SUMMARY: SUSTAINABLE MANAGEMENT OF POLLUTANTS UNDERNEATH LANDFILLS

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Elevated levels of iron have been observed in groundwater and soils around municipal solid waste landfills in Florida. The levels have been attributed to reductive dissolution of the native chemistry in the soil perhaps caused by a shadowing effect of the landfill liner, which inhibits the reaeration of the shallow aquifer beneath a properly lined landfill. In this study, the research team will refine a preliminary list of potential engineering management alternatives for controlling the release of contaminants in-situ and conduct laboratory experiments on management methods for dealing with this issue. In a previous research grant, "*Management of subsurface reductive dissolution underneath landfills*," funded by the Hinkley Center, an innovative groundwater circulation well technology was investigated for control of iron releases in-situ.

The source of the elevated iron contaminations has not been verified yet, but is potentially caused by either one or both of the following mechanisms: 1) direct release of iron from the municipal solid waste leachate, or 2) naturally-occurring iron mobilized from the soil due to changes in soil chemistry or local hydrology. It is clear from our previous literature review as part of the previous project, "*Management of subsurface reductive dissolution underneath landfills*," that if the fate of released iron depends on the biogeochemistry, then we would see a strong influence of pH, redox, and microbial conditions on iron speciation. If the main cause of iron mobilization is microbially-mediated, then the natural organic material in the soils will be the primary food source that is consumed by microorganisms that will utilize all of the available oxygen in the subsurface leading to reducing conditions that foster iron mobilization. If the landfill gas (CO_2 + CH_4) is entering the system and somehow displaces the oxygen and adds organic matter to the soil, then this could stimulate the microbially-mediated reductive dissolution of iron. Finally, if the presence of the landfill cuts off recharge of oxygen to the subsurface, this would have the effect of artificially boosting the mobilization of iron in the subsurface.

Regardless of the source of the elevated iron, the next step is to develop an effective strategy for remediation. 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: Sustainable Management of Pollutants Underneath Landfills
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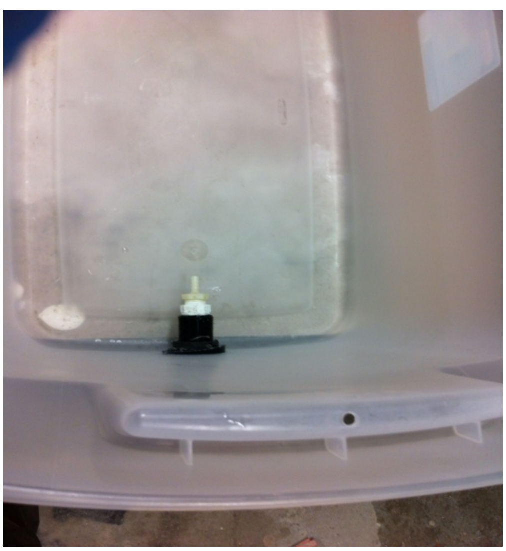
Progress to Date:

- **Task 1**. **Conduct a literature search of key parameters governing reductive dissolution**. Ahmed Al Basri has completed his literature review and will submit his draft report on August 31, 2014.

- **Task 2. Refine a list of engineering alternatives for managing elevated iron levels.** Ahmed Al Basri has completed his review and will submit his draft report on August 31, 2014.

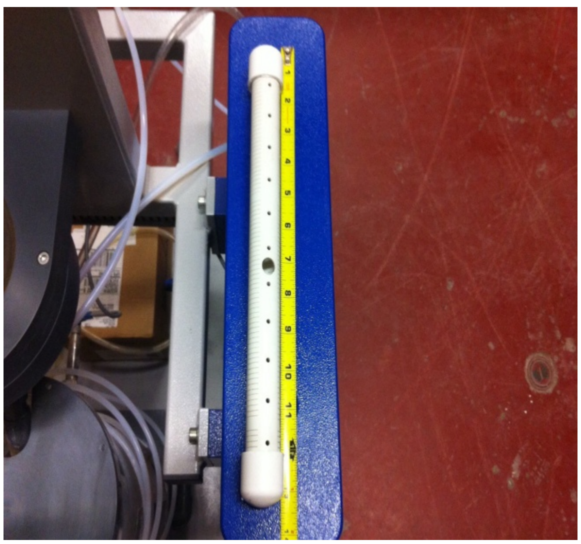
- **Task 3. Conduct laboratory experiments on selected treatment technologies for managing iron dissolution**.
  To implement the planned design for the prototype the aquarium, the thesis committee and technical advisory group recommended to adjust the aquarium size to a larger scale to create a sufficient hydraulic gradient, which led to construction of a treatment model using a 30-gallon tank with a discharge outlet to permit the water passed through the circulation system to be tested as it is shown below:




The feeding pipe and discharge pipe were made up from O.S.E. S40 1/2"×5' .025, these pipes have pre-cut slits on both sides along the length of each pipe. Additional holes were drilled 1-

inch on center on both sides of the pipe as a precaution for early clogging to allow sufficient water flow to create a flow through system, as shown in the pictures below:






The groundwater circulation wells were adjusted from vinyl tubing to 3/4" PVC pipe which is 10-inches long, divided into 4 zones (2 of them have slits, so there is 2.5-inches between the two 2.5-inch slit zones, of which each zone has 20 slits. The slits were created manually by electric belt saw as shown in the photos below:

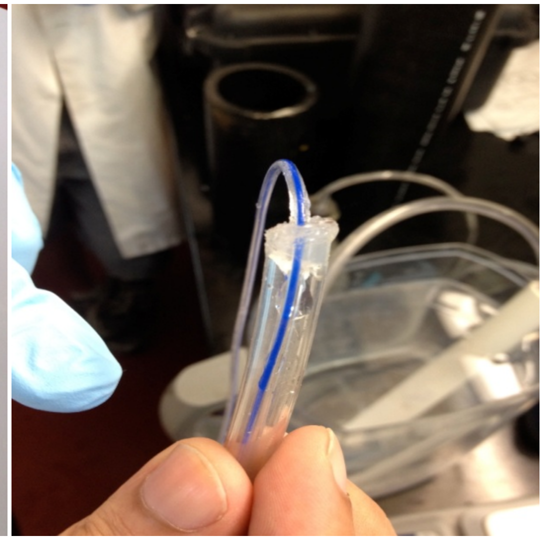

Two feeding tanks were designed to establish stable feeding to the treatment cell. This system feeds groundwater spiked with iron into the soil which has the groundwater circulation well treatment unit and several monitoring wells in key locations.

Primary flow tests were conducted to ensure the flow through the system is steady and reproducible for both cases of the system without and with soil as shown in photo below:

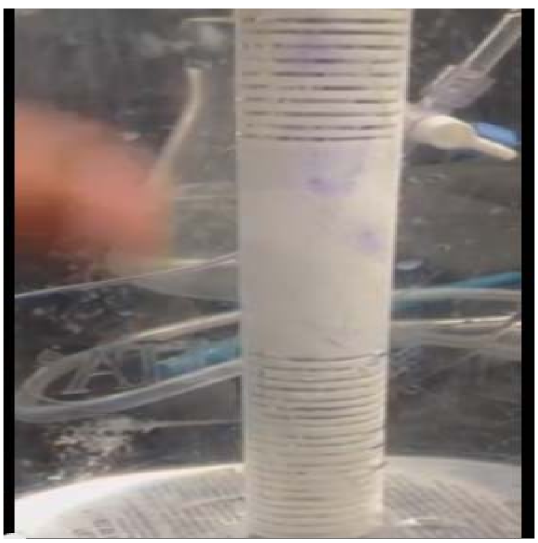

The feeding and discharge pipes were protected by a thin layer of fine gravel to prevent clogging due to fine soil particles. After loading three 5-gallon buckets of soil, the soil was saturated with water until the voids were full. The flow of water was initiated to measure the flow from the discharge point as shown in the photos below:


After saturation of the soil, the water volume flowing out of the discharge was collected for 60 seconds, and it was 90 cm^3, but that flow was attributed to high voids existing in the soil in addition to the clean system of discharge. Therefore, the conditions were kept under constant feeding equal to the stable discharge obtained from the system after couple of days, and the discharge was remaining steady at 45-47 cm^3/min, which is basically what feeding load going to get set through setting the main experiment flow for the experiment that will be conducted at the Boca Raton Glades Road water treatment facility.


An additional test required to ensure the flow through the new setting has been prepared in the lab for the groundwater circulation well prototype. The test was conducted in a clear container to ensure the process of circulation using the ¾-inch PVC pipe with slits with the vinyl connections designed to take the air bubbles to the upper slits to induce circulation. The air provided by micro-IV tubing has a fine glass tip to create small sized bubbles. Crystal violet was used as an indicator to the flow pattern after being injected close to the upper slits and driven by the negative pressure to the bottom slits creating a half circle flow pattern as shown in the pictures below:

An additional experiment was performed to test the tubes set to be monitoring wells for determining the radius of influence of each groundwater circulation well that can be achieved through the treatment process. The tube had 5 holes that were drilled at 1-inch spacing. The sampling process will be by syringe, the crystal violet and the monitoring well prototype are shown below:




- **TASK 4. Develop final recommendations**. Using the data developed in Tasks 1-3, an assessment will be conducted to evaluate the recommended management approaches to deal with reductive dissolution issues underneath Florida landfills. If the recirculating aeration wells tested in task 3 are found to be successful in ameliorating the iron dissolution issue (with the goal of lowering the iron concentration to below 0.3 mg/L), the process will be evaluated for a preliminary cost analysis and a preliminary model for scale-up will be developed. The preliminary cost analysis will include the capital cost (recirculation well, aggregates, fittings, blowers, connection tubes, installation cost, etc.) and the operating cost (electricity, maintenance, operator fees, etc.). No work has been initiated on this to date.

- **TASK 5. Prepare publication materials**. Interim and final reports will be developed and submitted. A plan will be developed for follow-up work based on comments from reviews of same. Furthermore, a scholarly publication will be developed, including but not limited to, a poster and a conference paper.

Research planned for the upcoming months:

- Complete the evaluation matrix of iron removal/trapping technologies.
- Complete larger-scale model preliminary testing and begin groundwater testing at Boca WTP.
- Develop design model and cost estimates.
- Prepare final report draft.