Florida A&M University – Florida State University
College of Engineering
Gang Chen, Ph.D.
Department of Civil & Environmental Engineering
2525 Pottsdamer Street, Tallahassee, FL 32310-6046
Tel (850) 410-6303 Fax (850) 410-6142
E-mail: gchen@eng.fsu.edu

Project Title

Impact of Landfill Leachate on Iron Release from Northest Florida Iron Rich Soils

Tag Members

Michael S. Kennedy, Charles Goddard, Lee Martin, David L. Anderson,
Amy B. Chan Hilton, and Subramanian Ramakrishnan

Second Progress Report

(November 1, 2006 to January 31, 2007)

Submitted to

John D. Schert
Director
Hinkley Center for Solid and Hazardous Waste Management
2207 NW 13th Street, Suite D
University of Florida
Gainesville, FL 32609

by

Gang Chen, Tarek Abichou, and Jeffrey Chanton
Department of Civil and Environmental Engineering
FAMU-FSU College of Engineering
Department of Oceanography
Florida State University

1. Introduction

We now have evidence that microbial mediated iron reduction should be blamed for elevated levels of iron observations in the groundwater from monitoring wells downgradient of landfills:

$$CH_2O + 2Fe_2O_3 + 3H_2O = CO_2 + 4Fe^{2+} + 8OH^-$$

Landfill associated iron problems are more obvious in Northwest Florida owing to the high iron content in the soil. Nevertheless, the soil iron content may vary from county to county, and so does the leachate composition. During this research period, we conduct batch experiments by reacting iron-rich soil collected from each of the 16 counties in Northwest Florida with corresponding landfill leachate in the presence of iron reducing bacteria.

2. Objectives

Our objectives for this research period of the project include:

1. Collect soil and leachate samples from 16 counties in Northwest Florida
2. Conduct batch experiments by reacting iron-rich soil with corresponding landfill leachate in the presence of iron reducing bacteria.

3. Project Progress

3.1 Soil and Leachate Sample Collection

Soil and leachate samples were collected from all 16 counties in Northwest Florida (Figure 1). For each county, we selected a typical landfill and sampled both the soil and the leachate (Table 1). We used direct push technologies (e.g., cone penetrometer) to sample the soil at the target site. Soil samples were labeled with the appropriate date and sampling location and were taken to the lab for analysis immediately following sampling. During transportation, the soil samples were stored in temperature-controlled containers or in a sealed ice chest. If ice was used, ice was placed in separate plastic bags and sealed. For the leachate samples, we collected leachate from the sampling wells of each landfill. Site and sample pictures from Santa Rosa Central Landfill (Santa Rosa) and Perdido Landfill (Escambia) are shown in Figure 2.

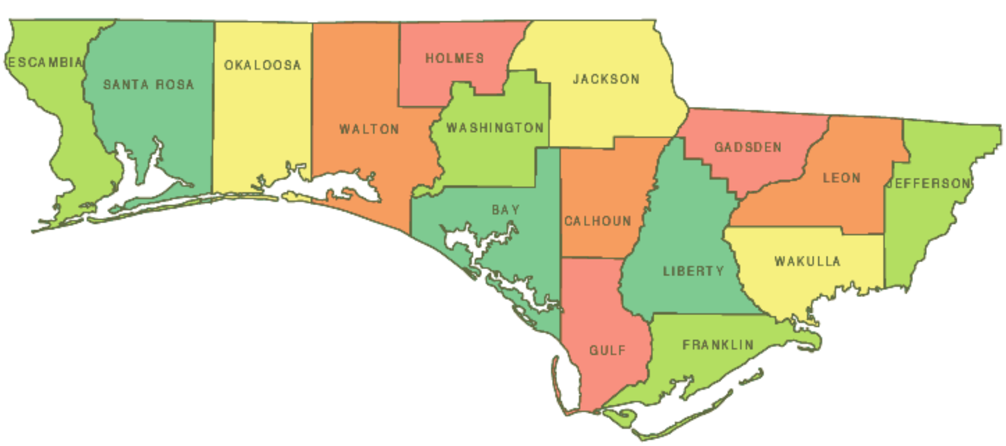

Figure 1. Counties in Northwest Florida

Table 1. Sampled Landfills and Locations

COUNTY	NAME OF FACILITY
BAY	STEELFIELD LANDFILL
ESCAMBIA	PERDIDO LANDFILL
CALHOUN	CALHOUN COUNTY LANDFILL
FRANKLIN	FRANKLIN COUNTY CENTRAL LF
GADSDEN	BYRD LANDFILL
GULF	FIVE POINTS CLASS III LANDFILL
HOLMES	HOLMES COUNTY LANDFILL
JACKSON	SPRINGHILL REGIONAL LANDFILL
JEFFERSON	JEFFERSON CO CENTRAL LANDFILL
LEON	US 27 SOUTH LANDFILL
LIBERTY	LIBERTY COUNTY LANDFILL LFC2
OKALOOSA	BAKER EAST AND WEST
SANTA ROSA	HOLLEY LANDFILL
WAKULLA	LOWER BRIDGE LANDFILL
WALTON	WALTON CO CENTRAL LANDFILL
WASHINGTON	CHIPLEY LANDFILL

Figure 2. Site and Sample Pictures from Santa Rosa Central Landfill (Left) and Perdido Landfill (Right)

3.2 Laboratory Iron Reduction Experiments

Laboratory iron reduction experiments are currently being conducted using soil collected from each of the sampled landfills reacting with corresponding leachate under chemistry and biology conditions similar to the concerned site in the presence of cultured iron reducing bacteria (Figure 3). All the experiments are being conducted in a sealed glass reaction vessel in the anaerobic chamber to mimic the situations in the subsurface where landfill leachate interacts with the soil. As a control, sampled soil also reacts with simulated storm runoffs. We monitor ferrous iron, ferric iron, dissolved oxygen, pH, and redox potential, etc. on a daily basis. We now have the available data using the soil collected from Leon County Lanfill reacting with simulated landfill leachate (Leachate samples from the landfill were not available when the experiments were conducted) (Figure 3). We will repeat the experiments using the sampled leachate when the leachate is available.

Figure 3. Laboratory Iron Reduction Experiments Using Soil Collected from Leon County Landfill (Left) and Site Picture of Leon County Landfill (Right)

We found that ferrous iron was released when landfill leachate contacted with iron rich Norwest Florida soil in the presence of anaerobic microbial cultures. With elapsed time, more ferrous iron was released. When this part of research was conducted, landfill leachate was not available. We simulated a landfill leachate based on the typical landfill leachate composition (Table 2). Precipitation was observed for the simulated landfill leachate and we consequently reacted the sampled soil with the supernatant of simulated landfill leachate and mixed landfill leachate respectively. When the soil reacted with mixed landfill leachate, more ferrous iron was produced than that of reacting with the supernatant of the landfill leachate (Figure 4). As a control, the experiments were also performed in the absence of iron reducing bacteria. Since minimal ferrous iron release was observed in the absence of iron reducing bacteria (control 2), iron release by reacting iron rich soil with landfill leachate was believed a microbial mediated iron reducing process.

Table 2. Chemical Analysis of MSW Leachate Used as a Permeant Liquid*

Parameter	Units	Result	Typical Range	U.S. EPA Method
pH	------	6.33	3.35 – 10.1	9045
BOD	mg/L	11700	N/A	5210
COD	mg/L	20900	N/A	5210
Total Dissolved Solids	mg/L	393	3.95 – 3370	6010
Chloride	mg/L	2030	N/A	9250
Sulfide	mg/L	3	1 – 20	9030
Sulfate	mg/L	199	121 – 638	9035
Sodium	mg/L	1380	18 – 1360	6010
Manganese	µg/L	5420	3.87 – 60200	6010
Barium	µg/L	1140	N/A	6010
Beryllium	µg/L	<2	N/A	6010
Cadium	µg/L	103	N/A	6010
Chromium	µg/L	102	N/A	6010
Cobalt	µg/L	927	N/A	6010
Copper	µg/L	26	N/A	6010
Lead	µg/L	124	1.6 – 300	6010
Zinc	µg/L	2370	30 – 2000	6010
Nickel	µg/L	298	0.18 – 60000	6010
Silver	µg/L	38	0.009 – 120	7760
Kjeldahl Nitrogen	mg/L	463	0.5 – 3600	351.1
Nitrate and Nitrite Nitrogen	mg/L	0.32	0.015 – 806	351.1
Total Phosphorus	mg/L	3.14	0.005 – 240	365.1
Total Sulfate	mg/L	199	0.01 – 4150	9035
Total Sulfide	mg/L	3	1 – 125	9030
Total Suspended Solids	mg/L	393	1 – 89800	160.2
Hardness	µg/L	6910	N/A	130.1
Benzene	µg/L	25	N/A	8021A
1,4-Dichlorobenzene	µg/L	30	2 – 250	8021A
1,1-Dichloroethane	µg/L	120	N/A	8021A
Cis-1,2-Dichloroethane	µg/L	200	N/A	8021A

Ethylbenzene	µg/L	75	N/A	8021A
Methylene Chloride	µg/L	950	N/A	8021A
Naphthalene	µg/L	50	4.6 – 186	8021A
Styrene	µg/L	30	N/A	8021A
Toluene	µg/L	800	1 – 11800	8021A
Trichloroethene	µg/L	45	N/A	8021A
1,3,5-Trimethylbenzene	µg/L	50	N/A	8021A
M&P-Xylene	µg/L	220	N/A	8021A
O-Xylene	µg/L	85	9.4 – 40	8021A

* Wisconsin Landfills per Sridharan and Didier (1988).

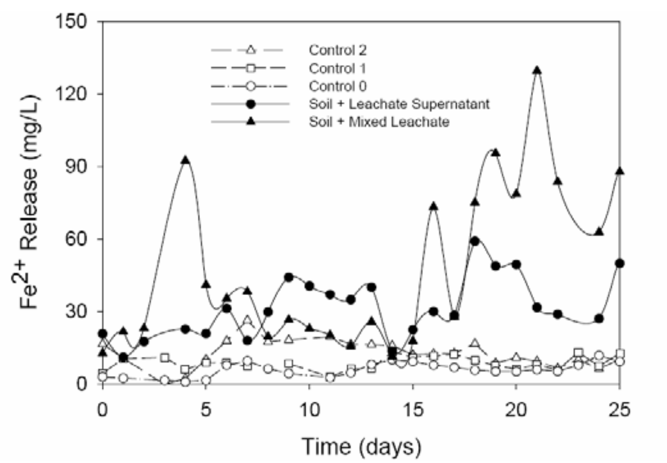

Figure 4. Batch Iron Reducing Experiment Results Using Iron Rich Soil from Leon County Landfill Reacting with Simulated Landfill Leachate

To further provide evidence that the released iron is from the iron rich soil, above experiments were repeated using low iron content soil collected from a Tallahassee residential community (Golden Eagle Golf and Country Club) (Figure 5).

Figure 5. Laboratory Iron Reduction Experiments Using Low Iron Content Soil Collected from a Residential Community (Left) and Site Picture of the Sample Location (Right)

Much less iron release was observed when low iron content soil reacted with simulated landfill leachate as compared with that of iron rich soil (Figure 6). Similarly, more iron was leased when low iron content soil reacted with the mixed simulated landfill leachate than that of the supernatant. It should be pointed out that iron release was not obvious when low iron content soil reacted with the supernatant of the leachate as compared to the control.

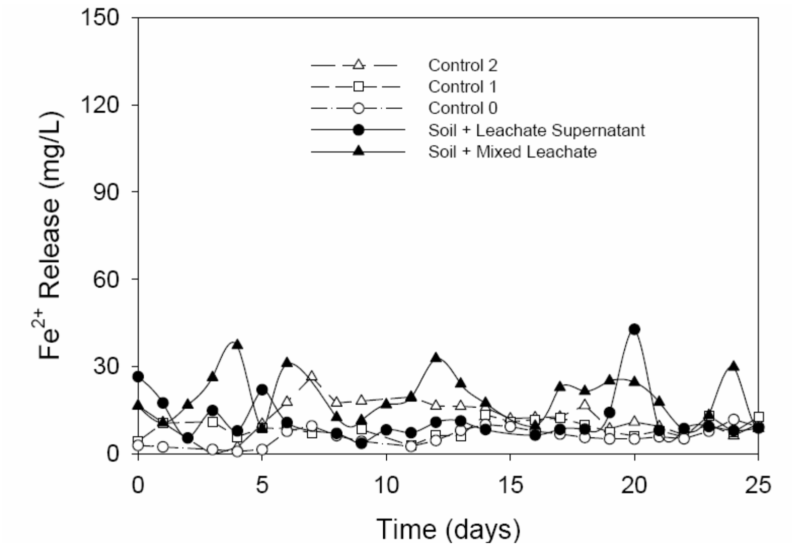

Figure 6. Batch Iron Reducing Experiment Results Using Low Iron Content Soil from a Residential Community Reacting with Simulated Landfill Leachate

4. Future work

4.1 Iron Characterization and Soil Characterization

To assess iron content in the soil, soil samples will be analyzed following the extraction and oxidation of iron from soil to determine the concentration of iron in the extract using spectrophotometric analysis techniques. Specifically, iron will form highly colored complexes when reacted with the thiocyanate ion:

$$Fe^{3+} (aq) + 6\ SCN^{-} (aq) \rightarrow [Fe(SCN)_6]^{3-} (aq)$$

Because the thiocyanate complex is colored red, it will absorb at 447nm on the absorption spectrum. The measurement will be performed using the spectrophotometer at the wavelength of 470nm.

4.2 Column Experiments

We will conduct the following column experiments to simulate the kinetic iron release processes (Figure 7). The column experiments will be conducted using the bulk soil sampled at Santa Rose Central Landfill. The column will be sprinkled with corresponding landfill leachate to mimic situation actually occurring underneath the landfills. The column will be sampled at different depth regularly for ferrous iron, ferric iron, dissolved oxygen, pH, and redox potential, etc. We suspect that the oxygen profile in the column should have an impact on iron release within the column. Since iron release is believed to be a microbial mediated iron reduction process, more iron release is expected from the lower section of the column where oxygen content is lower.

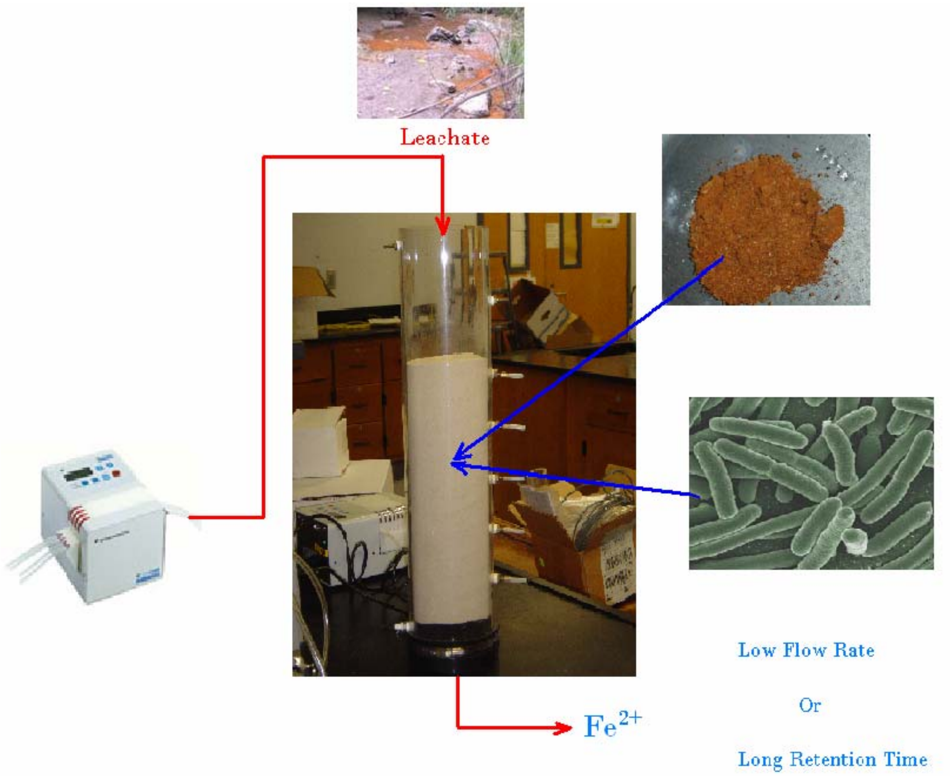

Figure 7. Column Iron Release Experiments in the Presence of Landfill Leachate

5. Miscellaneous

We have set up a website (www.eng.fsu.edu/~gchen) for this project to facilitate the dissemination of our research discovery. We have also presented part of our ongoing research at IRON AT LANDFIILS convened at Destin on October 18, 2006. We had the first TAG meeting on October 13, 2006. We plan to have the second TAG meeting in March, 2007. We will notify the Center in advance once the meeting schedule is available. Detailed information of the project is available at www.eng.fsu.edu/~gchen.