CONSORCIO DE INVESTIGACION Y POLITICA AMBIENTAL DEL SUROESTE
SOUTHWEST CONSORTIUM FOR ENVIRONMENTAL RESEARCH & POLICY

Evaluation of inexpensive sorption technologies for arsenic removal from groundwater in the Arizona-Mexico border region

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Outline

1. Need for the study
2. Goal and objectives
3. Research approach
4. Findings
5. Conclusions
6. Research benefits

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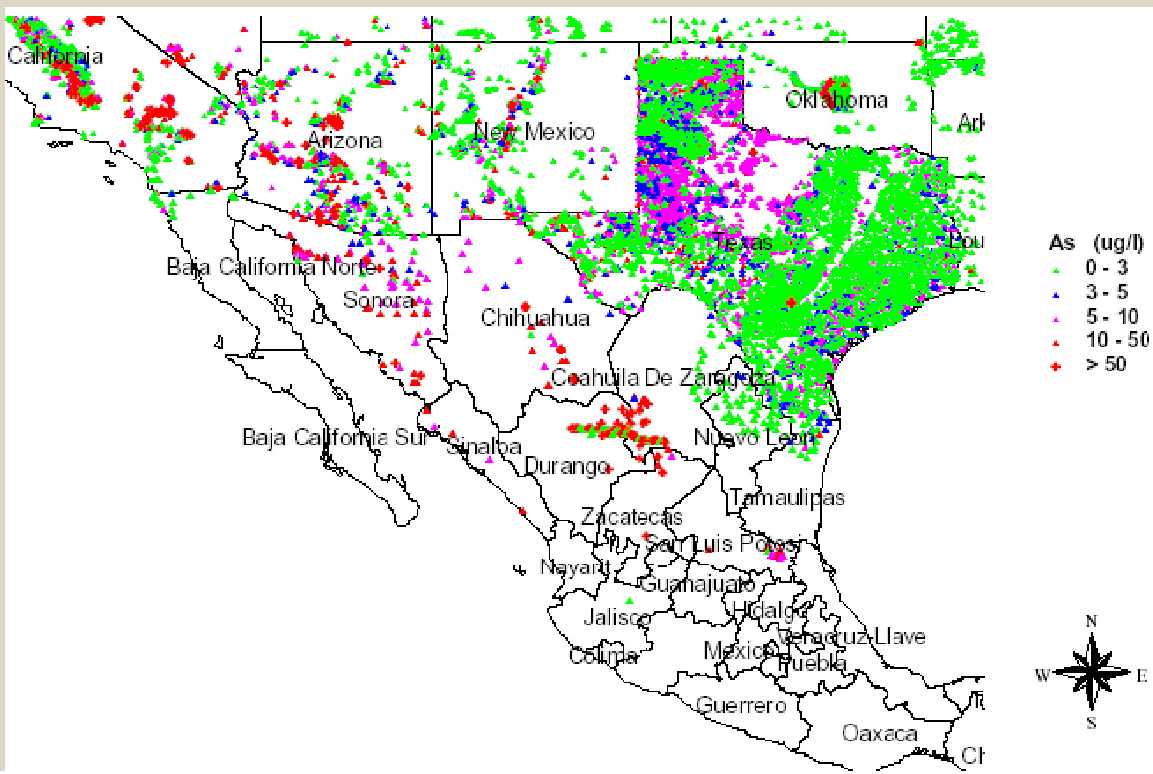
Need for the Study

- New toxicity data suggests As causes health problems in low doses
- High levels of As in US/Mexico border region groundwater
- Small poor and rural communities in US/Mexico border region cannot afford expensive potable water treatment system



Goal and Objectives of the Study

To develop and evaluate inexpensive surfactant or metal (hydr)oxide based technologies capable of removing arsenic from groundwater with chemistry typical for the Arizona-Mexico border region.

Objective 1: Formulate model water with a chemistry matrix representing the chemistry of groundwater found in the Arizona-Mexico Border region.

Objective 2: Fabricate and characterize inexpensive surfactant-coated media and/or metal (hydr)oxide based media capable of ample arsenic removal.

Objective 3: Conduct isotherm experiments to evaluate the arsenic removal capacity of the fabricated media, and select the best performing media.

Objective 4: Conduct short bed adsorber column tests to evaluate the arsenic sorption kinetics for the best performing media.

Research Approach

Objective 1: Evaluated chemistries of 83 groundwater matrices from the US-Mexico border region. Representative model groundwater matrix prepared and used in all experiments.

Objective 2: Fabricated Iron (hydr)oxide GAC, Zirconium oxide GAC, Surfactant clinoptilolite and Surfactant GAC media.

Objective 3: Determined arsenic adsorption capacity under equilibrium conditions. Assessed if metal (hydr)oxide GAC can remove organics

Objective 4: Conducted short bed adsorber column tests in model groundwater to evaluate the sorption kinetics impact on arsenic removal performance.

Findings

Developing a standardized model groundwater matrix to realistically represent the US/Mexico border region groundwater

Contaminant Species	Concentration of Ion (mg/L)	Added As	Concentration of Compound (mg/L)
N as NO_3^-	1.60	$NaNO_3$	2.20
F^-	1.10	NaF	2.43
PO_4^{3-}	0.069	$NaH_2PO_4.H_2O$	0.10
B^-	6.60	H_3BO_3	37.7
Pb(II)	0.002	$Pb(NO_3)_2$	0.003
Cr(III)	0.001	$CrK(SO_4)_2.12H_2O$	0.010
Fe(III)	0.075	$FeCl_3.6H_2O$	0.363
Mn(II)	0.029	$MnCl_2.4H_2O$	0.104
V(III)	0.007	Na_3VO_4	0.025
Se(IV)	0.003	$SeCl_4$	0.008
As(V)	0.12	$Na_2HAsO_4.7H_2O$	0.500
Al(III)	0.046	$Al_2(SO_4)_3.18H_2O$	0.568
Cu(II)	0.031	$CuSO_4.5H_2O$	0.194
Zn(II)	0.101	$ZnSO_4.7H_2O$	0.444
Mo(VI)	0.007	$Na_2MoO_4.2H_2O$	0.018
SiO_2	20	$Na_2SiO_3.9H_2O$	94.6
Mg^{2+}	12	$MgSO_4.7H_2O$	626
SO_4^{2-}	197	$MgSO_4.7H_2O$	626
Ca^{2+}	40	$CaCl_2$	110

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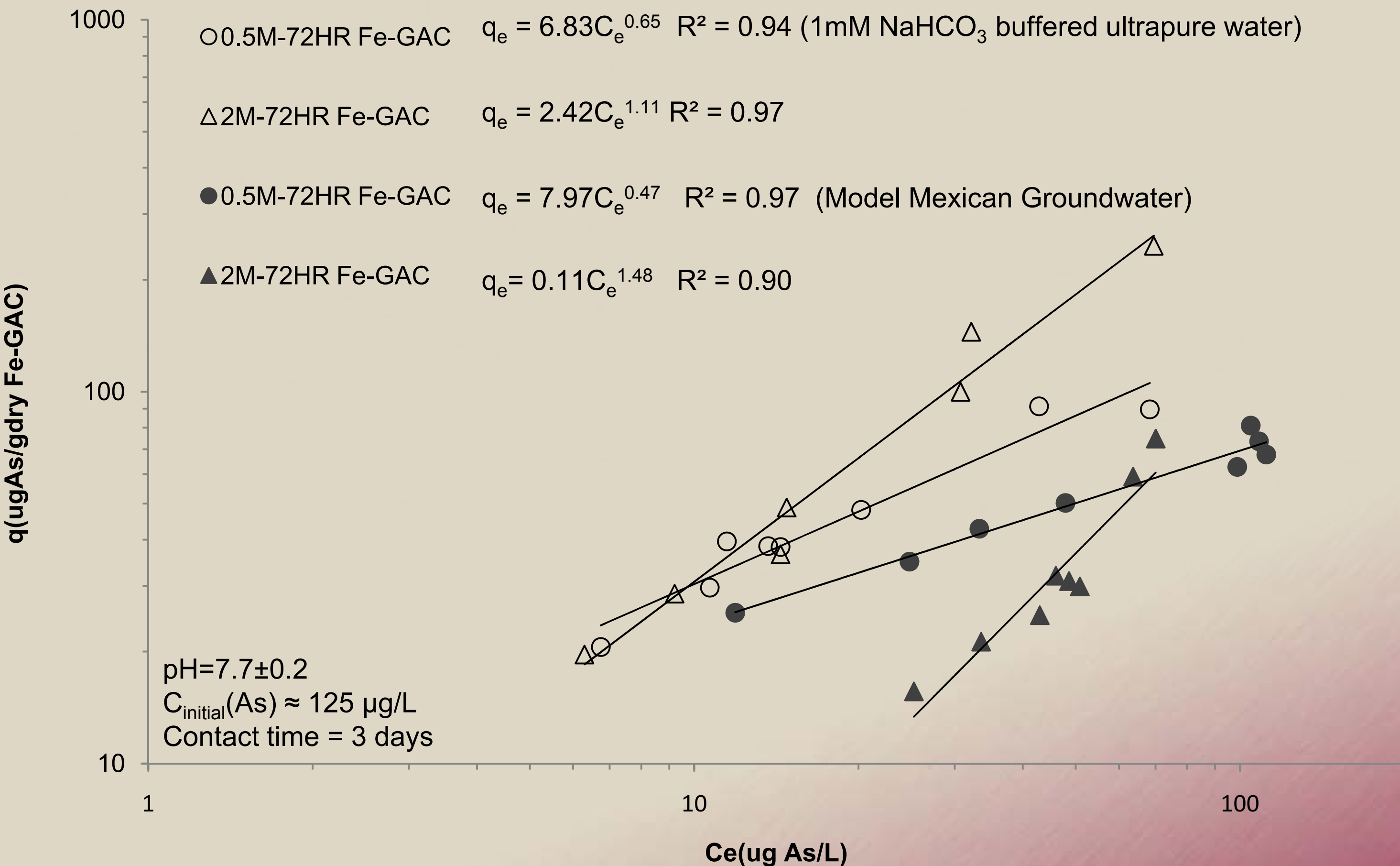
Findings

Freundlich Arsenate Adsorption Isotherms for Fe-GAC



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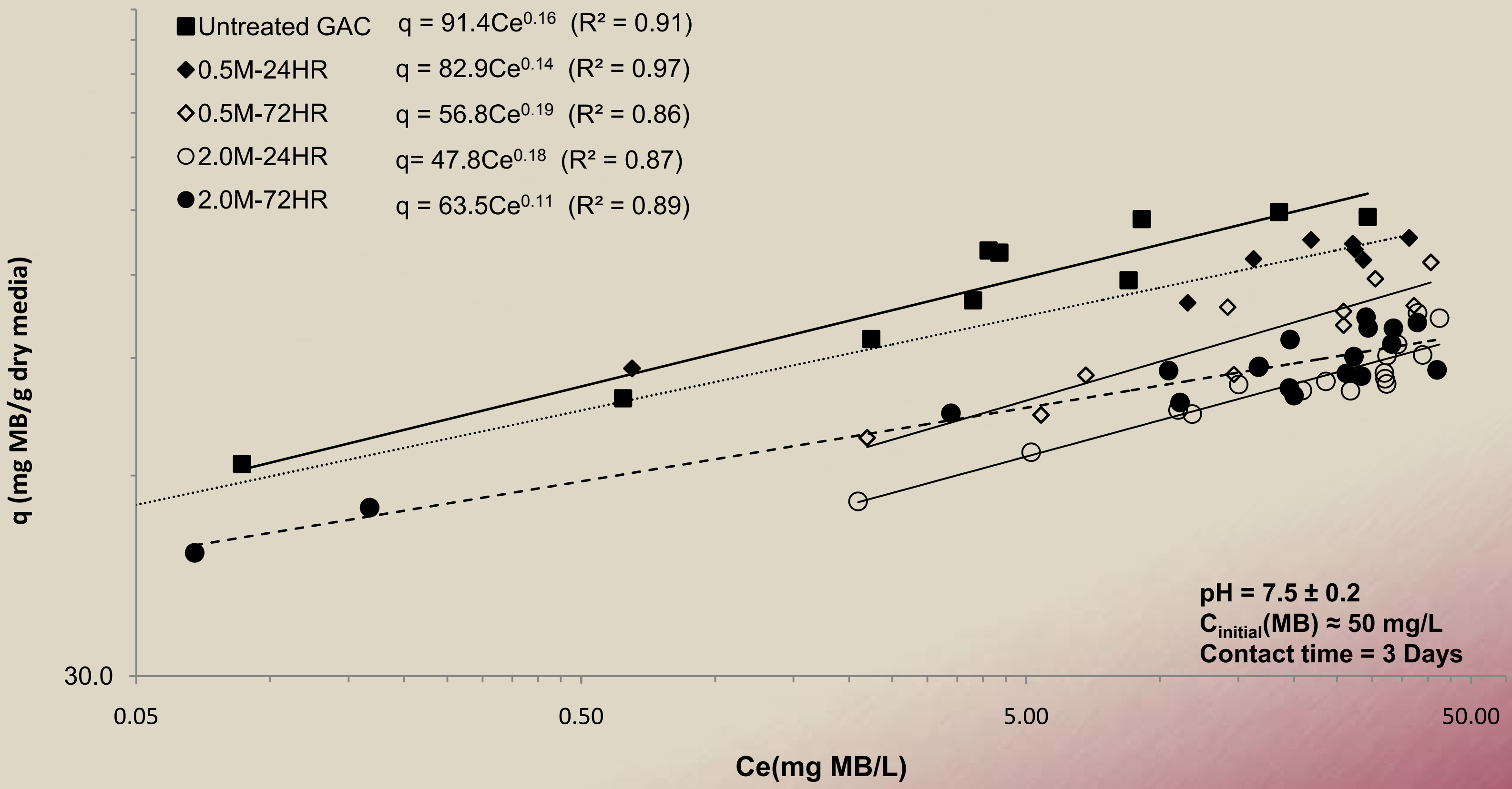
Findings

Freundlich Methylene Blue Adsorption Isotherms



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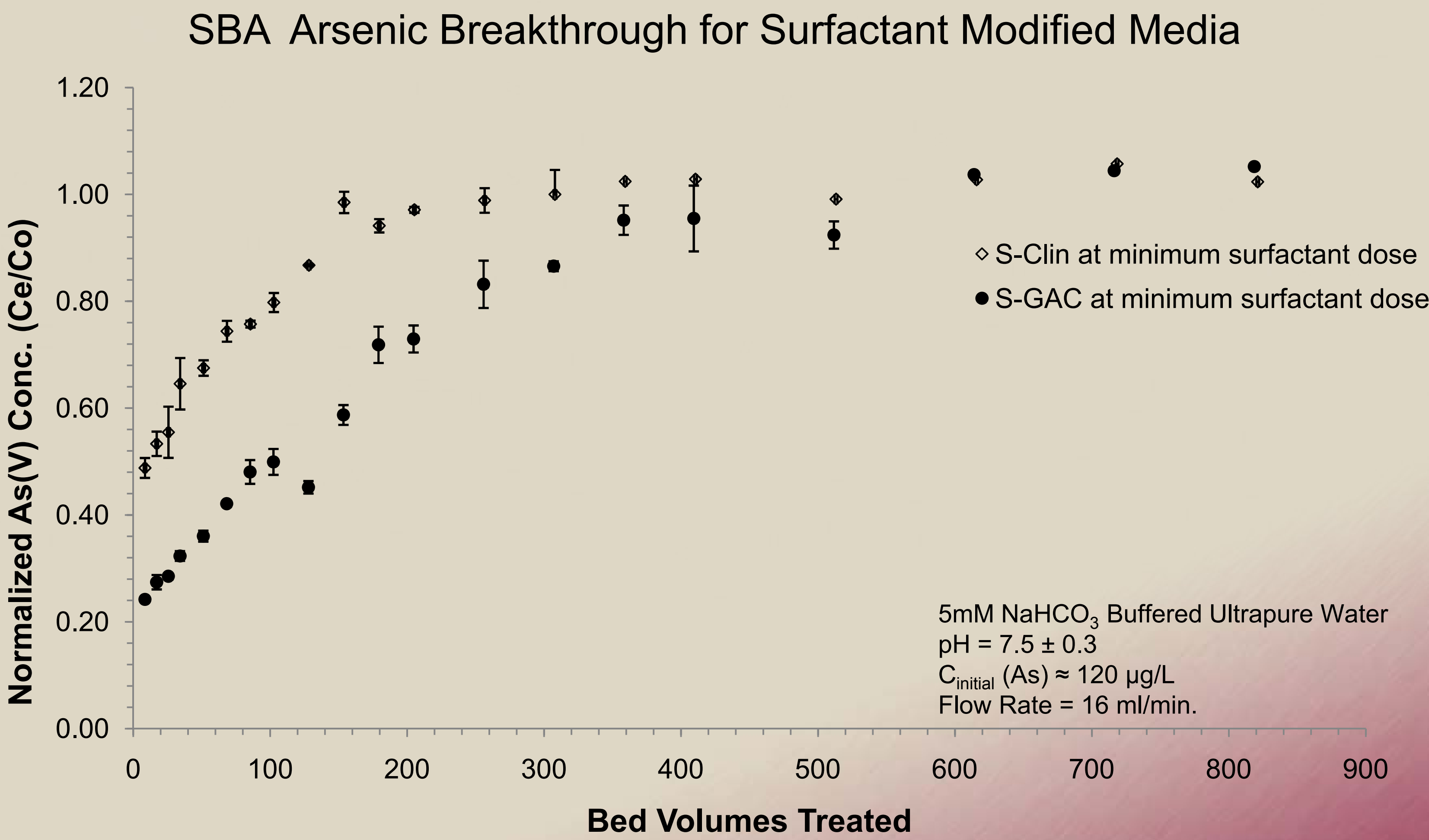
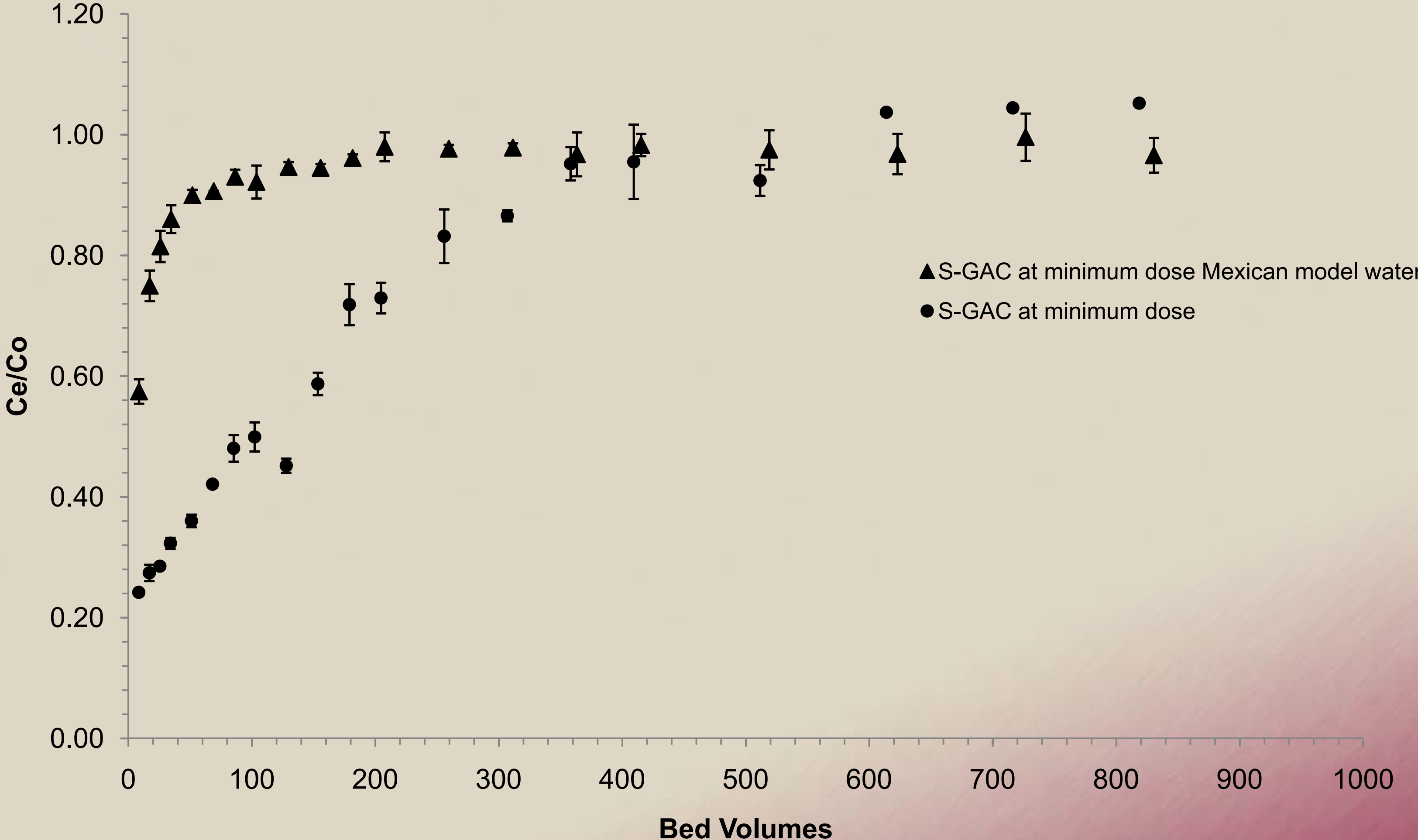
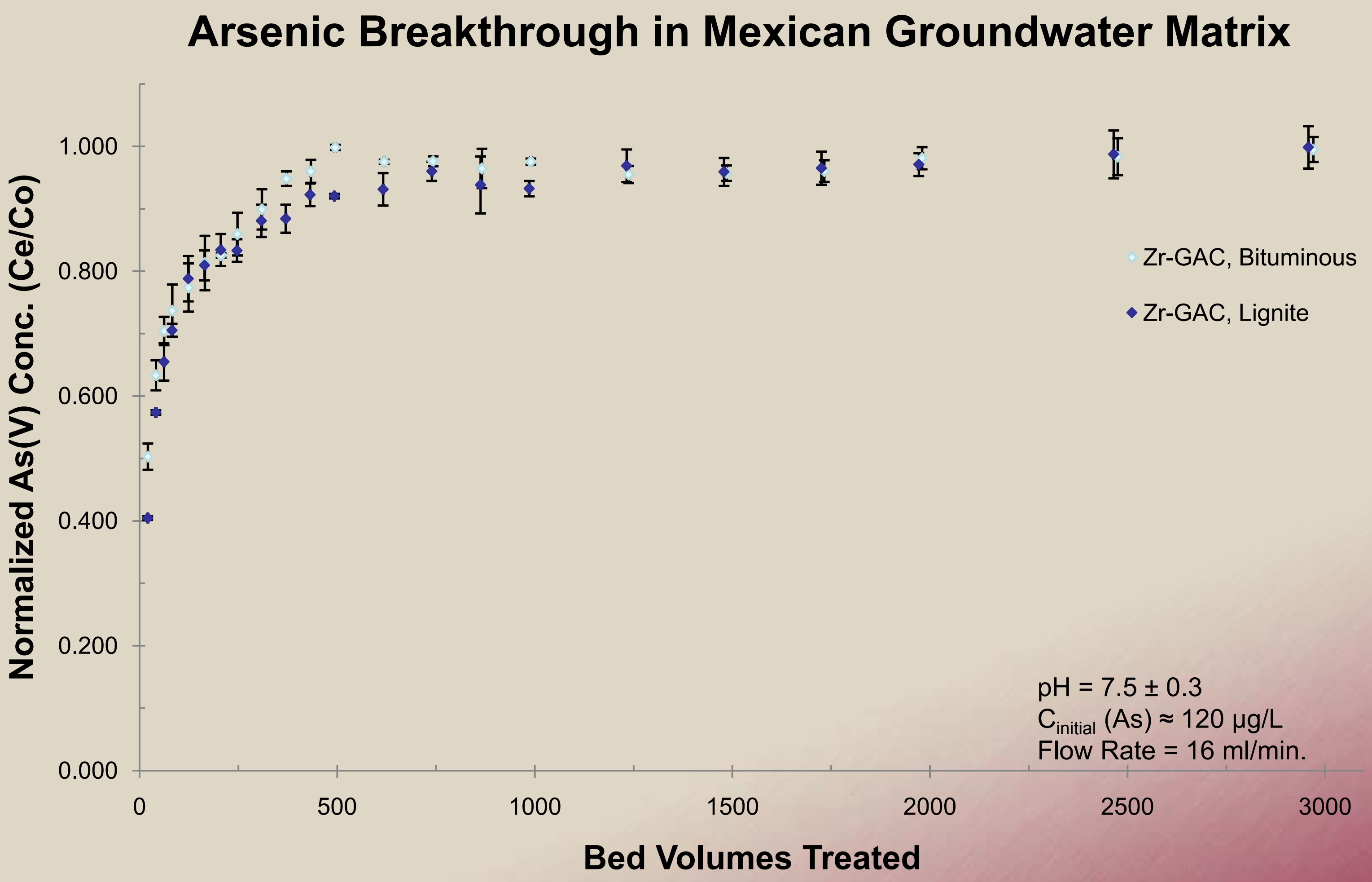
Findings


SBA Arsenic Breakthrough for Surfactant Modified Media
Normalized As(V) Conc. (Ce/Co)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
100
200
300
400
500
600
700
800
900
Bed Volumes Treated
S-Clin at minimum surfactant dose
S-GAC at minimum surfactant dose
5mM NaHCO3 Buffered Ultrapure Water
pH = 7.5 ± 0.3
Cinitial (As) ≈ 120 µg/L
Flow Rate = 16 ml/min.

Findings


1.20
1.00
0.80
0.60
0.40
0.20
0.00
Ce/Co
0
100
200
300
400
500
600
700
800
900
1000
Bed Volumes
S-GAC at minimum dose Mexican model water
S-GAC at minimum dose

Findings


Arsenic Breakthrough in Mexican Groundwater Matrix
Normalized As(V) Conc. (Ce/Co)
1.000
0.800
0.600
0.400
0.200
0.000
0
500
1000
1500
2000
2500
3000
Bed Volumes Treated
Zr-GAC, Bituminous
Zr-GAC, Lignite
pH = 7.5 ± 0.3
C_initial (As) ≈ 120 µg/L
Flow Rate = 16 ml/min.

Findings
Comparison of media

Media Type	Maximum adsorption capacity in model Mexican groundwater* (µg As/g dry media)	Maximum adsorption capacity in model bicarbonate buffered water (µg As/g dry media)
0.5M-24HR Fe-GAC	77.4	166.4**
0.5M-72HR Fe-GAC	30.0	161.6**
2.0M-24HR Fe-GAC	16.7	325.7**
2.0M-72HR Fe-GAC	24.0	537.4**
Bituminous Zr-GAC	151.9	1160.2**
Lignite Zr-GAC	101.8	1030.7**
S-GAC (min)	8.2	304.1*
S-GAC (5x)	11.5	383.7*
S-Clin (min)	NA	6.1*

*** maximum continuous flow arsenic adsorption capacities**
**** maximum equilibrium adsorption capacities**

Conclusions

1. Metal (hydr)oxide media performed better than the surfactant modified media.

2. Metal (hydr)oxide media performed comparable to or better than commercially available arsenic treatment media on metal basis.

3. Treatment of arsenic in model (U.S.-Mexican) groundwater matrix was significantly reduced

4. The GAC based media retained its ability to remove organics

5. Presence of competing ions in the model (U.S.-Mexican) groundwater significantly reduced arsenic removal performance of surfactant modified media.

6. Surfactant modified media leached surfactants.

Research Benefits

Significant benefits:

1. A groundbreaking effort in developing solutions for the drinking water problems of small, impoverished and rural communities in the U.S.-Mexico border region.
2. A model U.S.-Mexico border region groundwater, allows for normalization and comparison of systems tailored to serve impoverished and rural communities in the U.S.-Mexico border region.
3. Findings contributed to obtaining funding for another project to assist the region.
4. Systems using hybrid metal (hydr)oxide-GAC media suitable for water contaminated with organics.
5. Surface area is the key factor affecting the arsenic removal performance of these media

Acknowledgements

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Southwest Consortium for Environmental Research & Policy

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Arizona State University, Polytechnic Campus

Questions