SUMMARY: MANAGEMENT OF SUBSURFACE REDUCTIVE DISSOLUTION UNDERNEATH LANDFILLS

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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.

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PROGRESS REPORT
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Project Title: Management of subsurface reductive dissolution underneath landfills
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Progress to Date:

- **Task 1**. **Develop a list of engineering alternatives for managing elevated iron levels**. Ahmed Al Basri is continuing his literature review based on the previous work done by former graduate students Richard Reichenbach and André McBarnette. Mr. Al Basri has focused his search on the literature review of in-situ management methods for iron mitigation, and he is completing his review on the rationale and historical data from landfills experiencing iron dissolution problems as well as the known 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 1-5). Al Basri is also working to prepare a prototype of the groundwater circulation well, which he tested using crystal violet dye to confirm the recirculation pattern (Figure 6). The system has been tested for hydraulics and circulation pattern. It is nearly ready for experimentation scheduled for the second week of December 2011. We have received input on the design from Frederick Bloetscher, Ph.D., P.E., Whitt Van Cott, P.G., and Jeff Ahrens, P.E. from Geosyntec, all of whom have experience in well design, sparging, and groundwater remediation. Al Basri has developed methods for measuring the iron concentrations in the water and soil for both sets of samples collected from Polk County and Palm Beach County.

Figure 1. Construction of recirculating well installation

Figure 2. Construction of recirculation well slits for the recirculation zone

Figure 3. Bench scale testing of soil and water iron levels

Figure 4. Aquarium testing unit

Figure 5. Close up of aquarium testing unit.

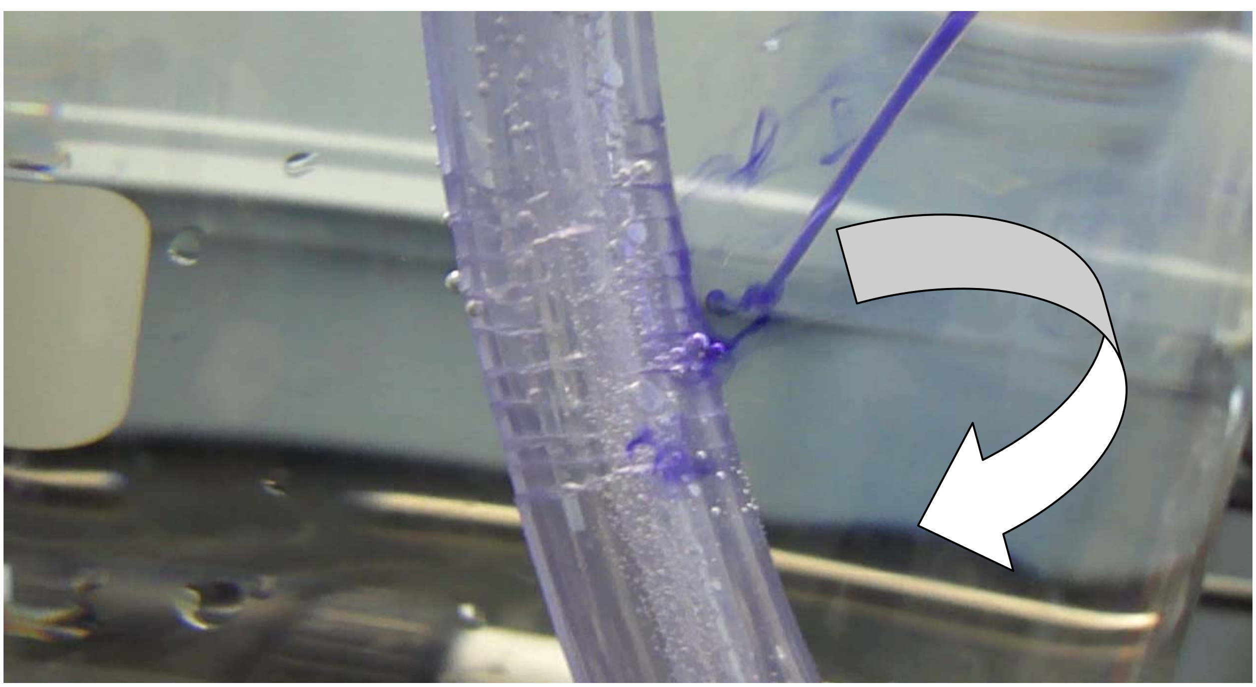

Figure 6. Close up of well screen testing using crystal violet dye.

Ahmed has perfected the analysis technique using spectrophotometric methods to determine the iron concentrations in the soil, leachate, and groundwater samples. We have refined the soil digestion procedure based on Florida Department of Environmental Protection Standard Operating Procedures, but we encountered a great deal of unexpected turbidity in the spectroscopic method caused by the large amount of carbonates in the soil sample and the conditions after soil digestion. We established a remedy suggested by the developer of the method. Once we completed modifications to the analytical method, we confirmed the accuracy of the method using historical data from the soil sampling sites. We conducted 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 was conducted using a crystal violet dye test and by varying the air flow rate in the recirculation well pump. Now that the demonstration well is completed, we are constructing 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.

On November 7, 2011, Dr. Meeroff returned to the Polk County facility, and he and Mr. Choate collected additional soil samples from various locations at the site (Figure 8 and 9).

Figure 8. Southeast corner site at Polk county Landfill.

Figure 9. Southwest corner site at Polk county Landfill.

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.