SUMMARY: MANAGEMENT OF SUBSURFACE REDUCTIVE DISSOLUTION UNDERNEATH LANDFILLS

Daniel E. Meeroff (PI)[1]

High concentrations of iron have recently been observed in groundwater and soils around municipal solid waste landfills in Florida. The levels have been attributed to reductive dissolution from native iron in the soil perhaps caused by a shadowing effect of the landfill liner, which inhibits the reaeration of the shallow aquifer beneath the landfill. In this study, the research team will evaluate the validity of this hypothesis, develop a list of engineering management alternatives for controlling the release of iron in-situ, and conduct laboratory experiments on management methods for dealing with this issue.

Recently elevated concentrations of iron have been observed in groundwater monitoring wells down gradient of lined landfills in Florida. The source of this iron contamination has not been verified yet, but is potentially associated with the presence of the landfill by either one or both of the following mechanisms: 1) the source of the iron is direct release of iron from the municipal solid waste leachate, or 2) the source is from naturally-occurring iron mobilized from the soil due to changes in soil chemistry or local hydrology. After the source is determined, the immediate question is if iron is being mobilized, is this a sign that other, potentially more toxic metals, like arsenic, are also being transported downstream too? If this is the case, then how do we control these releases?

Once the source of the elevated iron is determined, the next step will be to determine if co-liberation of toxic metals is also occurring, and if so, to come up with an effective strategy to remediate the problem. The research team will focus on identifying viable engineering alternatives that will minimize the potential disturbance to the system, limit treatment costs, and produce the most effective results. The goal of this research is: 1) to investigate the key parameters governing reductive dissolution of iron; 2) to develop a list of engineering management alternatives for controlling the release of iron in-situ; and 3) to conduct laboratory experiments on methods for iron and co-contaminant removal from groundwater at landfill impacted sites.

[1] Associate Prof., Dept. of Civil, Environmental & Geomatics Engineering, Florida Atlantic University, 777 Glades Road, 36/222, Boca Raton, FL 33431-0091, Phone: (561) 297-3099, FAX: (561) 297-0493, E-Mail: dmeeroff@fau.edu

PROGRESS REPORT
(September 2011)

Project Title: Management of subsurface reductive dissolution underneath landfills
Principal Investigators: Daniel E. Meeroff, Ph.D.
Affiliation: FAU
Phone number: (561) 297-2658
Project website: http://labees.civil.fau.edu/leachate.html

Progress to Date:

- **Task 1**. **Develop a list of engineering alternatives for managing elevated iron levels**. The graduate research team of Richard Reichenbach, Ahmed Al Basri, and André McBarnette has started the literature review of in-situ management methods for iron mitigation. Preliminary results were compiled in late March 2011, and further refinement is ongoing. Ahmed Al Basri is completing the work which focuses on the rationale and historical data from landfills experiencing iron dissolution problems as well as literature review on causes of reductive dissolution such as: biogeochemical, microbial, hydrologic, soil chemistry (pH, Eh, iron sequestration, iron mobility), and leachate pollution. Al Basri is also investigating literature on the co-liberation of toxic metals with iron to evaluate the potential problem of arsenic levels. The most current focus of the literature review is on engineering alternatives for managing elevated iron levels in-situ. These include but are not limited to: aeration, oxidation agents, chelation/iron sequestration, pH control, bioprecipitation/bioremediation, zero valent iron, trench fill, ion exchange, advanced oxidation, recirculating well technology, and others like adsorptive filtration. These alternatives will be evaluated for process efficiency, ease of operation, minimal site disturbance, and environmental considerations.

- **Task 2. Conduct laboratory experiments on selected treatment technologies for managing iron dissolution**. We have conducted preliminary experiments to develop the aquarium testing unit set-up (Figures 1, 2, 3, 5, and 6).


Figure 1. Aquarium testing set-up

Figure 2. Construction of recirculating well installation

Figure 3. Construction of recirculation well slits for the recirculation zone

Figure 4. Bench scale testing of soil and water iron levels

Figure 5. Aquarium testing unit

Figure 6. Close up of aquarium testing unit.

Figure 4 shows a picture of the soil samples after digestion being prepared for analysis using spectrophotometric methods to determine the iron concentrations in the soil, leachate, and groundwater samples. We have been refining the soil digestion procedure based on Florida Department of Environmental Protection Standard Operating Procedures, but we have encountered a great deal of unexpected turbidity in the spectrospopic method caused by the large amount of carbonates in the soil sample and the conditions after soil digestion. We are in the process of testing a remedy suggested by the developer of the method. Once we complete modifications to the analytical method and confirm the accuracy of the method, we will proceed with the experiment. We are planning to conduct a hydraulic test to determine the aeration conditions, mixing, radius of influence, depth, drawdown, hydraulic grade line, hydraulic conductivity, porosity and other important parameters. This will be conducted using a dye test and by varying the air flow rate in the recirculation well pump. After the demonstration well is completed, we will construct up to 5 units to test side-by-side conditions for the following parameters: air flow rate (0-1 cfm), time (0-24 hrs), and iron concentrations at three distances/depths from the well (initial concentration will be 3 mg/L). Ahmed Al Basri has also measured the aquaria and determined the appropriate amount of sample required for our first preliminary tests with the in-situ recirculating well technology.

After the TAG meeting on February 25, 2011, Allan Choate (TAG Member) informed us that Polk County (Figure 7) would like to participate in the study. On May 11, 2011, the principal investigator met with Polk County officials to obtain samples of soil, leachate, and groundwater for preliminary testing.

Figure 7. Polk County landfill site

Mr. Choate gave the team a brief summary of the Polk County facility. Phase 3 (60 acres) is currently active, receiving Class 1 waste since November 2006. The original facility was 100 acres of unlined landfill (pre-1985). Phase 1 is a single bottom liner (43 acres) and Phase 2 is double lined and consists of another 43 acres in final closure. Phase 3 has a 2 acre test liner with an array of 20 monitoring wells. This is where the iron/arsenic problem was first detected. The general direction of groundwater flow is from NE to SW. The facility is located in an area that was used for phosphate mines originally. The leachate is stored in an onsite storage tank and is pumped to the local POTW (Central Region WWTP) by gravity (5 miles). There are no pretreatment requirements according to a negotiated 5 year contract to dispose of the WWTP sludge residuals in exchange. This contract is renewable for up to 30 years. The amount of leachate generated is on the order of 20,000 gpd from the 150 lined acres on the site. This is down from 50,000 gpd after final closure of Phase 2. The Central Regional WWTP at the end of Eagle Lake Road in Winter Haven, FL. This facility is a 1.1 MGD permitted capacity contact stabilization system with rapid infiltration basins and irrigation disposal.

Dr. Meeroff and Mr. Choate collected leachate and soil samples from various locations at the site (Figure 8-13).

Figure 8. Leachate sample collection from Polk County facility.

Figure 9. Allan Choate assisting with the leachate sample collection.

Figure 10. Soil sampling from the downstream SE corner (left) and from the upstream NE corner (right). The NE corner samples were taken just south of the monitoring wells that reported elevated iron readings.

Figure 11. Location of downstream SE corner Polk County landfill site.

Figure 12. Location of upstream NE corner Polk County landfill site.

Figure 13. Location of monitoring well for SE corner sampling location.

Also Tim Vinson informed our team that Drs. Townsend and Ma have information that might assist our study. Mr. Al Basri will be collecting this information when it becomes available.

Research planned for the upcoming months:

- Complete the preliminary literature review.
- Complete the hydraulic testing of the recirculating well.
- Begin aquarium-scale preliminary testing.
- Design and conduct experiments to test the process for iron treatment.
- Develop design model and cost estimates.