Characterization of Sediment and Groundwater Samples form NABIR Field Research Center in Oak Ridge, Tennessee

Jasquelin Pena, Tetsu Tokunaga, Keith Olson, Donald Herman[1], Dominique Joyner, Terry Hazen, Joern Larsen, Eoin Brodie[1], Mary Firestone[1], and Jiamin Wan

Lawrence Berkeley National Laboratory
[1]University of California, Berkeley

Introduction

Sediments and groundwater samples containing varying levels of uranium and nitrate were requested by Wan et. al. for use in batch and column experiments studying the "Coupled Transport and Biogeochemical Effects on Reduction of U(IV) and NO3- as Co-contaminants in Natural Sediments and Soils." Samples were received from the three locations highlighted below.

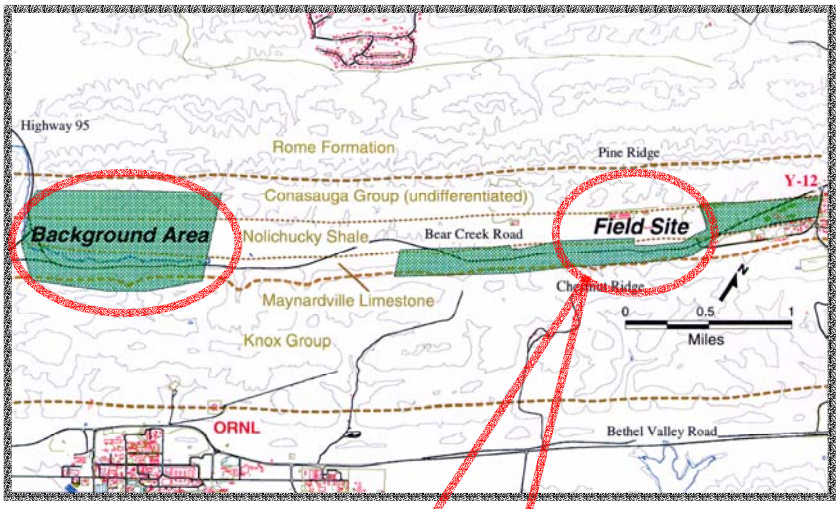

Figure 1: Map of FRC (http://public.ornl.gov/nabirfrc/fig03.htm#fig3)

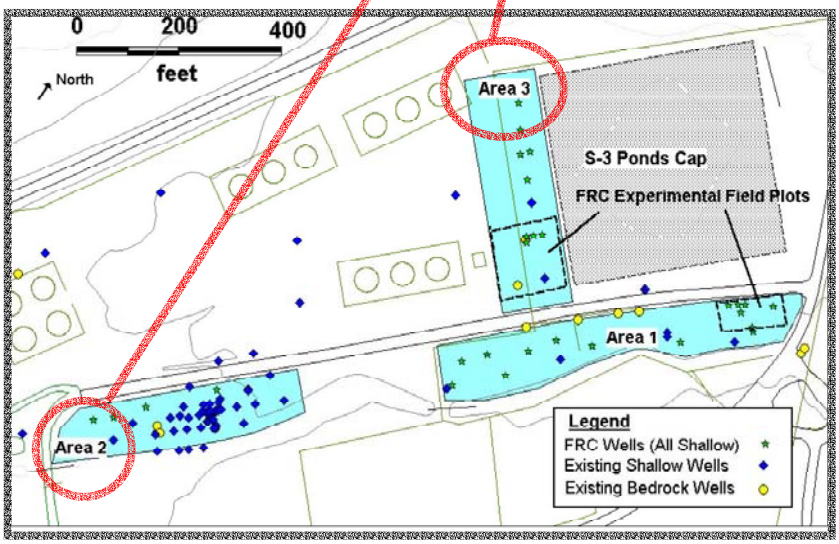

Figure 2: Contaminated Field Site (http://public.ornl.gov/nabirfrc/FigureA4.html)

(1) **Background Soil** (Cores labeled FB602, FB603, FB604, and FB605)
Background Groundwater (Containers labeled FW300-00730, FW300-00731)

(2) **Area 2 Soil** (Cores labeled FB010, FB011, FB012, FB013, and FB014)
Area 2 Groundwater (Containers labeled TPB16-000732, TPB16-000733)

(3) **Area 3 Soil** (Cores labeled FB006, FB007, FB008, and FB009)
Area 3 Groundwater (Containers labeled FW025-000728, FW025-00029)

More detailed information regarding the exact locations of the wells and field plots can be found at the FRC website: **http://www.esd.ornl.gov/nabirfrc/index.html.**

Sample Preparation

(1) Background Soil

Soil was passed though a 2 mm sieve. The fraction of particles <2.0 mm [~30% wt. of original sample] was used for batch experiments and for sediment characterization.

(2) Area 2 Soil (high uranium, low nitrate)

The majority of the work was performed inside a nitrogen purged glove bag or glove box to protect the microbial community and minimize the oxidation of any U(IV) to U(VI). Sieving and homogenizing the soil in its natural state was not possible because of the high clay content.

The soil was made into a slurry/solution using the Area 2 groundwater and passed through a 5.6 mm sieve [~25% wt. of original sample]. The mixed slurry was then poured into trays and placed inside a N2 glove box to evaporate the excess moisture. A strong desiccant was used to remove the moisture in the glove box. The sediment cakes were removed from the trays and again passed though the 5.6 mm sieve to re-homogenize and crumble back into a form appropriate for packing columns.

(3) Area 3 Soil (high nitrate, low uranium)

Soil was passed though a 2 mm sieve. The fraction of particles <2.0 mm [~45% wt. of original sample] was used for batch experiments and sediment characterization.

Data

The following tables are a compilation of data obtained thus far to characterize the aforementioned FRC samples. The method(s) used in making measurements are footnoted. Results are often presented as a value ± the standard error (measurements done in duplicate or triplicate). The name(s) and email address of the individual(s) responsible for the measurements are also provided.

Table A: Soil Particle Size Analysis

	Moisture Content[1] (%)	Grain Density[2] (g cm^{-3})	Sand[3] (%)	Silt[3] (%)	Clay[3] (%)
Background Soil	14.15 ± 1.4	2.86	54.7 ± 1.5	35.5 ± 1.1	9.9 ± .04
Area 2 Soil (<5.6 mm)	18.1	2.75	30.4 ± 7.8	41.1 ± 8.5	28.6 ± 0.7
Area 3 Soil (<2.0 mm)	12.28 ± 0.09	2.83 ± 0.08	51.5 ± 0.7	31.3 ± 0.2	17.4 ± 0.6

Methods:
[1]The moisture content reported was measured by drying a weighed amount of soil at 110°C overnight and re-weighing once the soil cooled down to RT (air dry).
[2]Density was determined by water pycnometer.
[3]The hydrometer method was used to determine the soil particle size distribution.

Table B: pH and Electrical Conductivity Measurements[1]

	pH[2]	EC (mS/cm)[3]
Background Groundwater	7.14	0.313
Area 2 Groundwater	5.04	0.804
Area 3 Groundwater	6.92	55.40
Background Soil	7.52	0.420
Area 2 (<5.6 mm) Soil	7.92	1.029
Area 3 (<2.0 mm) Soil	6.48	0.948
Area 3 (<5.6 mm) Soil	5.78	1.499

Methods:
[1]1:1 soil extractions (24 hrs) of soil samples were used to make pH and EC measurements
[2] Corning electrode
[3] YSI 3253 cell

Table C: Uranium Concentration[1]

	U conc. (ppm)	
Background Groundwater	<0.03	<0.06[2]
Area 2 Groundwater	1.1	1.2[2]
Area 3 Groundwater	<0.03	0.54[2]
	Acid Digested	1:1 Extraction
	U conc. (ppm)	U conc. (ppm)
Backgoround Soil	0.89	<0.03
Area 2 Soil	206 ± 7.02	1.06
Area 3 Soil (<2.0 mm)	12	0.43
Area 3 Soil (<5.6 mm)	25	<0.03

Method:
[1] KPA-11 (Kinetic Phosphorescence Analyzer, Chemchek Instruments)
[2] Liquid Scintillation

Table D: U(IV) and (U(VI) Fractions in Soils[1]

Sample	U(IV) fraction	U(VI) fraction	uncertainty
Area 2, sample 1	0.10	0.90	±0.07
Area 2, sample 2	0.30	0.70	±0.14
Area 2, sample 3	0.31	0.69	±0.11
Area 2 Soil, average of 3	**0.24**	**0.76**	**±0.12**
Area 3 Soil, sample 1	**0.18**	**0.82**	**±0.17**

Method:
[1] Determined through synchrotron x-ray absorption spectroscopy at NSLS Beamline X26A, Brookhaven National Lab.

Table E: Total $NO3^-$ + $NO2^-$ Analysis[1]

Groundwater	mg N/ L
Background Groundwater	0.0683
Area 3 Groundwater	11737
Soil[2]	mg N/ kg soil
Background Soil	0.408
Area 2 (<5.6 mm) soil	1.11
Area 3 (<2.0 mm) Soil	85
Area 3 (<5.6 mm) Soil	95

Methods:
[1] Lachat flow injection analyzer
[2] KCl extraction: 1:10 / soil: 2 M KCl

Table F: Native Organic and Inorganic Carbon Analysis[1]

	Organic Carbon (ppm)	Inorganic Carbon (ppm)	Total Carbon (ppm)
Background Groundwater	0.93	37.59	38.52
Area 3 Groundwater	3.48	3.34	6.82
Background Soil [2]	7.72	14.43	22.15
Area 2 (<5.6 mm) soil[2]	462.1	73.6	535.7
Area 3 (<2.0 mm) Soil[2]	4.53	0.21	4.74
Area 3 (<5.6 mm) Soil[2]	3.73	0.28	4.01

Method:
[1] Elemental Carbon Analyzer
[2]1:10 soil extraction (1 hr) were used to measure Carbon in soils

Table G: CaCO3 Analysis[1]

	CaCO3 (wt.%)
Background Soil	0.85
Area 2 Soil	3.0
Area 3 (<2.0 mm) Soil	2.0

Method:
[1]Manometer method, soil was reacted with 2N HCl

Table H: X-Ray Fluorescence Analysis

Major Elements	Concentrations in dried powder (wt. %)		
	Background Soil	Area 3 Soil	Area 2 Soil
SiO_2	61.09 ± 0.17	53.15 ± 1.27	64.00 ± 0.15
TiO_2	0.75 ± 0.01	0.72 ± 0.01	0.81 ± 0.00
Al_2O_3	17.96 ± 0.12	17.69 ± .26	17.10 ± .08
Fe as Fe_2O_3	6.27 ± 0.03	8.44 ± 0.38	6.27 ± 0.04
MnO	0.26 ± 0.00	0.37 ± 0.05	0.10 ± 0.00
MgO	2.09 ± 0.00	2.07 ± 0.11	1.7 ± 0.01
CaO	1.14 ± 0.00	3.81 ± 1.30	0.49 ± 0.00
Na_2O	0.81 ± 0.05	.37 ± 0.07	0.34 ± 0.07
K_2O	4.80 ± 0.02	5.06 ± 0.17	3.48 ± 0.06
P_2O_5	0.13 ± 0.00	0.08 ± 0.01	0.09 ± 0.01
SO_3	<0.04	<0.04	<0.04
Loss on Ignition	4.63 ± 0	7.87 ± 0.86	5.59 ± 0.41
*note: CO2 included in loss on ignition			
Trace Elements	Concentrations in dried powder (mg/kg soil)		
	Background Soil	Area 2 Soil	Area 3 Soil
Pb	13	33 ± 1	16 ± 1
Nb	14	3 ± 0	12 ± 0
Zr	251	155 ± 1	251 ± 1
Y	22	22 ± 1	30 ±0
Sr	67	92 ±1	66 ±1
Rb	134	131 ±2	114 ±0

Table I: Live/Dead Cell Counts

	# of cells
Background Soil	1.3×10^4
Area 3 Soil	3×10^4

Conctact Information

Table A,B,C Jasquelin Pena (jpena@lbl.gov)
Table D,G Tetsu Tokunaga (tktokunaga@lbl.gov), Keith R. Olson (kolson@lbl.gov)
Table E, F Donald Herman (skyhawk@nature.berkeley.edu)
Table H Rex Couture (314) 935-4194 Washington University (XRF Lab)
Table I Terry Hazen (tchazen@lbl.gov), Dominique Joyner (dcjoyner@lbl.gov)