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Project Title

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

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First Progress Report

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Submitted to

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1. Introduction

Landfill leachate is being blamed for elevated levels of iron and arsenic, especially iron observations in the groundwater from monitoring wells downgradient of landfills. By researching the soil in Northwest Florida, we find that iron content in Northwest Florida soil is much higher that the national average level. From previous research conducted at Beulah Landfill, we also have evidence that iron and sulfur bacteria are very active in the landfills. We thus suspect the microbial mediated geo-processes during which organic rich landfill leachate reacts with iron rich Northwest Florida soil should be responsible for the iron release nearby the landfills.

Iron data from Majette Landfill strongly support that microbial mediated iron reduction is the iron release mechanism. Specifically, the iron release data as a function of pH (Figure 1) is consistent with the following microbial mediated iron reduction reaction:

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

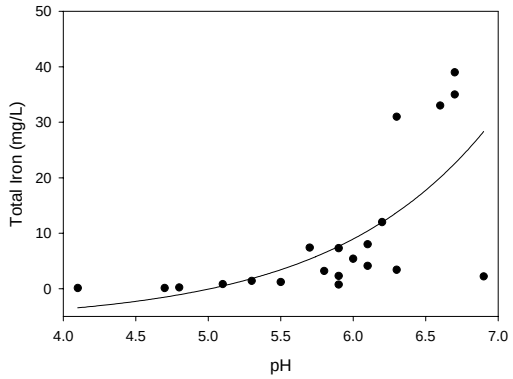

Figure 1. Iron Release as a Function of pH

Based on above consideration, we propose the following iron release mechanism:

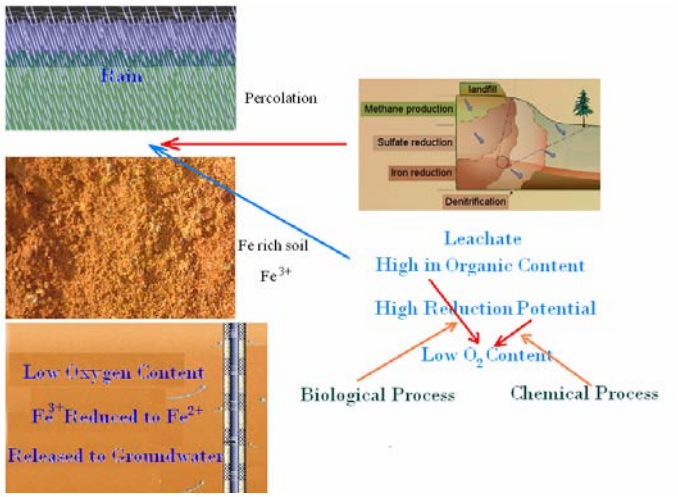

Figure 2. Proposed Iron Release Mechanisms

2. Objectives

Our objectives for the first section of the project include:

1. Simulate artificial landfill leachate based on available landfill leachate composition data.
2. Culture microbial species that are responsible for iron reduction.
3. Conduct batch experiments by reacting iron-rich soil with simulated landfill leachate in the presence of cultured iron reducing bacteria.

3. Project Progress

3.1 Landfill Leachate Simulation

Artificial landfill leachate was simulated based on available landfill leachate composition data from Florida Department of Environmental Protection, which include organic matter, pH, oxidation-reduction potential, dissolved oxygen, major solution cations (Na^+, K^+, Mg^{2+}, and Ca^{2+}, etc.), and major solution anions (Cl^-, NO_3^-, SO_4^{2-}, PO_4^{3-}, F^-, and S^{2-}, etc.), etc. (Figure 3).

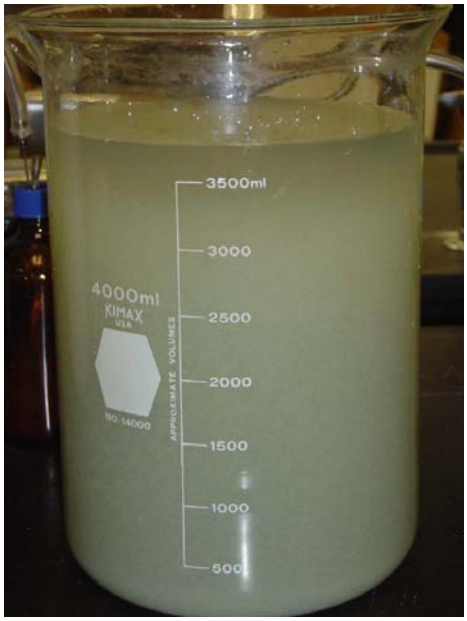

Figure 3. Simulated Landfill Leachate

3.2 Microbial Culture Cultivation

We have cultured the bacterial species using the sampled soil from Leon County Landfill as the base consortium (Figure 4). Since iron-reducing bacteria do not use oxygen as the electron acceptor, microbial culturing was conducted under anaerobic conditions. We used Teflon-sealed vials equipped with CO_2 entrapping devices and mineral salts medium. The vials were added with sampled soil and glucose (as the carbon source).

Figure 4. Iron Reducing Bacteria Culturing

3.3 Laboratory Iron Reduction Experiments

Laboratory iron reduction experiments are being currently conducted using soil collected from Leon County Landfill reacting with simulated leachate under chemistry and biology conditions similar to the concerned site in the presence of cultured iron reducing bacteria (Figure 4). 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.

Figure 4. Batch Iron Reducing Experiments

4. Future work

4.1 We are expecting soil and leachate samples from the following sixteen counties in Northwest Florida (Figure 5) from Michael S. Kennedy. Once we receive these samples, we will repeat above batch experiments for these samples.

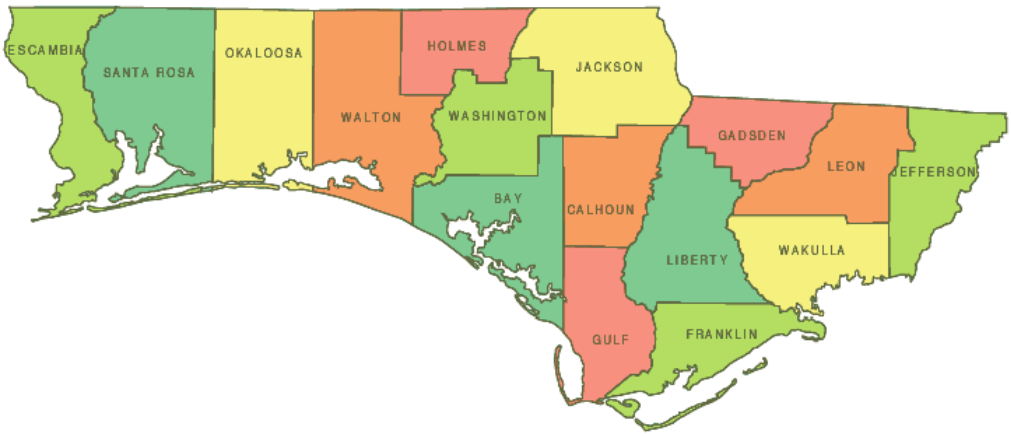

Figure 5. Counties in Northwest Florida

4.2 Column Experiments

We plan to conduct the following column experiments to simulate the kinetic iron release processes. The column experiments will be conducted during the second period of the project.

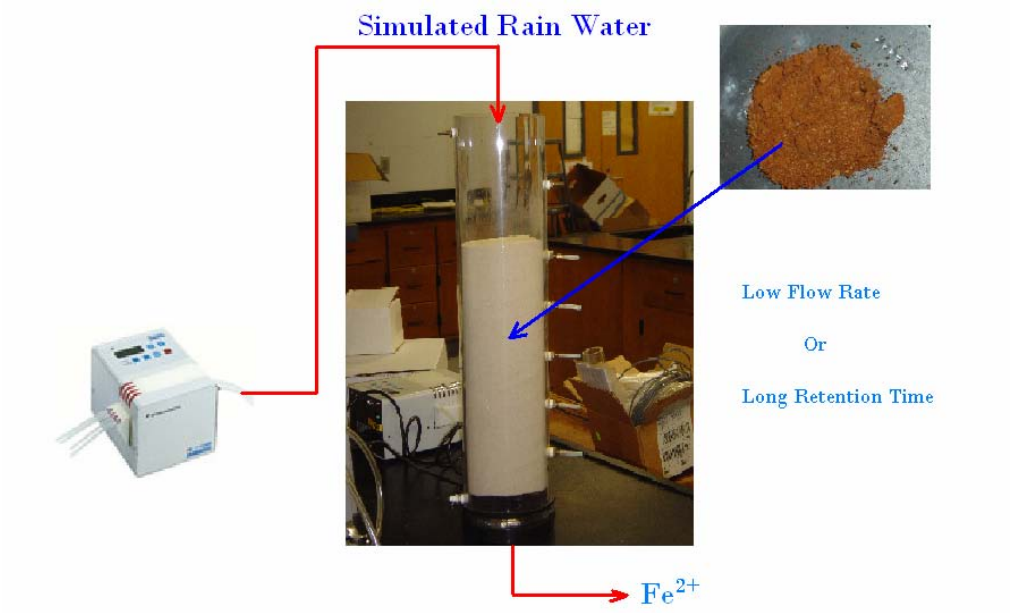

Figure 6. Column Iron Release Experiments in the Absence of Landfill Leachate

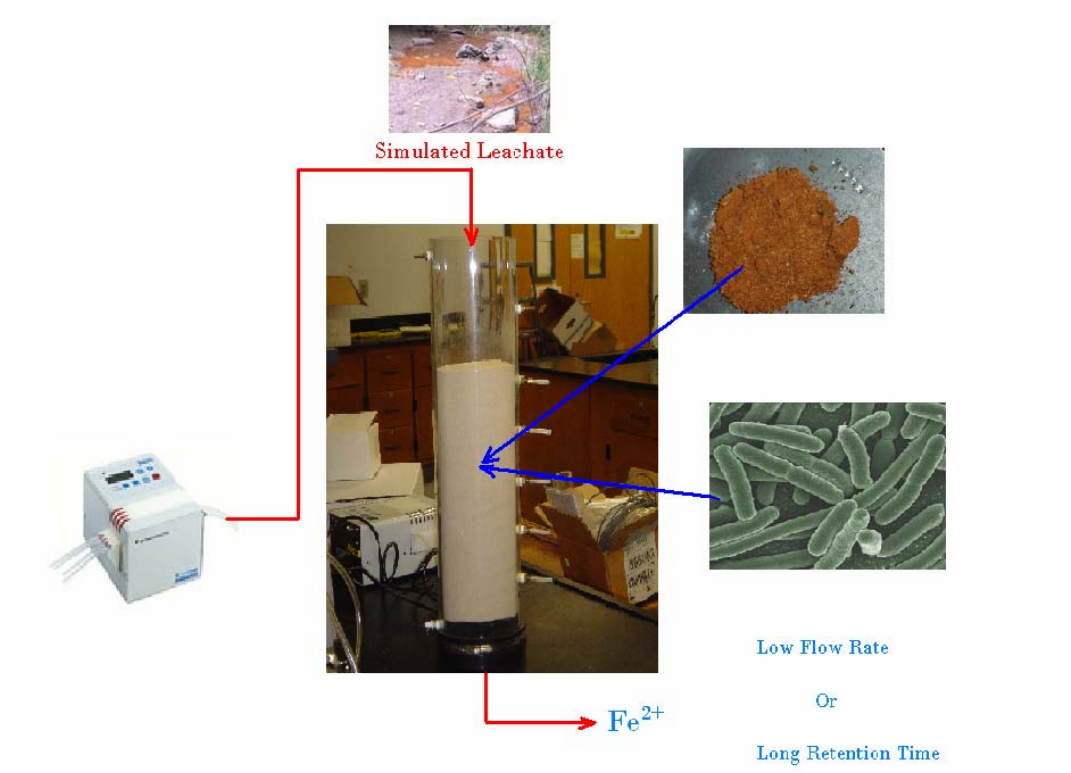

Figure 7. Column Iron Release Experiments in the Presence of Landfill Leachate

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. Detailed information of the first TAG Meeting is available at www.eng.fsu.edu/~gchen.