The Effects of Si and Humic Acid on U (VI) Removal from the Savannah River Site F/H Area groundwater

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Background

Between 1955 and 1988, the F/H Area Seepage Basins located in the center of SRS received approximately 1.8 billion gallons of acidic waste solutions (pH from 3.2 to 5.5) contaminated with a variety of radionuclides and dissolved metals. The constituents of concern (COCs) associated with the F-Area groundwater plume are tritium, uranium-238, iodine-129, and strontium-90. The COCs in the H-Area are tritium, strontium-90 and mercury. A pump-and-treat water treatment unit was designed and built in 1997. Soon they switched to a re-injection system using a carbonate base. However it has been shown that alkaline carbon solutions can enhance the mobility of uranium and reverse the effects of natural adsorption.

Objective

- Investigate if dissolved sodium silicate solutions have enough alkalinity to replace the carbonate base used to correct the acidic nature of the contaminated sediments.
- Determine if there are any synergistic interactions between U(VI) ions, HA and Si:
  - Study the influence of Humic Acid (HA) and Si on the sorption of U(VI) onto F/H Area sediments.

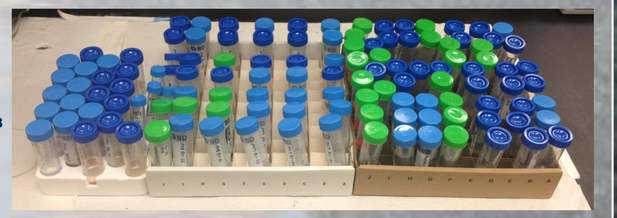
Results

Sample-Description pH 4	U(VI) Avg. Removal, %	Std.	Si Avg. Removal, %	Std.	Fe, ppm
Filtered Batch 1	34.36	23.13	97.83	1.81	No soil
Batch 2	22.33	1.65	93.02	0.95	No soil
Batch 3	15.18	3.42	No Si	NA	No soil
Batch 4	57.71	7.5	97.89	0.75	0.1-0.2
Batch 5	87.36	8.81	93.55	3.36	0.2-1.3
Batch 6	78.1	1.34	No Si	NA	0.2-0.6
Batch 7	45.83	3.02	No Si	NA	0.1-0.3

Sample-Description pH 5	U(VI) Avg. Removal, %	Std.	Si Avg. Removal, %	Std.	Fe, ppm
Batch 1/ Filtered	81.88/ 92.80	1.98/0.76	94.09	0.92	No soil
Batch 2	29.65	19.55	62.76	13.17	No soil
Batch 3	9.29	5.43	No Si	NA	No soil
Batch 4	88.66	0.39	79.19	2.27	0.01-0.02
Batch 5	81.16	3.70	83.37	5.58	0.09-0.11
Batch 6	86.05	2.47	No Si	NA	0.19-0.24
Batch 7	88.81	3.34	No Si	NA	0.1

Sample-Description pH 6	U(VI) Avg. Removal, %	Std.	Si Avg. Removal, %	Std.	Fe, ppm
Batch 1/ Filtered	82.19/98.8	3.44/0.05	94.09 /96.21	0.92 /0.51	No soil
Batch 2	59.84	4.37	62.76	13.17	No soil
Batch 3	55.72	11.79	No Si	NA	No soil
Batch 4	92.62	4.3	79.19	2.27	0.013
Batch 5	92.10	2.28	83.37	5.58	0.66-0.84
Batch 6	94.53	0.05	No Si	NA	0.82-1.05
Batch 7	99.08	0.3	No Si	NA	0

Figure R-1: Batches 4-8 Prepared



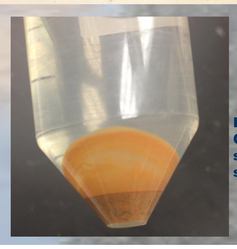


Figure R-2: Centrifuged sediment sample

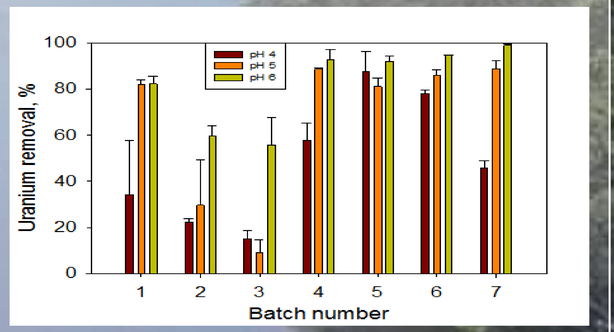


Figure R-3: Batches 4-6 Efficiency

Methods

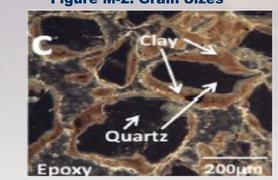
EXPERIMENTAL MATRIX

The following binary, tertiary and quaternary systems will be evaluated at each pH value between pH 4-6 in the presence and absence of Humic Acid (HA) for the removal of U(VI) from the aqueous solutions:

PH 4-6 Adjusted Set	*Constituents*							
	SiO_2 3.5mM	Humic Acid (HA) 10 ppm	Sediments 1:20	Uranium U(VI) 0.5 ppm	Acid 0.1M HCL	Base 0.1M NaOH	Water H_2O	Total Volume
	ml	ml	mg	ml	ml	ml	ml	ml
Batch No. 1	2.24			0.01	Var.	Var.	17.75	20
Batch No. 2	2.24	2.00		0.01	Var.	Var.	15.75	20
Batch No. 3		2.00		0.01	Var.	Var.	17.99	20
Batch No. 4	2.24		400.00	0.01	Var.	Var.	17.75	20
Batch No. 5	2.24	2.00	400.00	0.01	Var.	Var.	15.75	20
Batch No. 6		2.00	400.00	0.01	Var.	Var.	17.99	20
Batch No. 7			400.00	0.01	Var.	Var.	19.99	20

Figure M-1: Acquired Soil

Figure M-2: Grain Sizes



GENERAL PROCEDURES:

- Prepared colloidal silica stock solution at 2000 ppm in non-reactive bottles (polypropylene) to be injected in batch 1, 2, 4, and 5.
- For batches 2, 3, 5, and 6, added Humic acid (HA) stock at 10 ppm.
- Prepared soil mixture by combining soil samples gathered from various depths ranging from 60-105 ft.
- Prepared a 60 gram soil mixture using 10 grams of each of the 6 soil depths.
- Samples 4, 5, 6 and 7 each contain 400 mg of a soil/solution ratio of 1:20.
- Amended test solutions with 0.5 ppm U(VI), using a 1000ppm standard.
- Adjusted pH using 0.1M HCl or 0.1M NaOH.
- Each sample was prepared in triplicate.
- Centrifuged and analyzed via KPA and ICP.

Discussion

- At lower pH values silica (Si) and humic acid (HA) create good synergy in the presence of sediment.
- The synergy of Si and HA seems inversely related to the increase of pH value.
- In combination with sediments Si showed lower results on U removal than HA at lower pH levels.
- Attenuation of U(VI) via sediment sorption increases with pH.
- Sediment bearing samples with Si showed higher U removal at lower pH.
- HA slightly reduced U adsorption at higher pH values.
- The primary benefit of this study is to determine the most efficient means of reducing U(VI) using In situ adsorption.
- This research will aid in returning the ground water system to a natural pH while attenuating U(VI).

Future Work

- Analyze sediments' surface composition via scanning electron microscopy and energy-dispersive-spectrometry (SEM-EDS).
- Test to determine the effect of silicate solutions on the immobilization of U(VI).
- Perform experiments increasing the concentration of HA in the presence of sediment to analyse for efficiency of U(VI) adsorption.

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