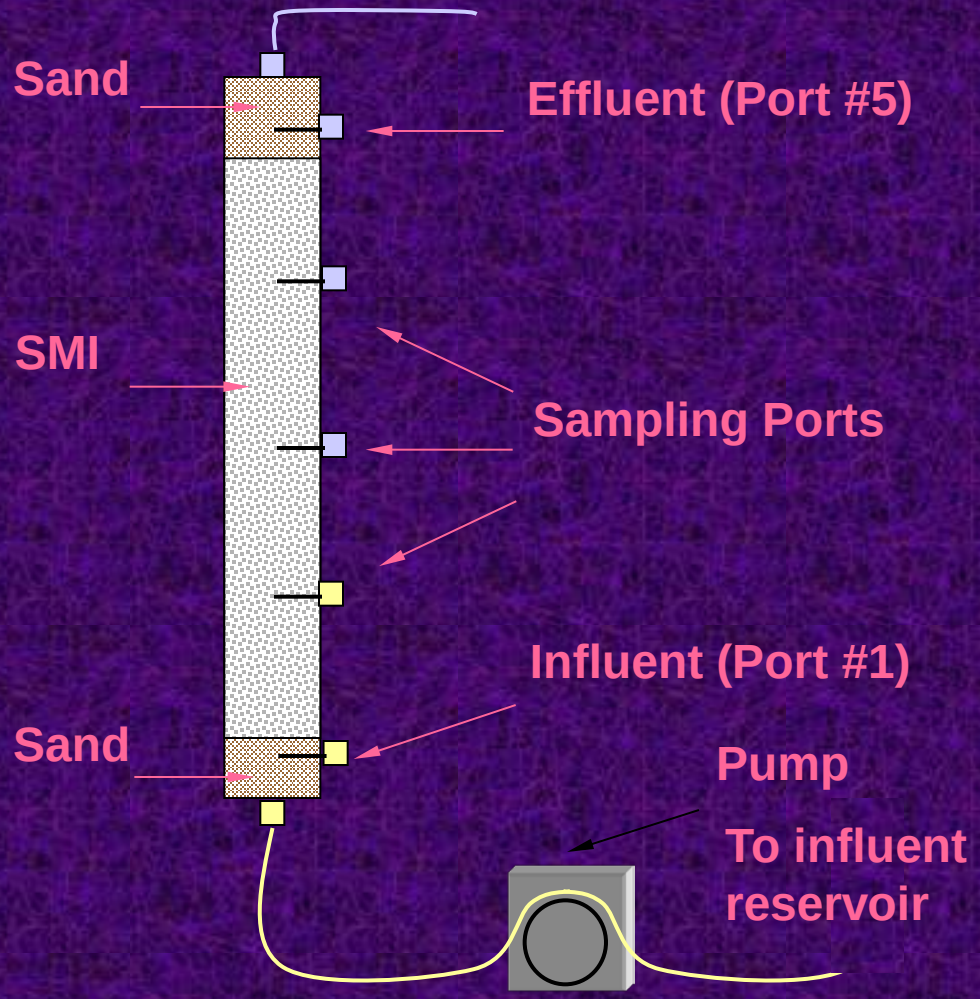
SMI Column Design (I)

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

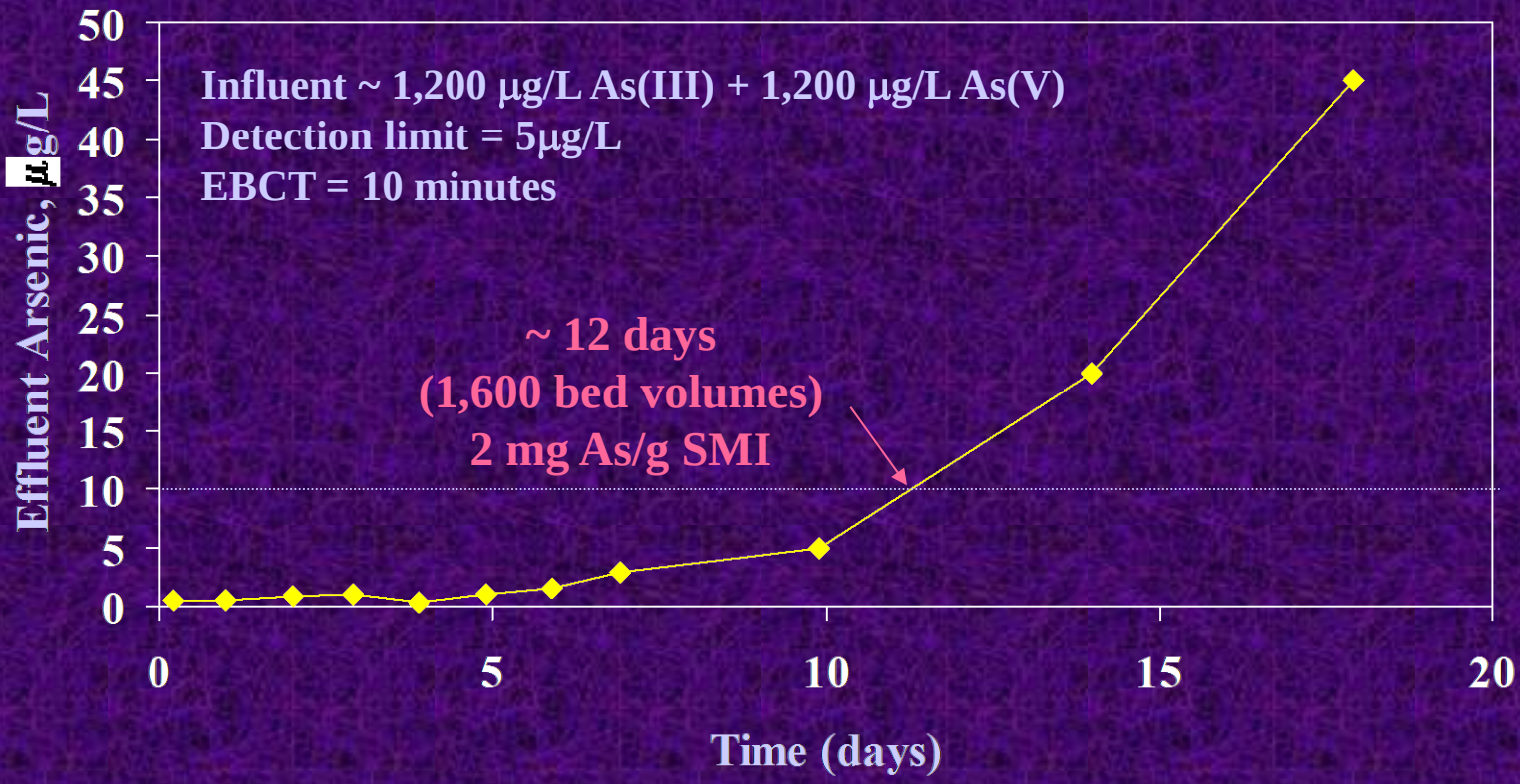


SMI Column Design (II)

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



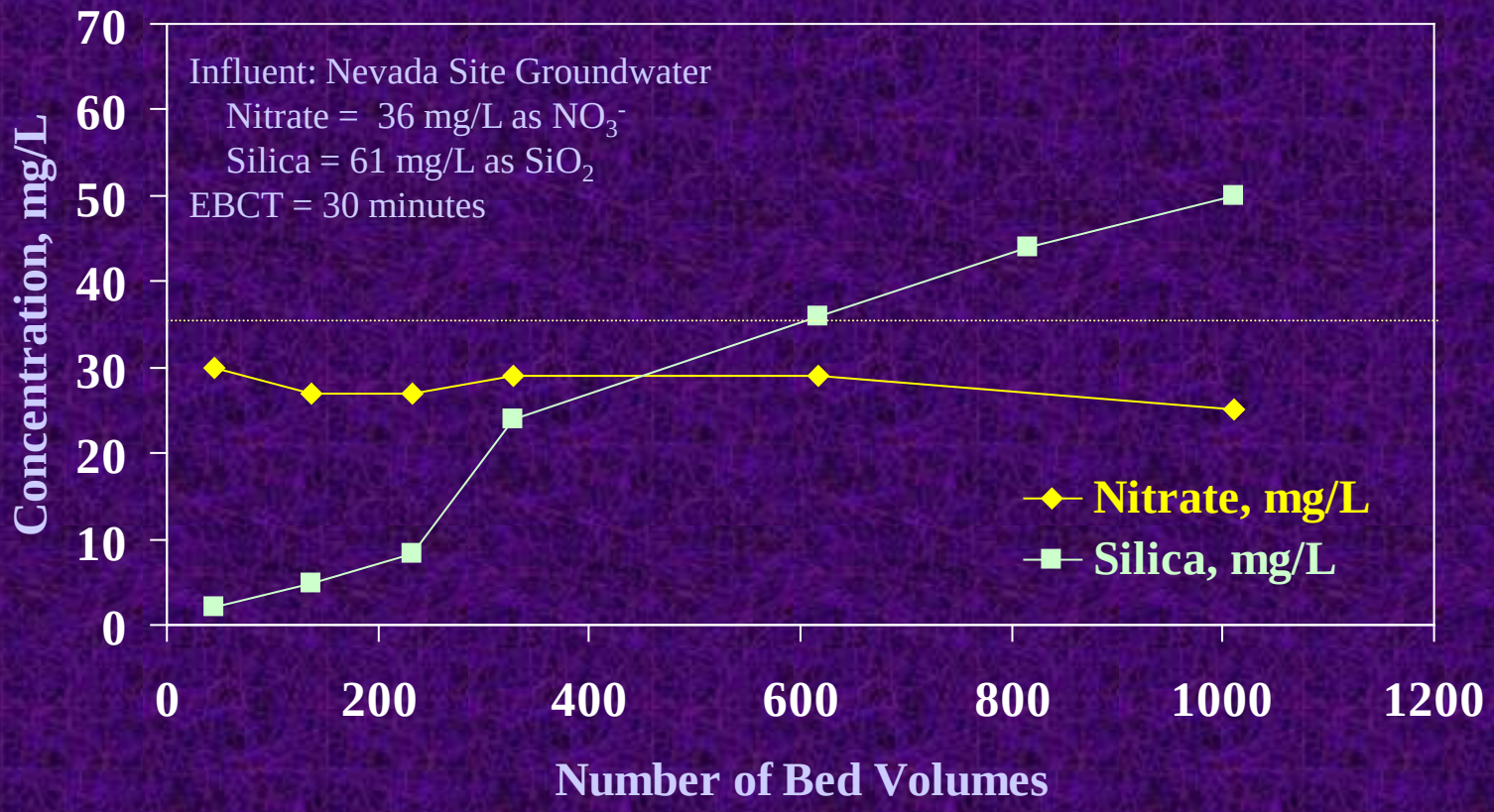
Arsenic Removal (Lab)



As Removal—Field Pilot Test

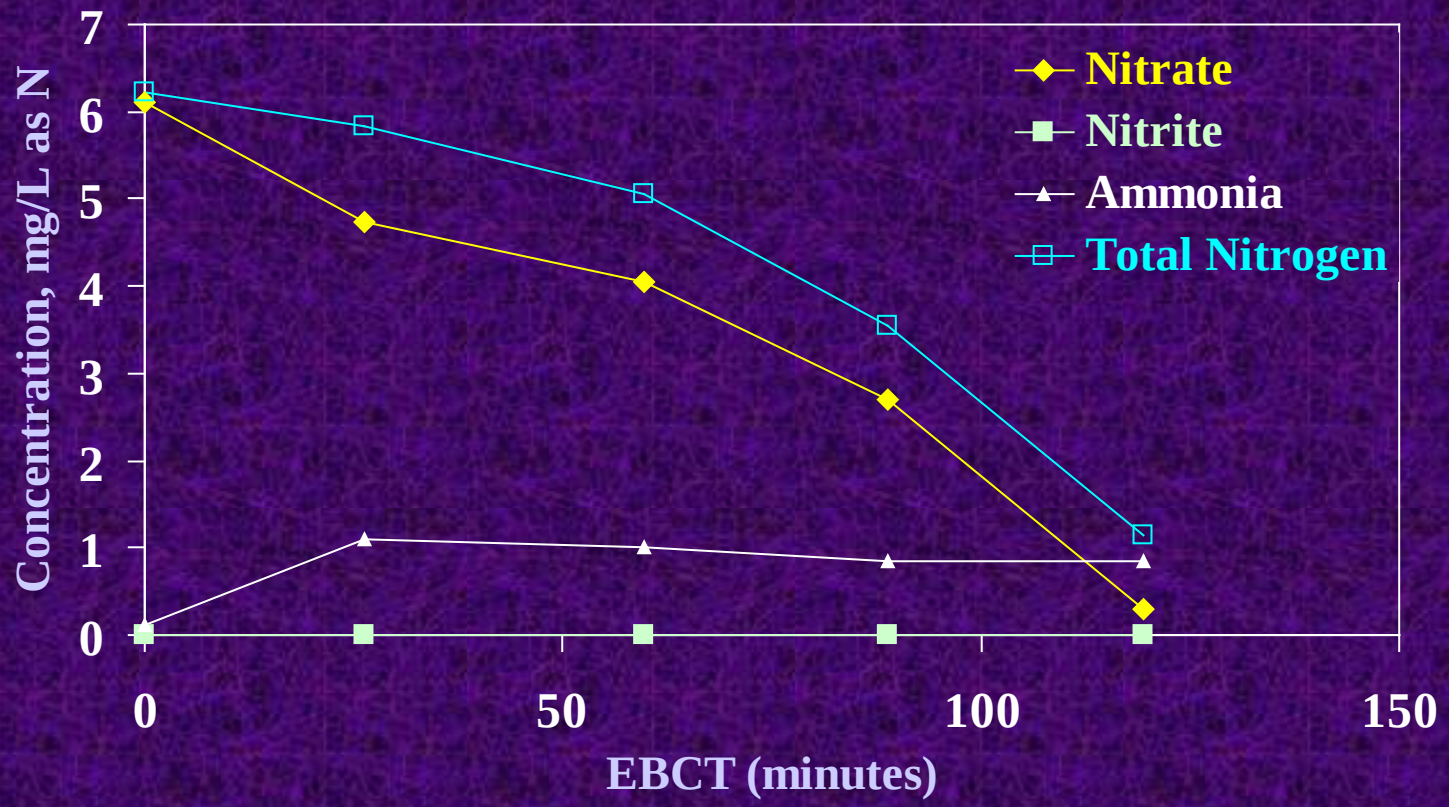
- **Field Test, East Niles, CA—groundwater**
  - **Column parameters**
    - **12” diameter column, 30” bed depth**
    - **2.5 GPM**
    - **Empty Bed Contact Time (EBCT) ~ 6 minutes**
    - **Backwash every 1000 gallons of production**
  - **About 200,000 gal (13,300 bed volumes) put through**
  -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

Nitrate Removal (Lab)



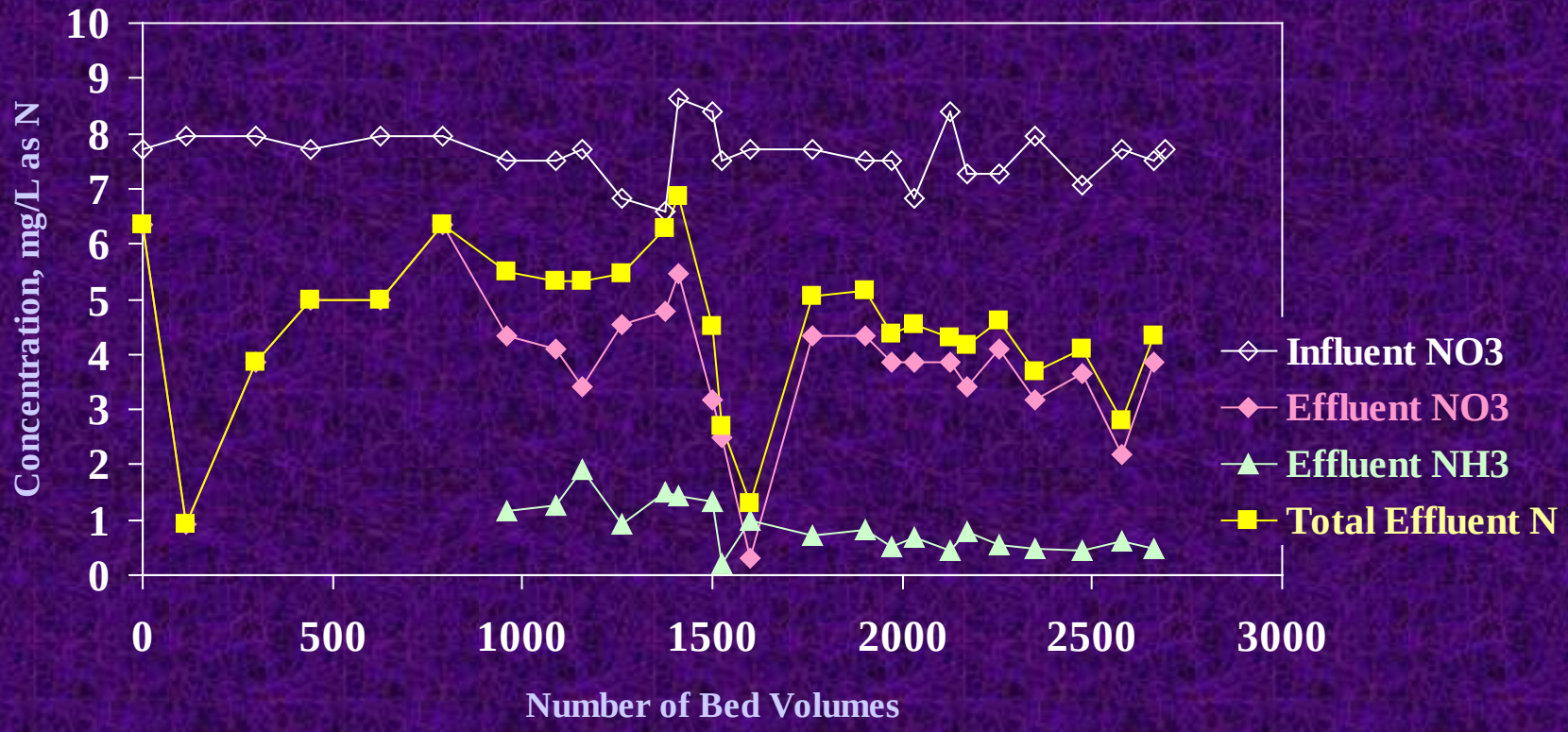
Nitrogen Mass Balance

Influent = Groundwater from Salinas, California



Nitrate Removal—Field Pilot

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



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

Application Information

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