

SUMMARY: ENERGIZED PROCESSES FOR ONSITE TREATMENT OF LEACHATE

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FAU has pioneered the advancement of landfill leachate treatment systems using the photochemical iron-mediated aeration process and the TiO₂ photocatalytic process at lab scale in previous research funded by the Hinkley Center. This proposal describes the development of the next logical step, which is the development of pilot scale onsite treatment systems capable of detoxifying leachate with the power of ultraviolet light and advanced oxidation. The objective of the proposed research is to test photooxidative processes at pilot scale for the removal of COD/BOD, ammonia, heavy metals, color, and pathogens.

Leachate management options include on-site treatment, municipal sewer discharge, natural attenuation (including deep well injection), hauling offsite, or a combination approach. Typically, some form of aerobic treatment is employed to reduce leachate strength prior to discharge. However, biological systems are not well-suited for 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 physical/chemical/biological treatment, or evaporative systems, is generally required. Unfortunately, activated carbon and certain advanced treatment processes, such as ozone or ultraviolet light, do not adequately address inorganics, and membrane systems or air stripping merely transfer organics to another phase. Furthermore, multiple barrier systems are complicated to operate, costly, and generally inefficient. Unfortunately, most current processes cannot adequately address inorganics and organics simultaneously. From our previous work funded by the HCSHWM, our research team evaluated 23 different engineering alternatives for long-term leachate management. The results indicated that the most effective and sustainable strategies for the future would involve technologies that can destroy different classes of harmful contaminants all at once, without producing adverse byproducts and residuals. **So the question is: “Can we develop systems to treat landfill leachate at the source, cost effectively?”**

If energized processes work as well in the field (at pilot scale) as they do in the laboratory, then the answer is **“yes,”** because energized processes are: 1) designed to use the power of sunlight, which is free and requires no additional energy input, 2) easy to operate because they just require sufficient contact time and do not rely on complex precipitation reactions or biochemical processes, 3) not subject to biological upsets because they are physico-chemical processes that create broad spectrum oxidants to remove aqueous contaminants, and 4) designed to avoid merely transferring the pollutant to another medium (i.e. air or sludge).

This research will address a major technological need for sustainable, economical options for routine leachate treatment and safe discharge to the environment by investigating energized processes, such as photochemical oxidation (which includes photochemical iron-mediated aeration, TiO₂, and UV/peroxide). Two of these emerging technologies are currently being developed at FAU. These include: photochemical iron-mediated aeration (PIMA) and magnetic-photocatalytic oxidation. These new and innovative processes work by using ultraviolet light

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(energy from sunlight) to activate the surface of a semi-conductor (i.e. titanium dioxide or metallic iron) to produce highly reactive substances derived from water. These reactive radicals rapidly destroy man-made organic chemicals, breaking them down into carbon dioxide, water, and innocuous salts. In addition, it has been discovered recently by a UM-FAU partnership (funded by HCSHWM) that these processes can also remove heavy metals and reduce nitrogen-containing constituents. Thus it may now be possible to eliminate impurities in water all at once using a single process.

The objective of the proposed research is to pilot test up to three energized treatment options for the removal of parameters of interest (such as COD/BOD, ammonia, heavy metals, color, pathogens, and others mutually agreed upon by FAU and the TAG) using non-biological methods that landfill operators with little training can routinely and reliably employ without spending too much time on the task.

PROGRESS REPORT (September 2010)

Project Title: Energized Processes for Onsite Treatment of Leachate

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Progress to Date:

- **Task 1.** Literature review. Richard Reichenbach, Anthony Ruffini, and André McBarnette have completed the literature review of landfill leachate treatment process efficiency with photocatalytic oxidation and other novel advanced oxidation processes. The main focus of the literature review topics has been to identify precedents using energized processes such as UV/peroxide, PIMA, photo-Fenton, aerated corrosive cell Fenton, and TiO_2 for water treatment applications. In these studies, specific questions were targeted, such as the following: 1) efficacy for various pollutants (in particular those targeted for this study), 2) appropriate UV intensity range using the new UV fluence determination methods, 3) appropriate testing conditions, 4) appropriate range of reactant or catalyst dose (in grams or m^2), 5) appropriate hydraulic retention times or reaction/exposure times for certain pollutants, 6) appropriate mixing regimes, 7) appropriate pilot reactor design and scale-up. In addition, any factors that can impact the efficiency of the process such as catalyst poisoning, pH/temperature effects, etc. were identified. The Southeast District DEP office took the researchers on guided tours of landfill facilities within the district, and CDM assisted the PI in expanding the database to other landfill sites currently served by CDM and provided assistance in setting up facility tours outside of the Southeast District. A chapter for the final report has been drafted and is in the process of a final round of revision to reflect this work.
- **Task 2. Conduct baseline leachate quality characterization.** Approval and permission for sampling raw leachate has been obtained from Jeff Roccapriore, District Manager, Broward County Central Disposal, Waste Management Inc. of Florida for the landfill facility located on Sample Road and Florida's Turnpike. Sample collection began in early January 2010 and is ongoing. We have characterized the leachate samples for pH, COD, alkalinity, TDS, TSS, HPC, BOD, conductivity, ammonia, copper, and arsenic.
- **Task 3. Concept testing for reactor configuration/design.** Using a prototype photocatalytic reactor module for aquarium-scale testing, we have completed preparations for mock scale up experiments with simulated and real leachates. Also, bench scale tests with simulated leachates have been performed to determine optimum dosing requirements as a starting point for scale-up testing. Testing of photocatalysis with artificial leachates to replicate the conditions of successful previous lab scale experiments in preparation for scale-up is essentially completed. Aquarium-scale testing of the flow-through reactor concept began in March with simulated leachates, in preparation for Task 4, but ran into hydraulics and

leaking issues. These have since been repaired. Testing of photocatalysis with actual leachates began as scheduled in late spring 2010. However, it was decided at the June 2010 TAG meeting to pursue a plug flow reactor design. To this end, a quartz coil was designed, and was ordered from a specialty manufacturer who had to custom blow the quartz glass. There was a delay in at the manufacturer which promised to deliver the coil in mid-August, but they could not meet the expected delivery date. At this time, we are expecting a late September delivery of the coil. The next step will be to adjust the hydraulics and residence time in the reactor with an appropriate pumping strategy. Then the pilot unit will be tested at the Sample Road Landfill. We also have reached out to Heyward Inc. and Atlantia for assistance in the UV reactor portion of the pilot design. We are in the process of developing a proposal for this work.

- **TAG Meeting.** A TAG meeting was held on June 25, 2010.
- **A scholarly article has been submitted to Journal of Hazardous Materials describing the results of our previous work.** It is currently under review.
- **The findings of the research were presented at SWANA2010 in Boston, MA.** A conference paper was published in the proceedings.

Research planned for the upcoming months:

- Supply Heyward Inc and Atlantia a proposal for assistance in prototype development and testing of UV platforms with photocatalytic oxidation technology.
- Begin aquarium-scale testing with the new reactor coil and plug flow configuration.
- Start actual leachate tests with aquarium-scale unit.
- Prepare for pilot tests and design experiments to test the new unit.