SUMMARY: INVESTIGATION OF ENERGIZED OPTIONS FOR LEACHATE MANAGEMENT

Daniel E. Meeroff (PI), C. T. Tsai (Co-PI)

Because of widely varying practices in solid waste management across the State of Florida, an understanding of emerging issues and an inclusive solution to long-term management of landfill leachate is currently not available. Leachate is too strong to be discharged to classical wastewater treatment systems, and deep well injection systems are becoming increasingly more difficult to implement in certain portions of the State. 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 the futuristic photochemical iron-mediated aeration (PIMA) and TiO_2-magnetite photocatalysis.

This research will build upon the FCSHWM-funded project entitled, "*Investigation of options for management of leachate and wastewater*," directed by Dr. J.D. Englehardt and Dr. D.E. Meeroff, who were the first to successfully demonstrate the iron-mediated aeration (IMA) process for in-situ remediation of organic and metallic contaminants in soil and groundwater at former nuclear weapons facilities managed by the U.S. Department of Energy, in laboratory tests. The IMA process was shown to remove 99.996% of arsenic and 99% of organic contamination from a high strength organic wastewater, with costs projected at one order of magnitude lower than competing processes. Dr. Meeroff designed the first photochemically-assisted iron-mediated aeration (PIMA) reactor and performed the first experiments to demonstrate its effectiveness using ethylenediamine tetraacetic acid (EDTA) and cadmium metal as the model contaminants. Results showed that PIMA accelerated reaction kinetics by a factor of 6 compared to non-energized controls without pH adjustment or chemical addition, indicating the potential that PIMA can be more rapid, and perhaps more thorough, than natural biodegradation and some forms of passive treatment (e.g. non-energized iron mediated aeration). Regarding photocatalytic nanoparticles, Dr. C.T. Tsai is a pioneer in this field and has recently developed a TiO_2-magnetite nanopowder through a collaboration between Florida Atlantic University and Dr. Xudong Sun (visiting research professor at FAU from Northeastern University, China) using a novel microemulsion method to coat a magnetic substrate for military applications. However, these nanoparticles have characteristics suitable for water treatment applications and are an excellent candidate for long-term leachate management. Dr. Tsai (Department of Mechanical Engineering) and Dr. Meeroff (Director of the Laboratories for Engineered Environmental Solutions) have teamed up to establish the Florida Atlantic University Nanopowder Laboratory to investigate other applications of nanocatalysts.

The objectives of the research are to:

1. To examine the literature on energized alternatives for detoxification and treatment of leachate; collect leachate quality data; identify issues/trends

associated with long-term leachate management; and prepare a list of energized alternatives ranked according to environmental sustainability, efficiency, risk, and economic factors.

2. To design and test laboratory reactors for leachate treatment using energized options such as the photochemical iron-mediated aeration technology (PIMA) and TiO_2-magnetite photocatalytic processes.
3. To prepare preliminary cost analyses and risk assessments on selected technologies to provide a Florida-specific matrix of engineering alternatives that are innovative, economical, and environmentally sound to aid solid waste management personnel in decision-making.

To date, Eli Brossell (undergraduate) and Courtney Skinner (graduate) completed construction of the PIMA process reactor. It is nearly functional, but the aeration system must be calibrated. Courtney Skinner, Tammy Martin (Lanny Hickman Internship Program) and Francois Gasnier have begun work towards their masters thesis on this project. Ms. Skinner and Mr. Gasnier conducted validation testing and method development of the equipment required to evaluate the concentrations of the five target pollutants (Pb, conductivity, TDS, ammonia, and COD) to be monitored during performance testing of the photochemical oxidation technologies. The aim is to determine the conditions necessary to allow for safe discharge of treated leachate to the sanitary sewer or reuse on site. Using existing data on currently available technologies in conjunction with performance data generated from laboratory tests to develop unit treatment costs for scale-up, a matrix of Florida-specific engineering alternatives that are innovative, economical, and environmentally sound will be developed to aid solid waste management personnel in decision-making. This tool will help to address current barriers to the use of futuristic technologies for reducing toxic loads in water, wastewater, and soils in addition to leachate.

PROGRESS REPORT

(January 2006)

Project Title: Investigation of energized options for leachate management
Principal Investigators: Daniel E. Meeroff, C. T. Tsai
Affiliation: FAU
Phone number: (561) 297-3099
Project website: http://slab.civil.fau.edu/~daniel/labees/html/leachate.html

Work accomplished:

- A literature review is ongoing concerning the photochemically-assisted iron-mediated aeration (PIMA) process and the TiO_2-magnetite photocatalysis experiments. The goal is to have a general idea of the characterization of typical landfill leachates and to produce a matrix of different technologies, ranked according to their efficiency in removal of selected pollutant classes, economics, and risk.
- Design and construction of the PIMA pilot scale reactor (see Figure 1 below).
- Method development for monitoring the concentration of the five target pollutants (Pb, conductivity, TDS, ammonia, and COD) is ongoing. Figure 2 shows a student (Francois Gasnier) working on the ammonia meter unit.

Figure 1: PIMA process reactor

Figure 2: Experiments to validate the ammonia meter.

Significant results:

- PIMA reactor nearly operational.

Next step:

- Pursue the literature review.
- Improve the aeration system of the PIMA reactor to consistently and reproducibly deliver the air needed for mixing and the air required for the reaction to take place.
- Prior to use of actual leachates from SWA (Solid Waste Authority of Palm Beach County), preliminary scoping tests with simulated leachates will be performed to minimize hazardous waste generation.

Here are some more pictures of the student working on the project.

Figure 3: Another view of the PIMA process reactor

Figure 4: Counter

Figure 5: Separation of the hazardous waste

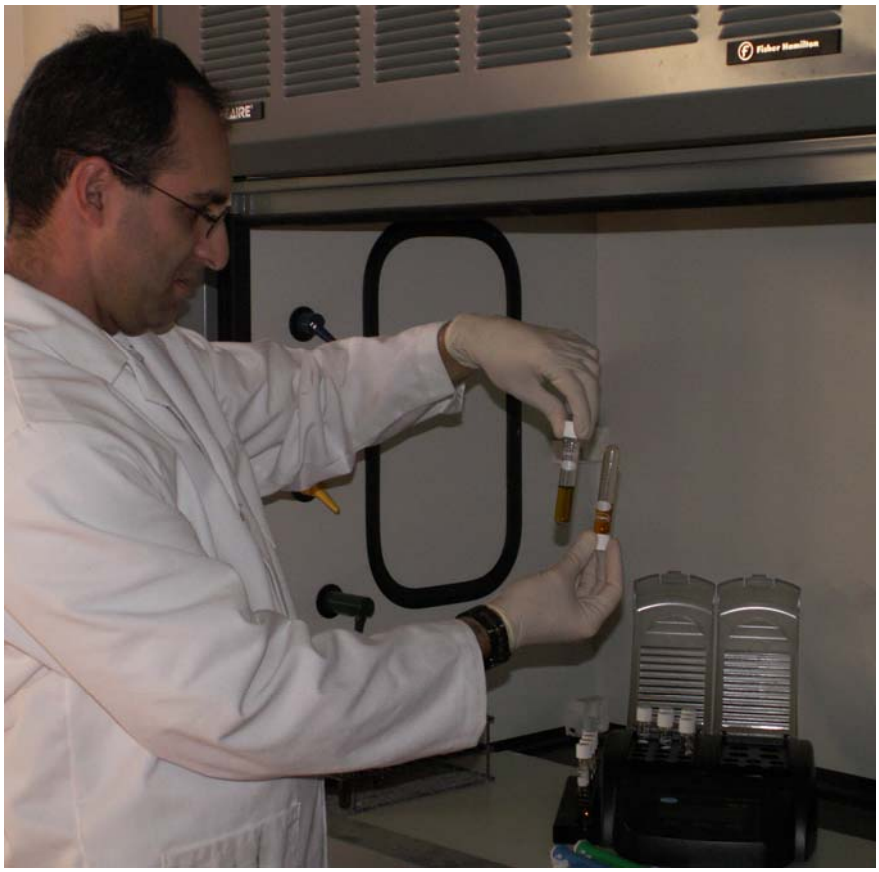

Figure 6: Dr. Meeroff performing chemical oxygen demand tests

Figure 7: Checking the light sensitivity of the new photoreactor