MEDIA PERFORMANCE: LABORATORY AND PILOT STUDIES

Xiaoguang Meng, Sunbaek Bang
Maria E. Pena, and Chuanyong Jing, George Korfiatis
Stevens Institute of Technology
Center for Environmental Systems,
Hoboken, NJ 08904, xmeng@steven.edu

Manish Patel
New Jersey Department of Environmental Protection
P.O. Box 409, Trenton, NJ 08625

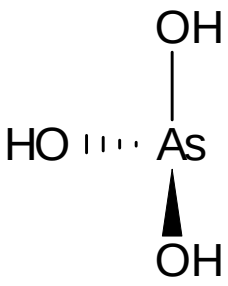
Overview

1. Basics of As adsorption by metal oxides and hydroxides
2. Batch adsorption results
3. Laboratory filtration results for removal of As(V) from the challenge water
4. Field pilot filtration results for removal of As(V) and As(III)
5. Field pilot filtration results for removal of As(III), As(V), monomethylarsonic acid (MMA), dimethylarsinic acid (DMA)

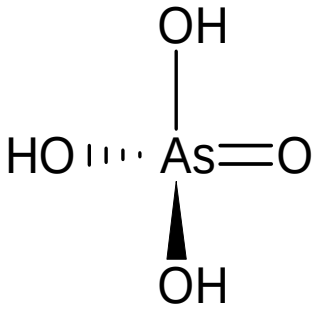
Adsorbents Tested

1. Granular TiO_2
2. Granular ferric oxide (GFO)
3. Granular ferric hydroxide (GFH)
4. Activated alumina (AA)
5. Iron-modified activated alumina

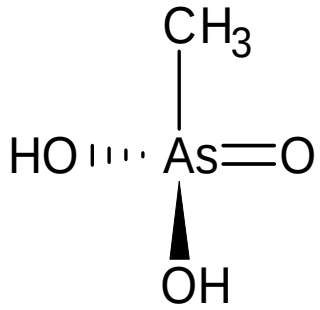
Common Arsenic Species



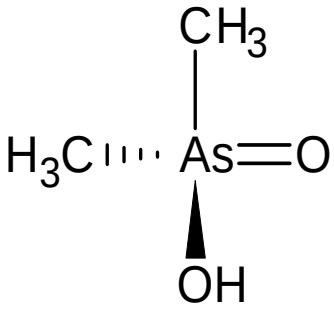
As(III)



As(V)



MMA



DMA

Parameters affecting As removal

STEVENS Institute of Technology

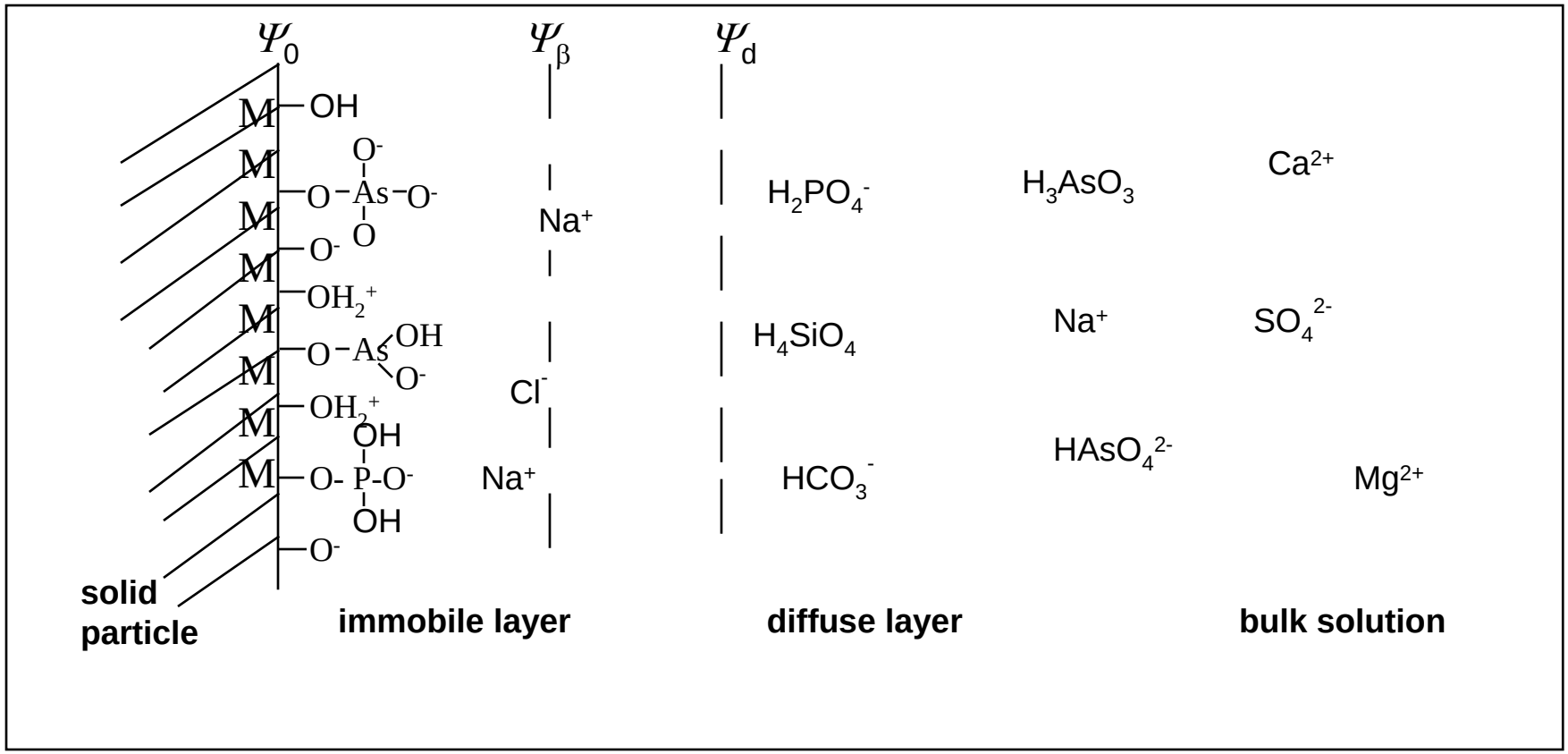
Properties of adsorbents

1. Activity and content of surface sites:
   Ti-OH, Fe-OH, Al-OH
1. Surface potential
   (pH_{ZPC}:TiO_2=5.8, α-FeOOH=7.8, α-Al_2O_3=9.1)
3. Specific surface area
4. Particle sizes
5. Pore size distribution

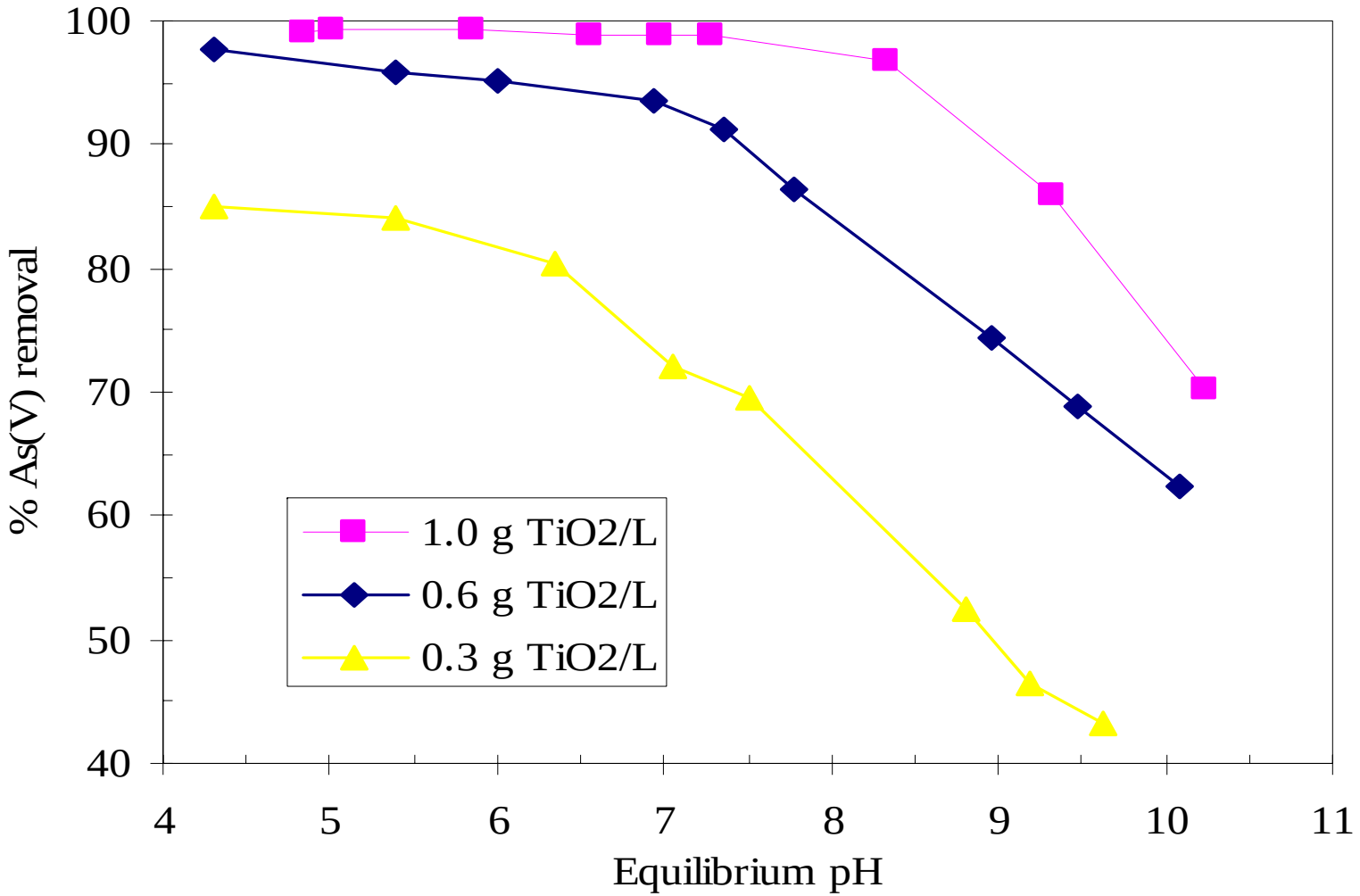
Water chemistry

- pH
- Phosphate, silicate, bicarbonate

Surface Adsorption Model

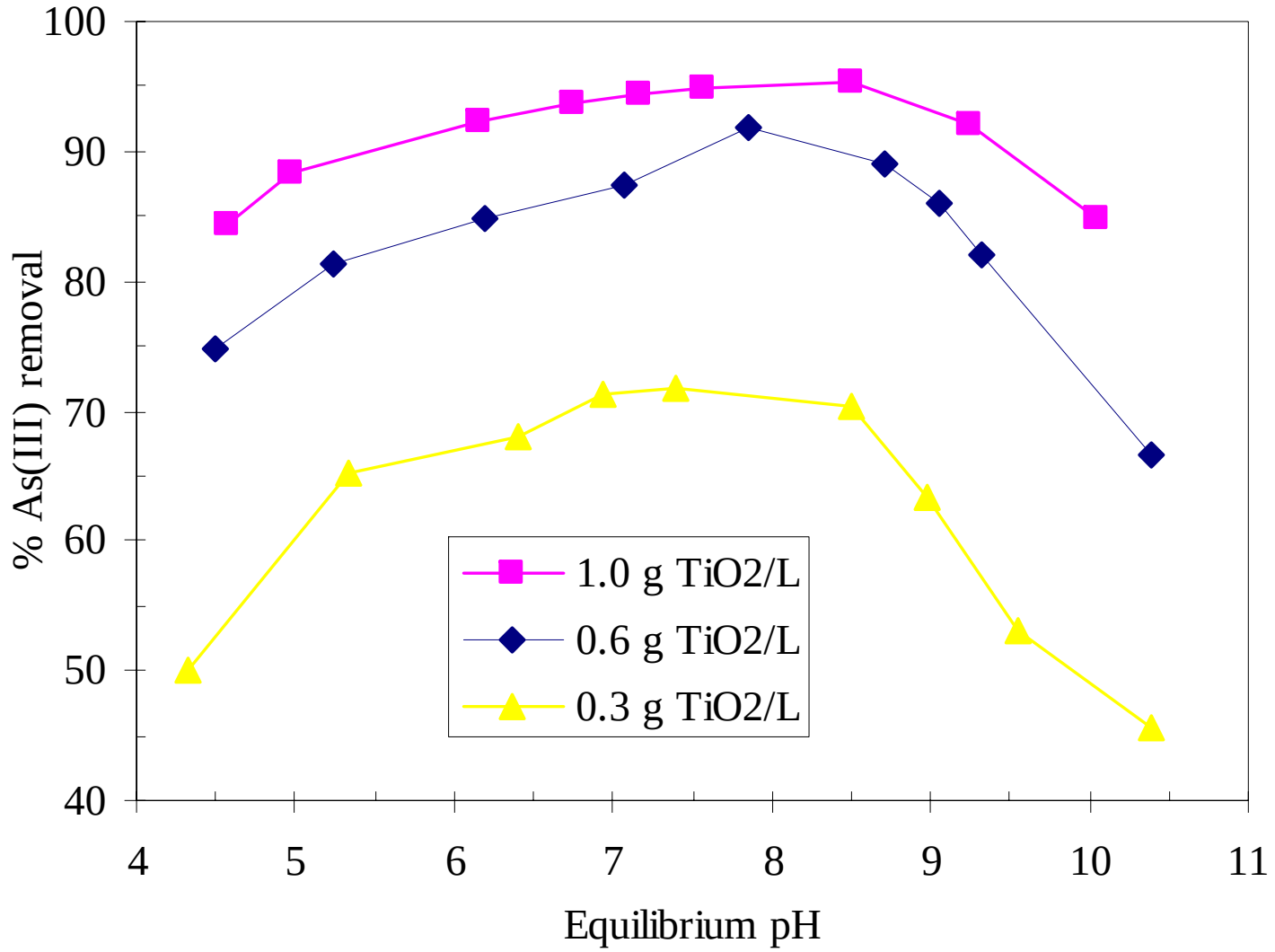


Batch Adsorption of As(V) by TiO_2



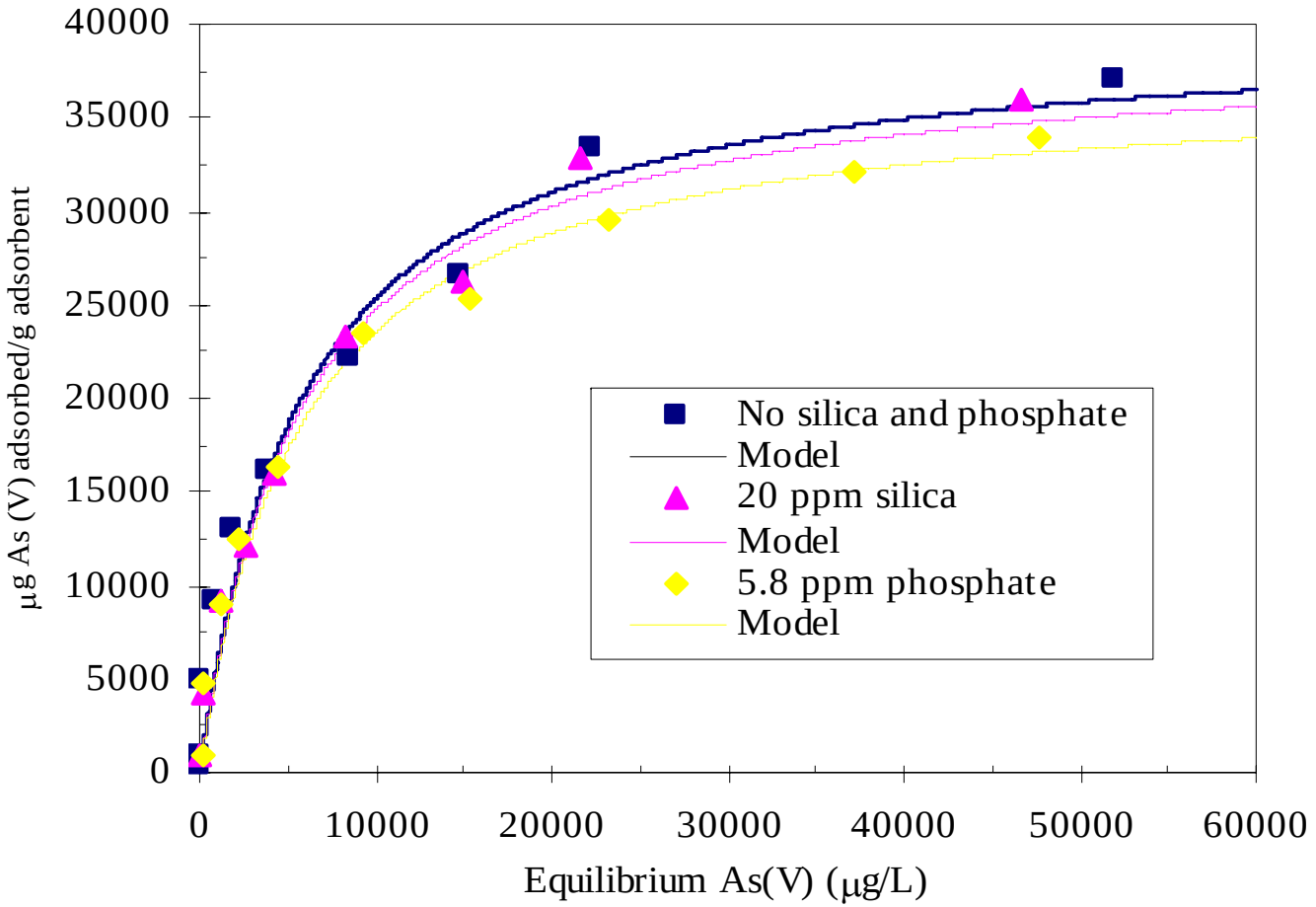
As=300 μg/L in spiked groundwater, mixing time=2 hr

Batch Adsorption of As(III) by TiO_2



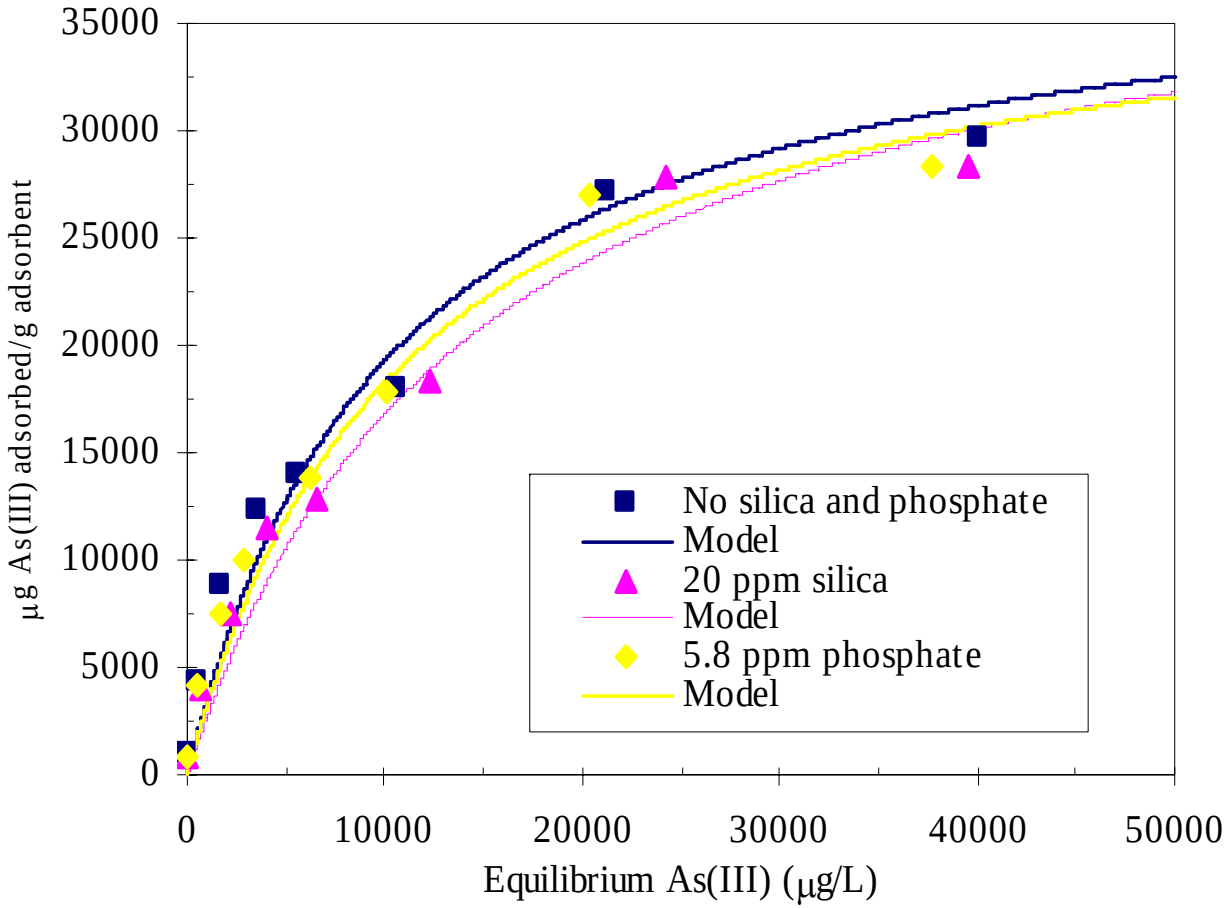
As=300 μg/L in spiked groundwater, mixing time=5 hr.

Effect of Si and P on As(V) adsorption



TiO_2=1.0 g/L, 2 hr, pH_{eq} = 7.0±0.1, Simulated groundwater (Ca = 100, Mg =20, Na =50 mg/L)

Effect of Si and P on As(III) adsorption



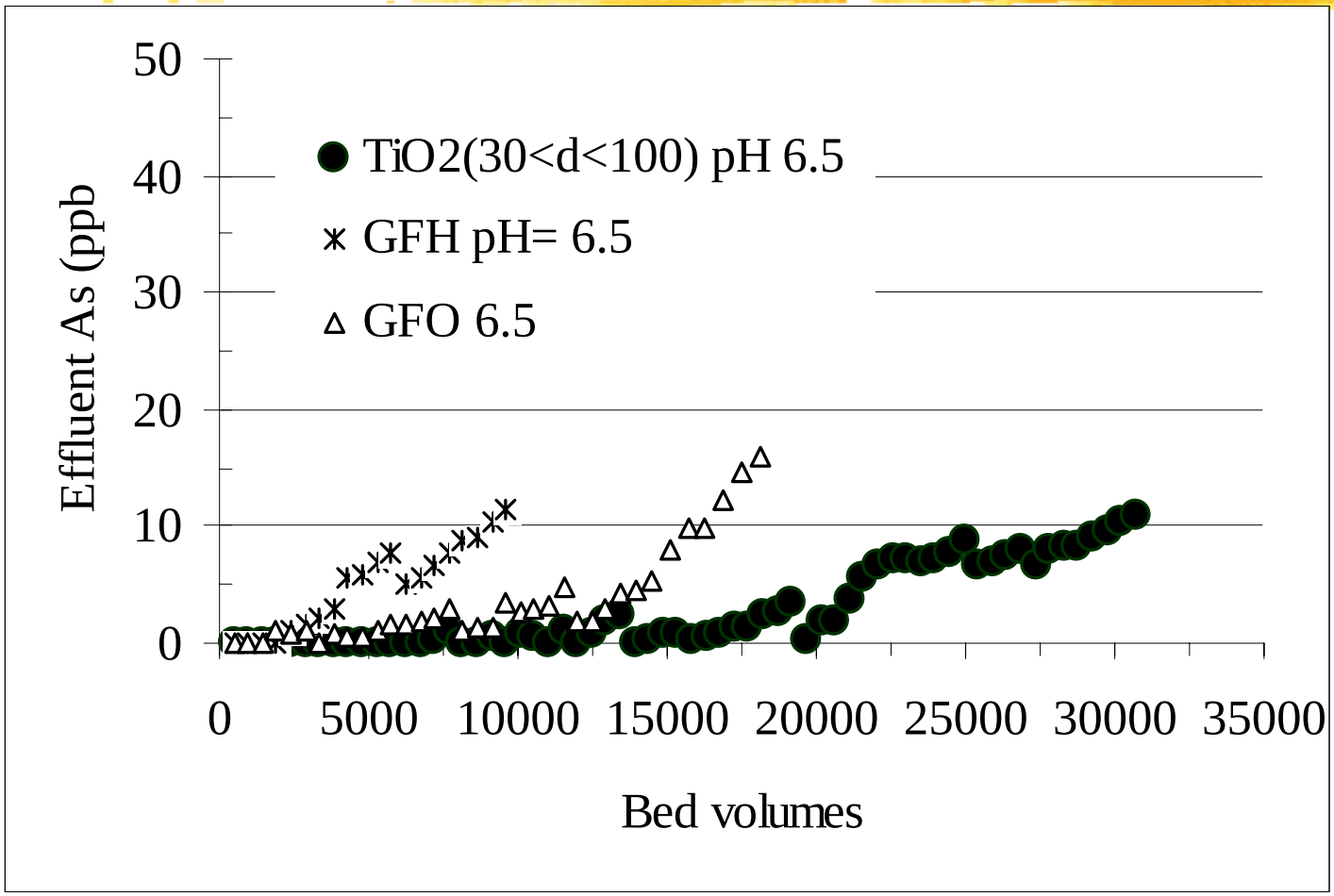
TiO_2=1.0 g/L, 5 hr, pH_{eq} = 7.0±0.1, Simulated groundwater (Ca = 100, Mg =20, Na =50 mg/L)

Laboratory Filtration of As(V) from Challenge Water, NSF International 53

STEVENS Institute of Technology

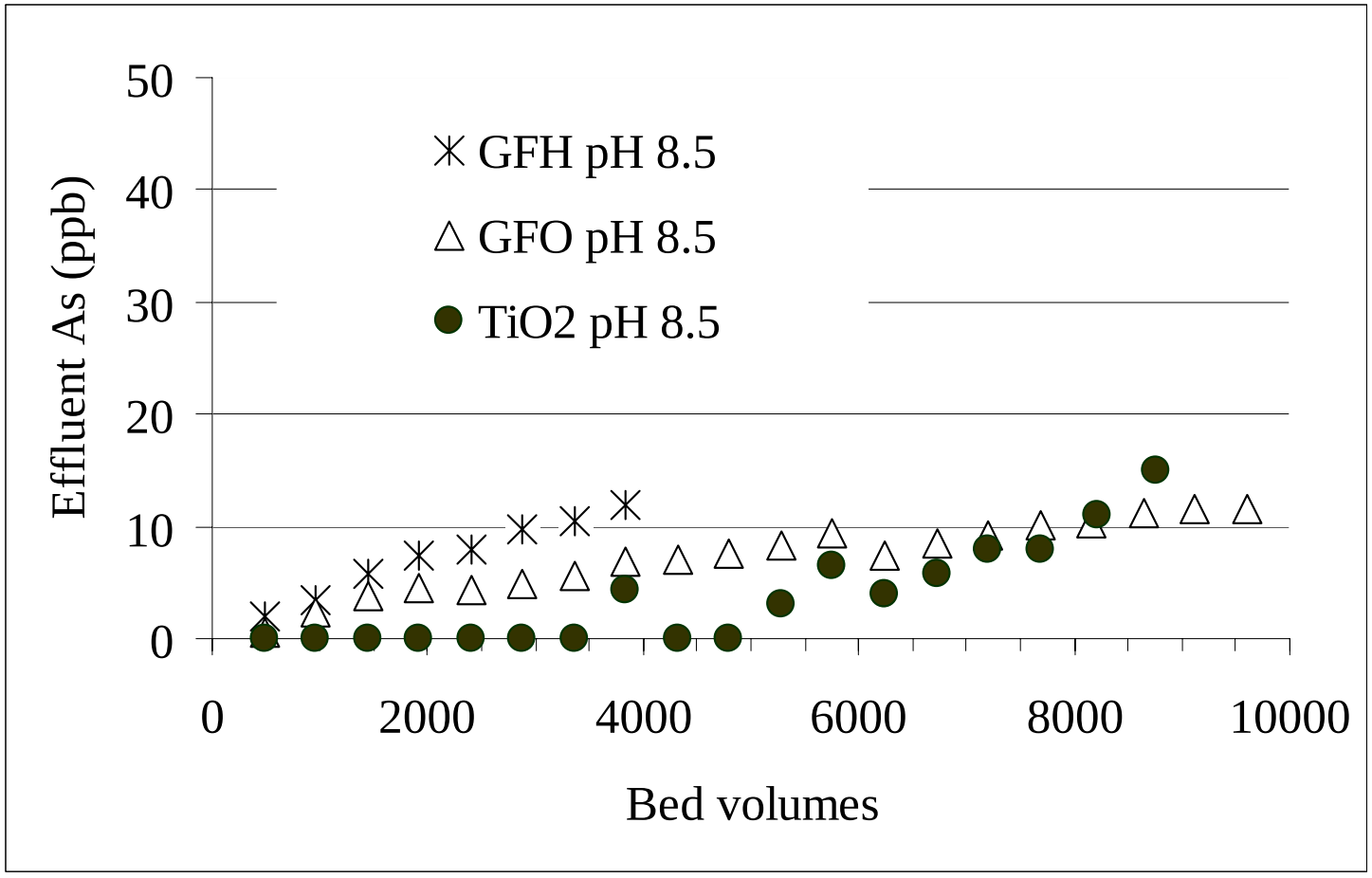
Water Chemistry	
As(V)	50, 300 μg/L
pH	6.5, 8.5
PO_4	0.04 mg/L
SiO_2	20 mg/L
$NaHCO_3$	250 mg/L
Filtration Conditions	
EBCT	15 sec.
Intermittent filtration	30min on /30min off 16 h test/d

Laboratory Filtration of As(V) from the Challenge Water



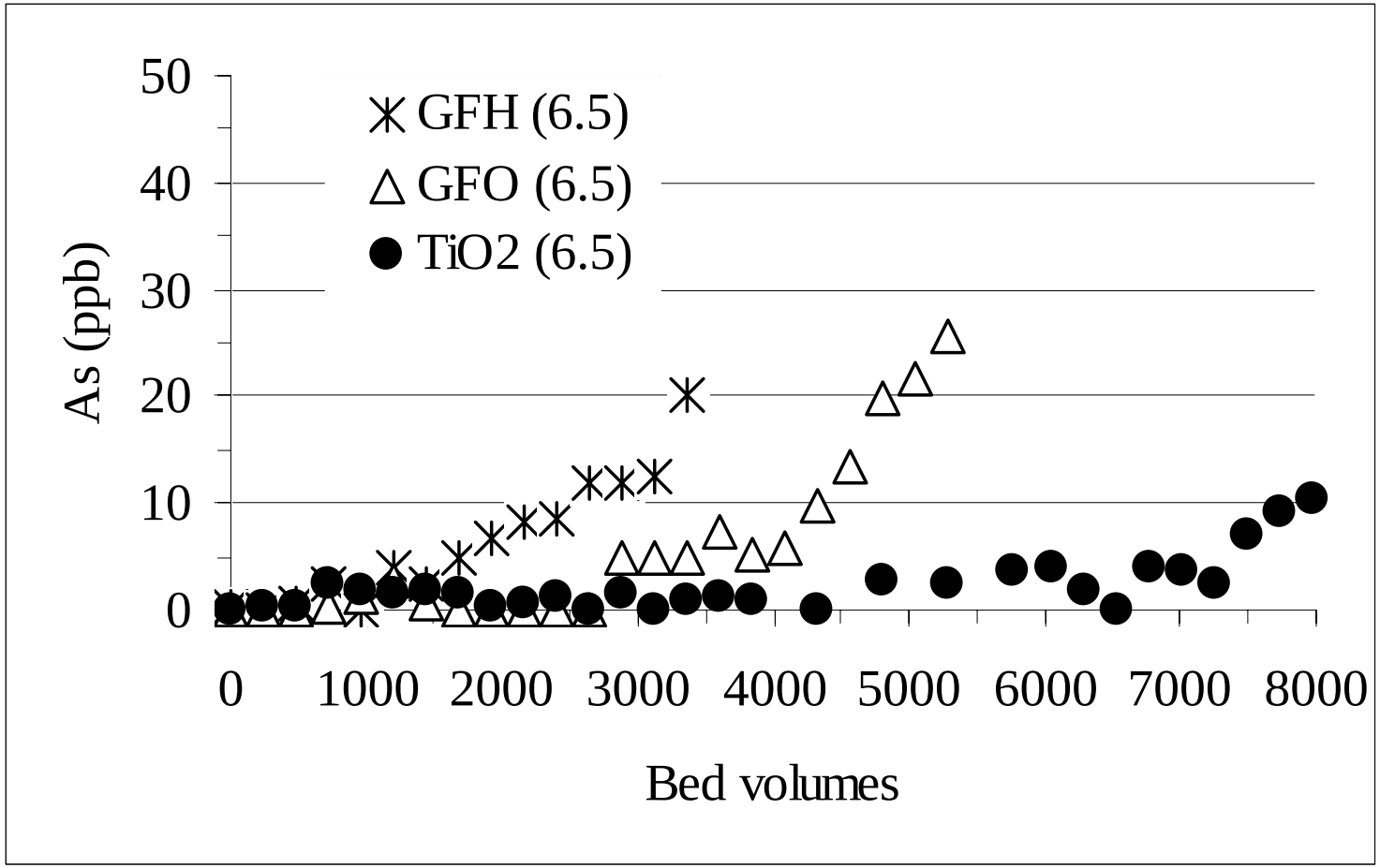
As(V)=50 ppb, pH=6.5, column D=1 in., H=3 in., bed volume=35ml

Laboratory Filtration of As(V) from the Challenge Water



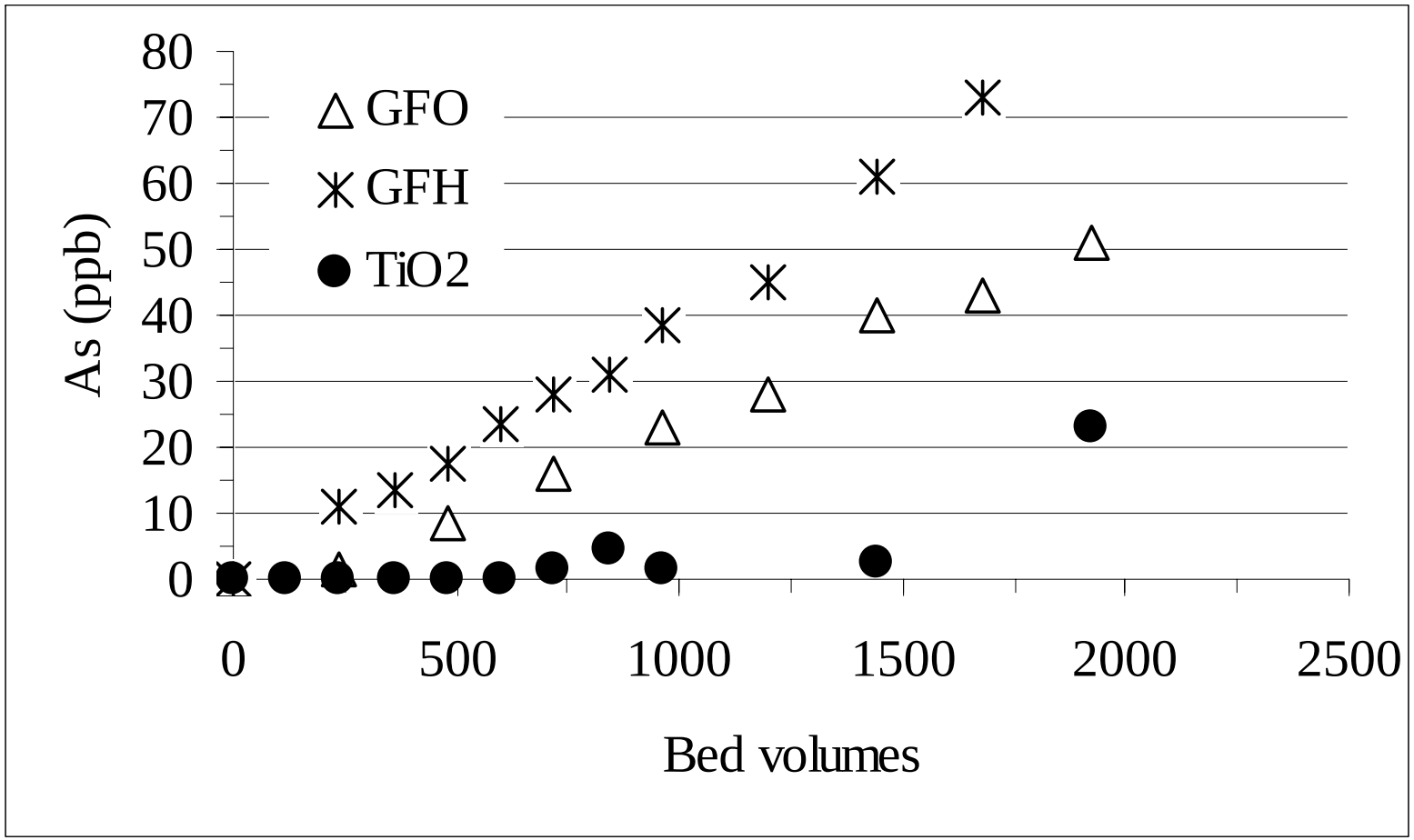
As(V)=50 ppb, pH=8.5

Laboratory Filtration of As(V) from the Challenge Water



As(V)=300 ppb, pH=6.5

Laboratory Filtration of As(V) from the Challenge Water



As(V)=300 ppb, pH=8.5

STEVENS
Institute of Technology

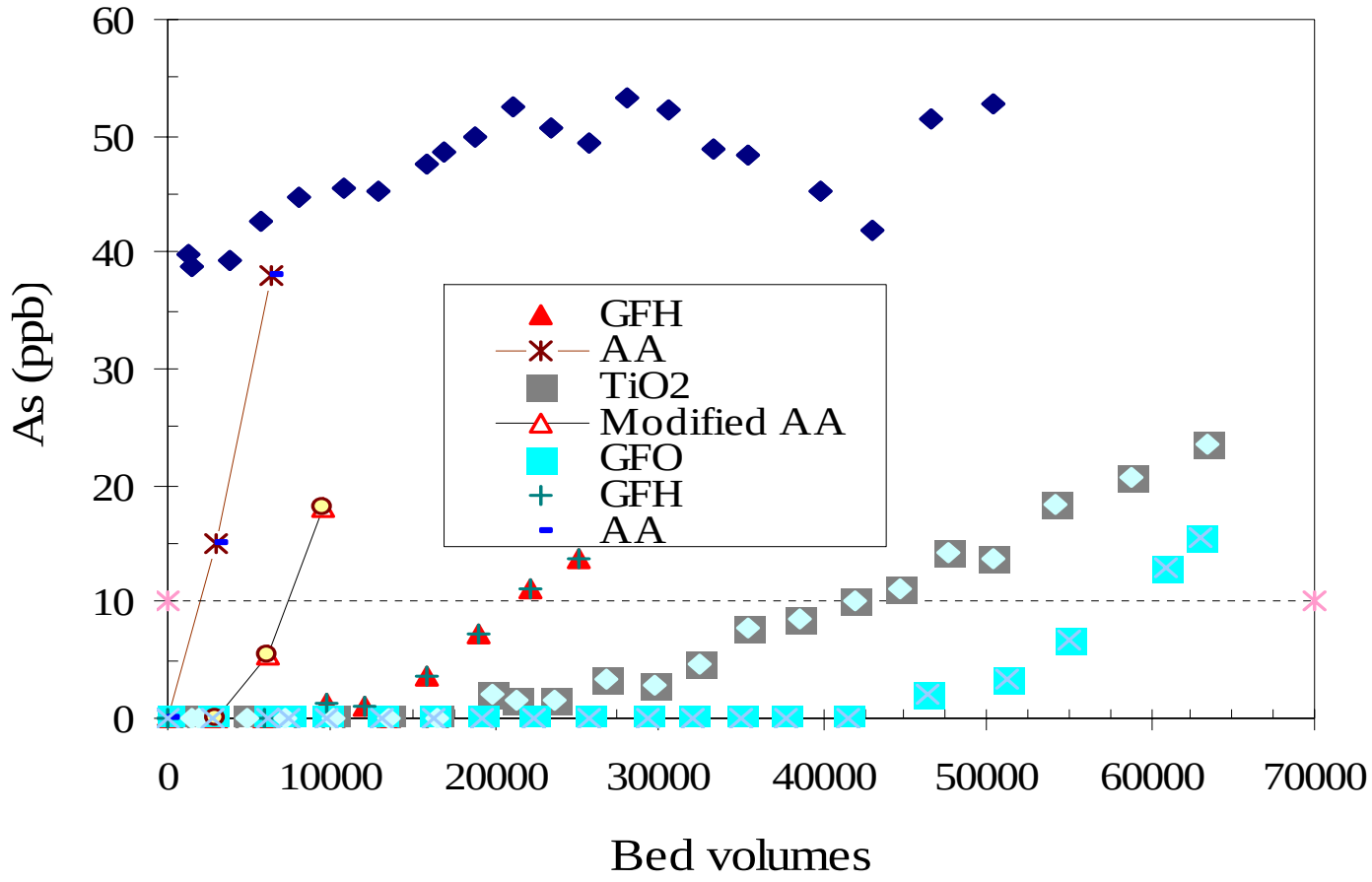
Filters tested in Hopewell, NJ

Chemical Properties of groundwater in Hopewell Borough

STEVENS Institute of Technology

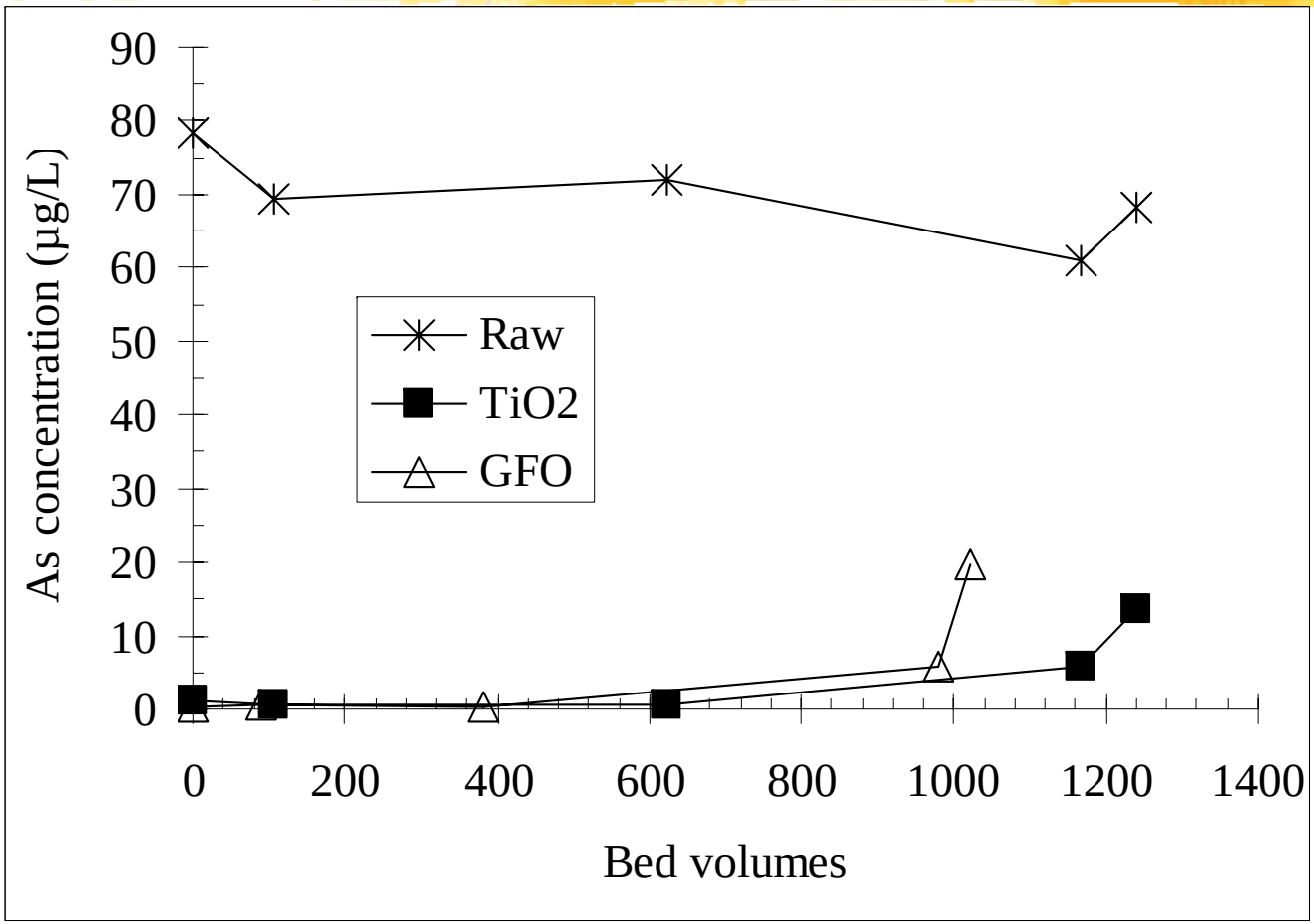
Alkalinity	130 mg $CaCO_3$/L
Calcium	40 mg/L
Magnesium	12 mg/L
Silica	20 mg/L
Iron	<0.02 mg/L
Sulfate	62 mg/L
pH	7.92
ORP	243 mV

Removal of As from Groundwater in Hopewell, NJ

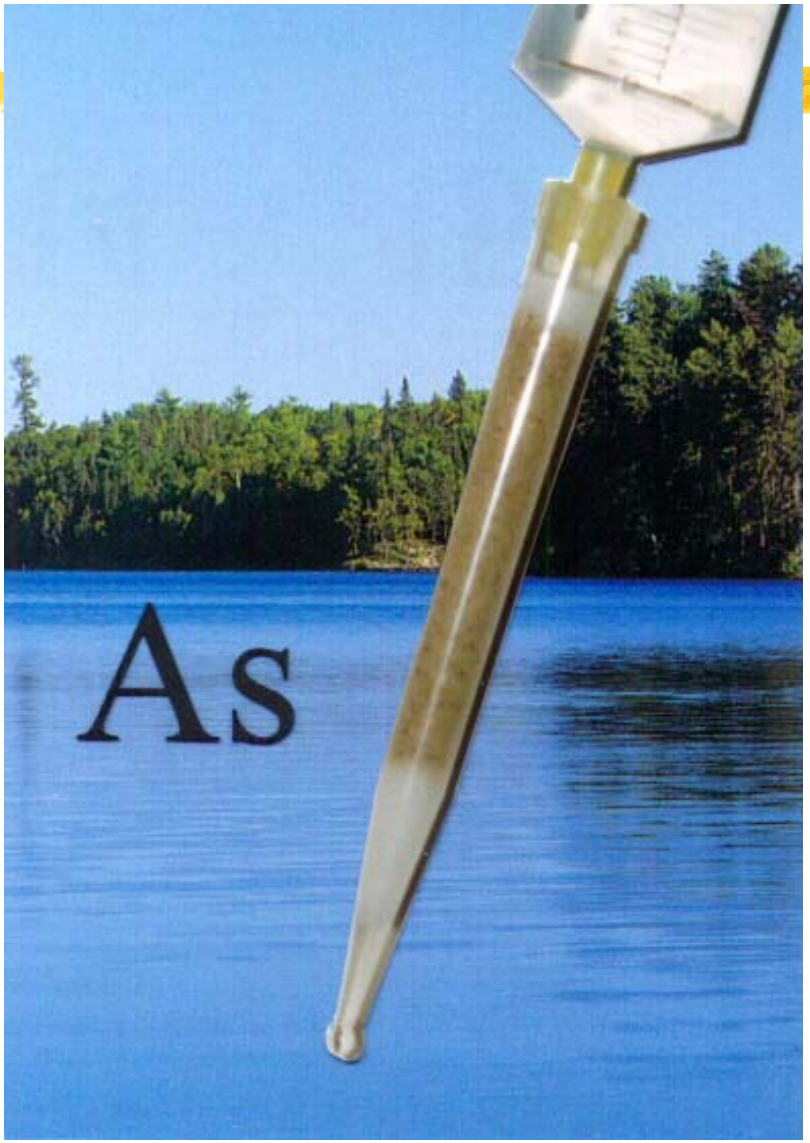


Bed volume=3 L, EBCT = 3 min

Removal of As(III) from Well Water in NJ



Water pH=7.3, ~80% As(III), BV=1.5 L, EBCT = 5 min, ORP=-100mV, P<20 ppb, Si=39ppm.



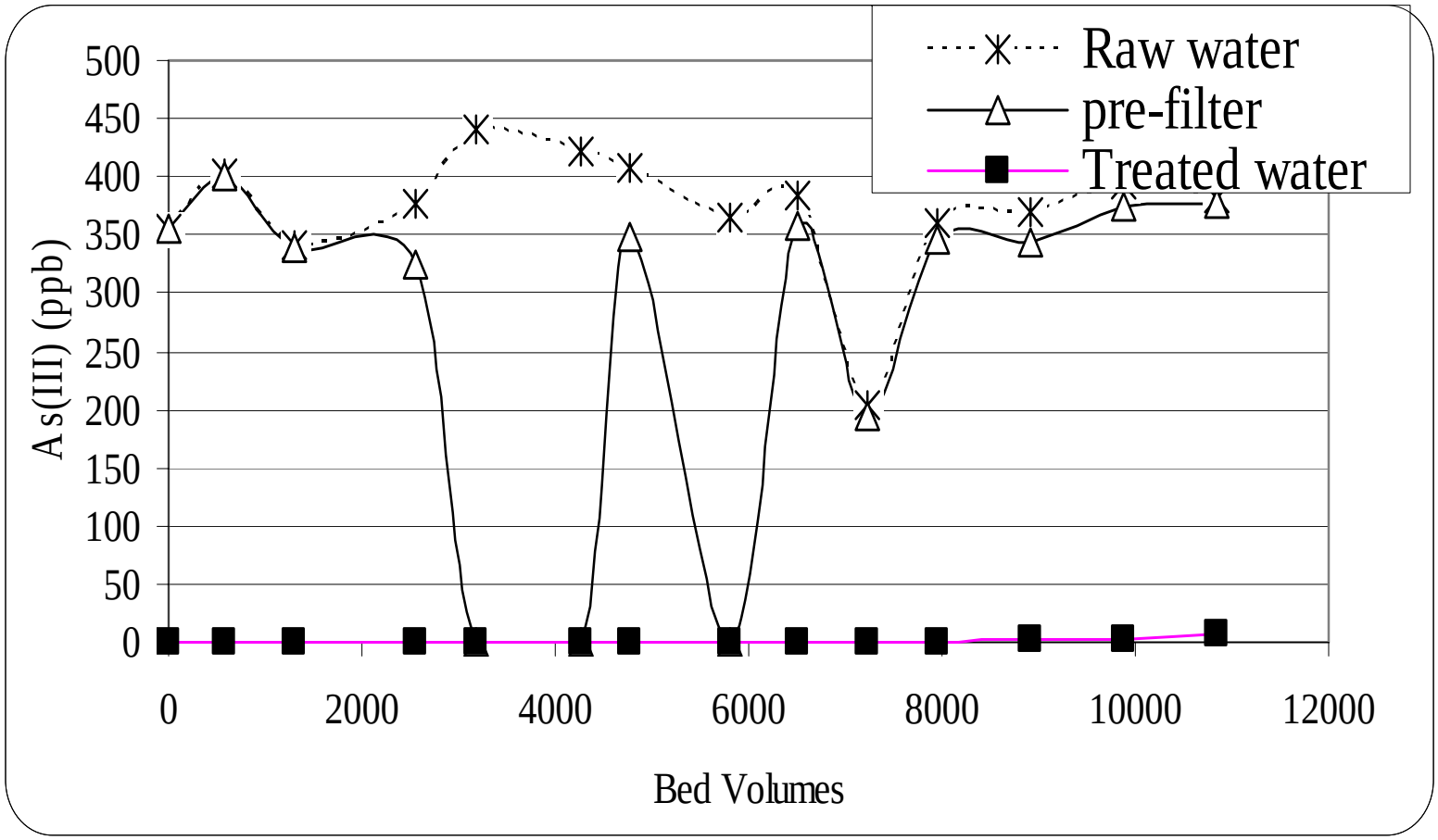
Speciation cartridge used for separation of As(V) and As(III), rapid flow, no pH adjustment

Chemical Properties of Groundwater at a Superfund Site

STEVENS Institute of Technology

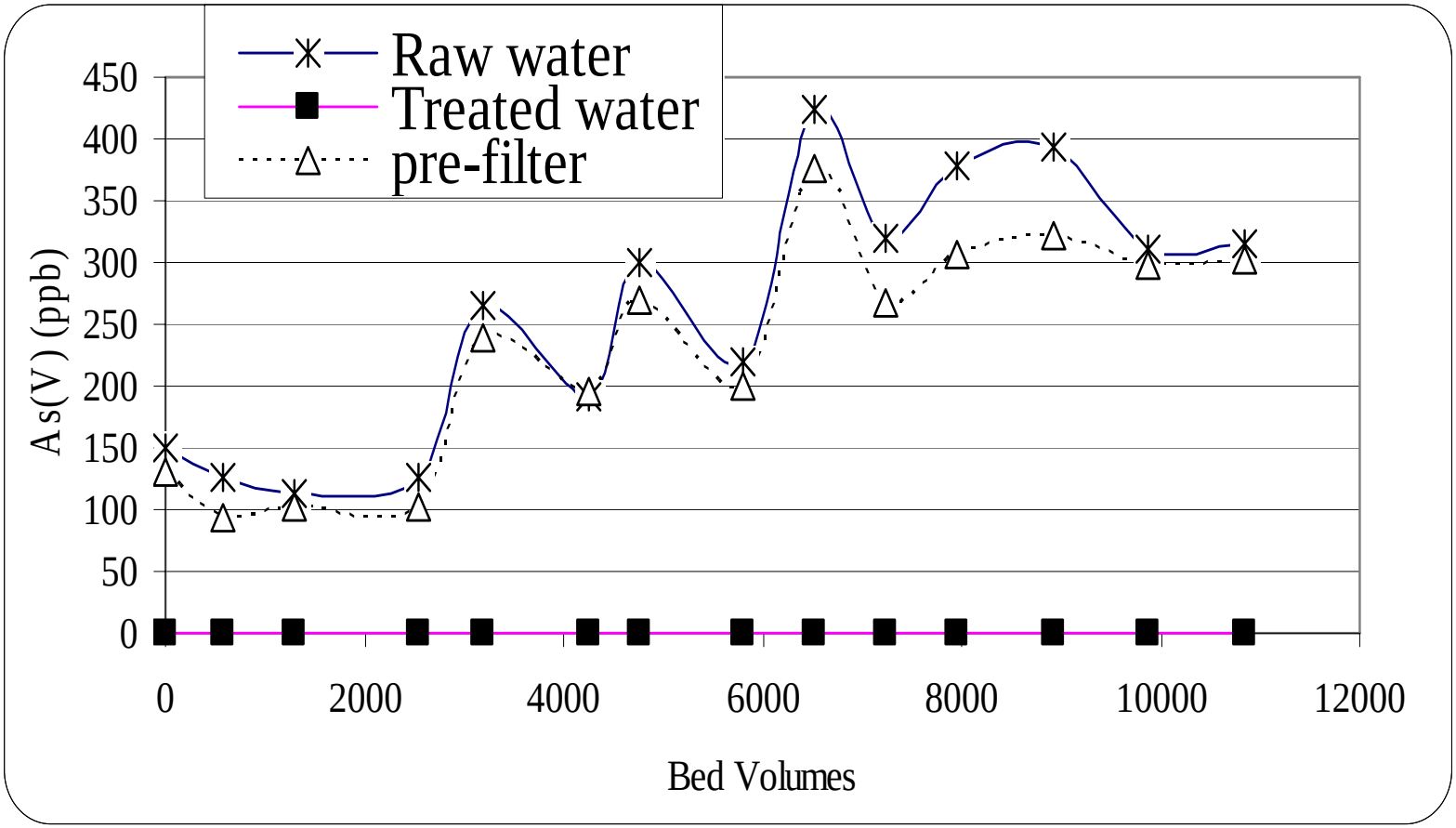
As(III)	205-440 μg/L
As(V)	112-425 μg/L
MMA	104-301 μg/L
DMA	123-490 μg/L
pH	5.5 – 6.2
ORP	123 mV
DO	1.8 ppm
PO4	74 ppb
SiO2	

Removal of As(III) from Groundwater at a Superfund Site



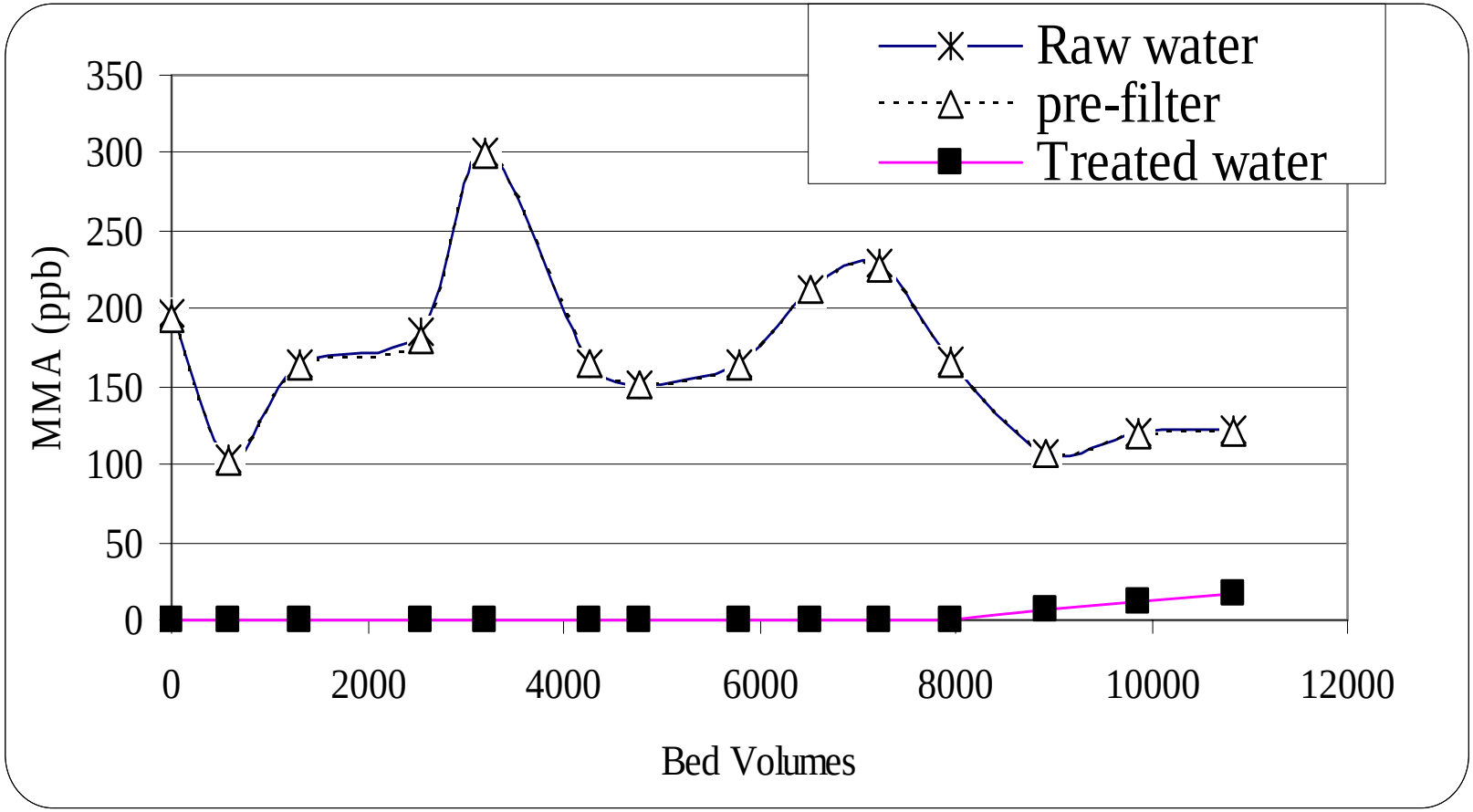
TiO_2 BV=3 L, EBCT = 6 min, pre-filter=5 μm

Removal of As(V) from Groundwater at a Superfund Site



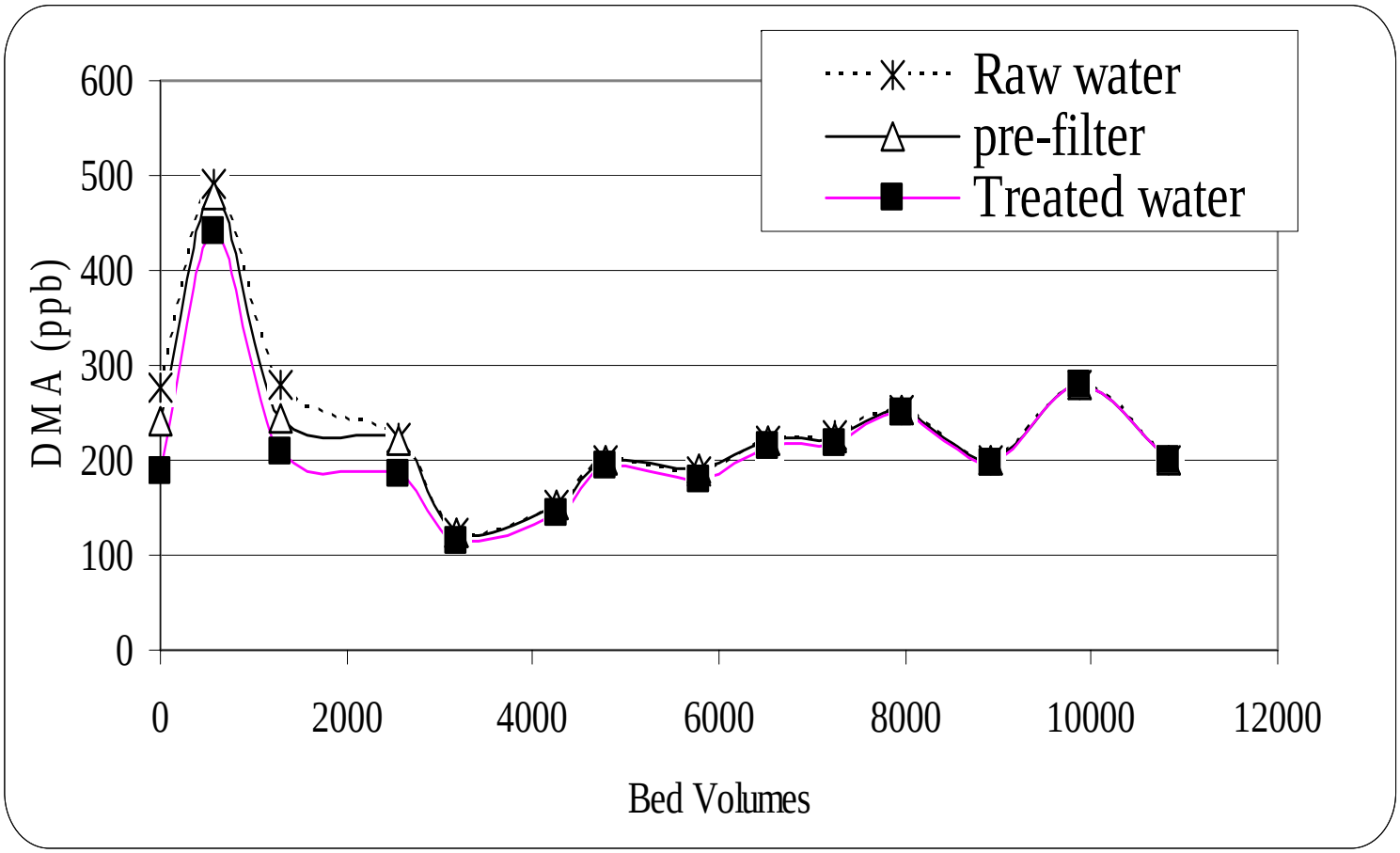
TiO_2 BV=3 L, EBCT = 6 min

Removal of MMA from Groundwater at a Superfund Site



TiO_2 BV=3 L, EBCT = 6 min

Removal of DMA from Groundwater at a Superfund Site



TiO_2 BV=3 L, EBCT = 6 min

Conclusions

STEVENS Institute of Technology

- TiO_2 and GFO are more effective for removal of As(V) than other adsorbents tested in the present work.
- Phosphate and silicate do not have significant effect on the removal of arsenic by TiO_2.
- TiO_2 performs better than other absorbents at short EBCT and in the presence of competing anions.
- TiO_2 is effective for removal of MMA.
- The adsorbents are not effective for removal of As(III) from an anoxic well water.