SUMMARY: SAFE DISCHARGE OF LANDFILL LEACHATE TO THE ENVIRONMENT, YEAR TWO

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Some closed or partially closed landfills still produce important quantities of leachate, but instead of blending this material with active Class I leachate for disposal, there may be better alternatives. If a relatively inexpensive way to pretreat the leachate and safely dispose of it onsite can be developed, a giant step toward the potential for zero liquid discharge can be achieved. FAU has pioneered the advancement of landfill leachate treatment systems using the photochemical iron-mediated aeration process and the TiO2 photocatalytic process at laboratory scale in previous research funded by the Hinkley Center, which has led to the development of reactor prototypes for pilot scale testing. The objective of the proposed research is to test a prototype photooxidative reactor at pilot scale for the removal of COD/BOD, heavy metals (i.e. arsenic, lead, and iron), ammonia, color, chlorides, and pathogens to determine the feasibility of safely discharging or reusing this leachate as a resource, such as irrigation for top caps and side slopes.

In previous work funded by the HCSHWM, 23 different engineering alternatives for long-term leachate management were evaluated (Meeroff and Teegavarapu 2010). For on-site treatment to work, some form of aerobic treatment would be expected to reduce leachate strength prior to discharge. However, biological systems are not well-suited for the removal of bio-toxics from water and are inefficient in dealing with wastes of varying quality, such as leachate. Thus post-treatment, using constructed wetlands, combined physicochemical treatment, or evaporation systems, would then be required. Unfortunately, technologies such as activated carbon and certain advanced treatment processes, such as ozone, do not adequately address inorganics, and membrane systems or air stripping merely transfer organics to another phase or create a side stream, like concentrate brine that cannot be discharged readily. Furthermore, multiple barrier systems are complicated to operate, costly, and generally inefficient. For on-site treatment options, the most effective strategies involve technologies that can destroy different classes of harmful contaminants all at once, without producing adverse byproducts and residuals.

Fortunately, FAU has been working to address this need for sustainable, economical options for routine leachate treatment and safe discharge to the environment by investigating energized processes, such as photocatalytic oxidation. In our previous studies involving the use of photocatalytic oxidation technologies for treatment of landfill leachate, we were able to demonstrate destruction of 1400 – 2500 mg/L of COD in just 24 hours. But these leachates had initial COD concentrations on the order of 6,000–10,000 mg/L, so if we start with a less concentrated material (e.g. partially closed landfill leachate), it should be possible to completely destroy the COD with the added potential of meeting the requirements of F.A.C. 62-302 for metals and 62-777 for surface water target levels or even meeting the less stringent industrial water quality guidelines for onsite beneficial reuse of this material.

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PROGRESS REPORT
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Project Title: Safe Discharge of Landfill Leachate to the Environment
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The Solid Waste Authority of Palm Beach (SWA) currently disposes of all leachate produced at the faculty by means of deep well injection. Any other cost effective method that could be developed to treat the leachate for reuse or discharge would interest the SWA. If certain types of leachate from the 45 acres of exposed side slopes on the partially capped Dyer Park landfill can be treated to a level safe for discharge to the environment, the current pipeline sending this leachate to the deep wells could be abandoned, and the leachate could be released into the nearby canal, or used to water the Dyer Park facilities that include baseball fields, soccer fields, a golf course, and all other sections of the closed landfill, or used for industrial process water onsite for dilution, cooling, etc.

Lab.EES has been developing leachate treatment technologies such as photocatalytic oxidation, which uses titanium dioxide with ultraviolet energy and also the critical orifice technology, which uses the power of magnetism and induced oxygen flow to accomplish advanced oxidation for removal of COD/BOD, ammonia, heavy metals, color, and pathogens from leachate. The current research is utilizing a falling film pilot reactor to establish parameters (i.e. reaction time, catalyst dose, etc.) for scaleup. Additional research will determine the appropriate UV intensity along with the effect of pH and temperature on the reaction. Once an optimal process is determined, the cost of treatment in dollars per gallon will be determined.

During testing, the valve that drains the reservoir was broken (Figure 1). This valve allows the reservoir to hold fluid to operate the reactor. The replacement was complicated because all of the piping system is metric; therefore, after shipping the replacement parts from Europe, the reactor became fully operational by 2/13/2015 and testing resumed on 2/23/2015.


Figure 1: Broken Valve

An oral presentation of year one findings was delivered on January 30, 2015 to the Hinkley Center and several members of the TAG group. The findings included lamp power test results and 8-hour reactor test results, along with alternative methods of removal and catalyst options. Suggestions from experts in the audience have been applied to the research. This input helped clarify some problems experienced in the lab and provided known solutions already in practice.

One reactor test has been conducted this year, 15-g/L of photocatalyst were added to 10-liters of leachate in a combined falling film-flow through reactor with both the 150-W and the 450-W lamps (Figure 2).

Figure 2: Dual Lamp-Falling Film and Flow Through

This experiment of the reactor included a new addition, a flexible pipe from the bottom of the falling film to the reservoir. This was done to replace the anti-foaming agent and prevent over-aeration that leads to splashing and excessive foam buildup. The device worked well, with only a small but different type of foam occurring as the leachate reached a pH of 9.0 in hour 4 (Figure 3).

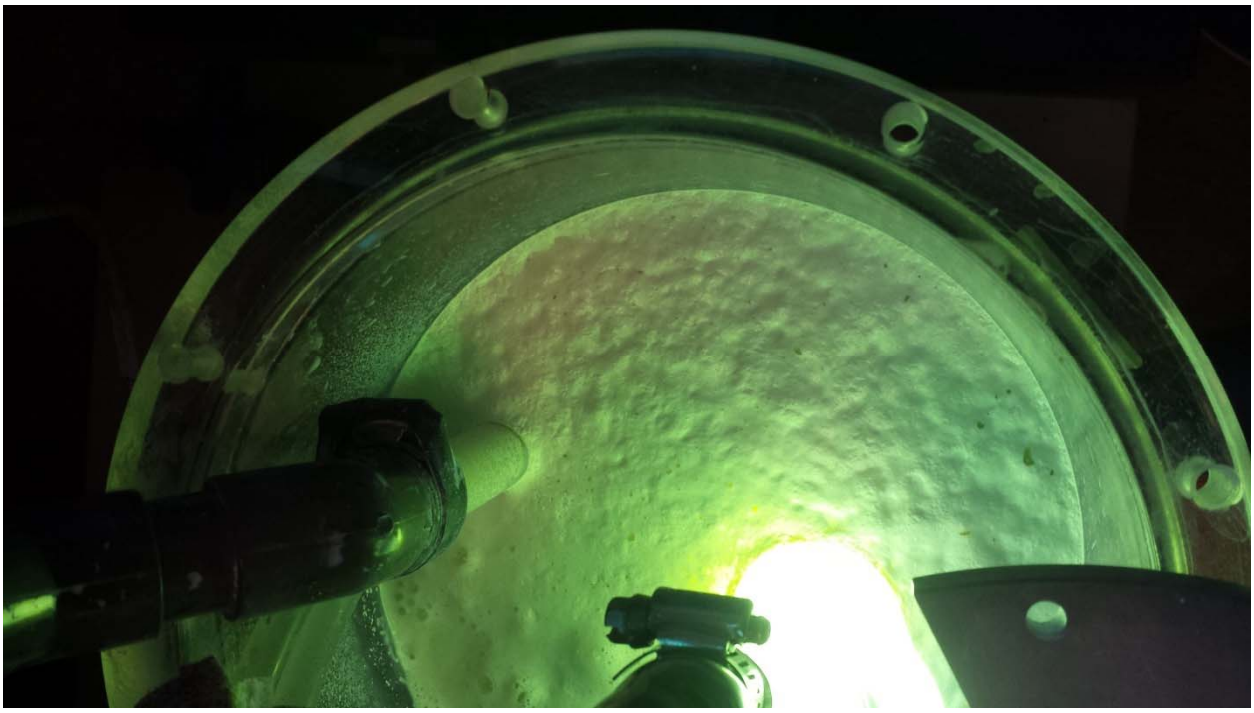
Figure 3: Foam in reservoir and flexible pipe to prevent foaming.

In this latest experiment, the COD dropped from 475 mg/L to 405 mg/L in four hour, and the calcium hardness had dropped from 425 mg/L to 170 mg/L in the same time. Nevertheless, the formation of the foam is thought to be some type of calcium precipitate that could block the UV light. A pH correction was attempted with acetic acid after the hour four mark. The foam dispersed quickly and did not reform after the pH was lowered to 7.3 in hour 4. The pH did climb back up to 8.3 at the eight hour mark at the end of testing. However, the pH correction with acid caused the COD to rise from 405 mg/L to 1362 mg/L, since acetic acid is an organic acid. The acid correction had no effect on the calcium removal, which remained constant. Acetic acid was selected because it is a simple carboxylic acid and used in many soft drinks, which means it is not a hazardous substance. However, the introduction of the additional carbon caused the COD to rise, making it a poor choice for pH adjustment in this case.

In March 2015, a pilot scale critical orifice advanced oxidation unit was built (Figure 4). The unit was tested in preliminary experiments with tapwater to adjust the hydraulics and induced oxygen rates. The device will be tested in several ways: 1) as a pretreatment step to knock down the COD, 2) as a post-treatment step following photocatalytic oxidation, and 3 as a final polishing step after lime softening.

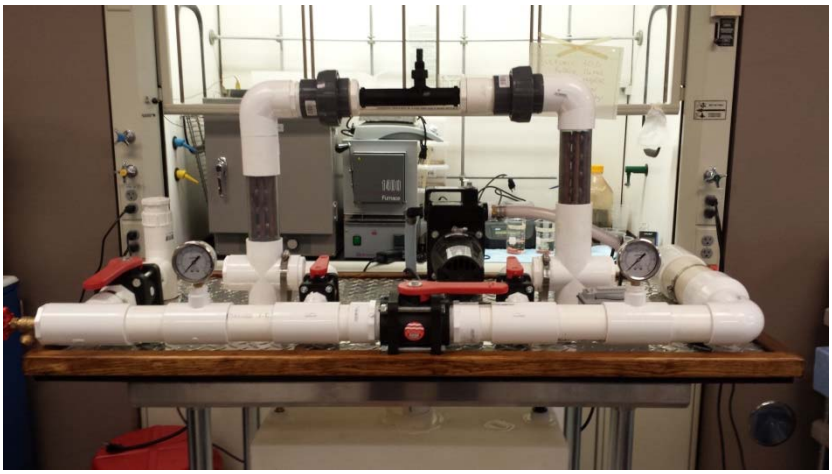
Figure 4: Critical Orifice Advanced Oxidation Device

On March 26, 2015, the research team presented the year one findings to Mark Eyeington, Marc Bruner, Amanda Krupa, and other members of the SWA team. The main questions that came up were the following: 1) why does the pH increase in certain reactions? 2) how does color impact the process? 3) what is the progress of meeting the treatment targets for reuse as dilution water? 4) what is the cost of the final process?

Research planned for the upcoming months:

- Complete the update to the literature review. The International Journal of Environmental Protection has invited our research group to submit a cover article on our work involving leachate treatment technologies.
- Meet with FDEP to discuss treatment targets for beneficial uses.
- Upcoming experiments will focus on pretreatment, post-treatment, and polishing steps involving the critical orifice unit in combination with the photocatalytic oxidation process.
- Another graduate student, Neil Coffman, is working on enhanced sedimentation and centrifugation techniques for separating the catalyst.