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 functional, and the aeration system has been calibrated. Courtney Skinner, Tammy Martin (Lanny Hickman Internship Program) and François 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

(May 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 process. Leachate composition data have been collected and composite characterization of typical leachate quality has been assembled. It appears that Florida leachate is slightly weaker than the worldwide average, likely due to higher local rainfall, which increases dilution. Table 1 summarizes these results.

Table 1: Average leachate composition

	Ammonia in mg/L as N		Conductivity in µS/cm		COD in mg/L as O2		Lead in mg/L	
	Average	Range	Average	Range	Average	Range	Average	Range
Global	844	0.1 - 8,752	13,467	5.2 - 95,000	10,573	0.4 - 152,000	0.11	BDL* - 5.0
Florida	488	BDL - 800	12,070	1,000 - 95,000	2,990	55 - 13,960	0.030	BDL - 0.1

	TDS in mg/L		TSS in mg/L		BOD5 in mg/L		pH	
	Average	Range	Average	Range	Average	Range	Average	Range
Global	11,404	0.0 - 88,000	843	10 - 45,000	4,092	BDL - 80,800	7.5	2.0 - 11.3
Florida	9,716	900 - 88,000	-	-	148	BDL - 445	7.5	2.0 - 11.3

- The second goal is to produce a matrix of different technologies, ranked according to process performance (removal efficiency of selected pollutant classes), economics, and risk. This work is underway and ongoing.
- Design and construction of the PIMA pilot scale reactor (see Figure 1 below) is complete and pilot scoping tests are underway.
- Method development for monitoring the concentration of the five target pollutants (Pb, conductivity, TDS, ammonia, and COD) is ongoing. Standard operating procedures for conductivity, ammonia, and COD have been developed, and Pb and TDS should be finalized shortly. Figure 2 shows a student (François Gasnier) working on the ammonia meter unit.
- The first technical advisory group meeting has been scheduled for May 18 to be held at the Solid Waste Authority of Palm Beach County. To date several members have confirmed their attendance. These include, Ray Schaur (Director of Engineering and Public Works, SWA), Bill Forest (FDEP, in place of Joe Lurix),

Richard Meyers (Project Manager, WRS/SWOD Broward County, in place of Ram Tewari), Alex Makled (Vice President CDM Palm Beach County, and three office staff will also attend), Eric Grotke (CDM, St. Lucie County). Those not confirmed as yet are Lee Casey (Miami-Dade County Solid Waste), Dr. Fred Bloetscher (P.U.M.P.S Inc.), Dave Gregory (Seminole County), James Bradner (FDEP), and a representative from Waste Management Inc.

- Scoping tests on conductivity, ammonia and COD have been performed. Figure 3 below is a graph showing the results obtain for the two experiments ran with COD.

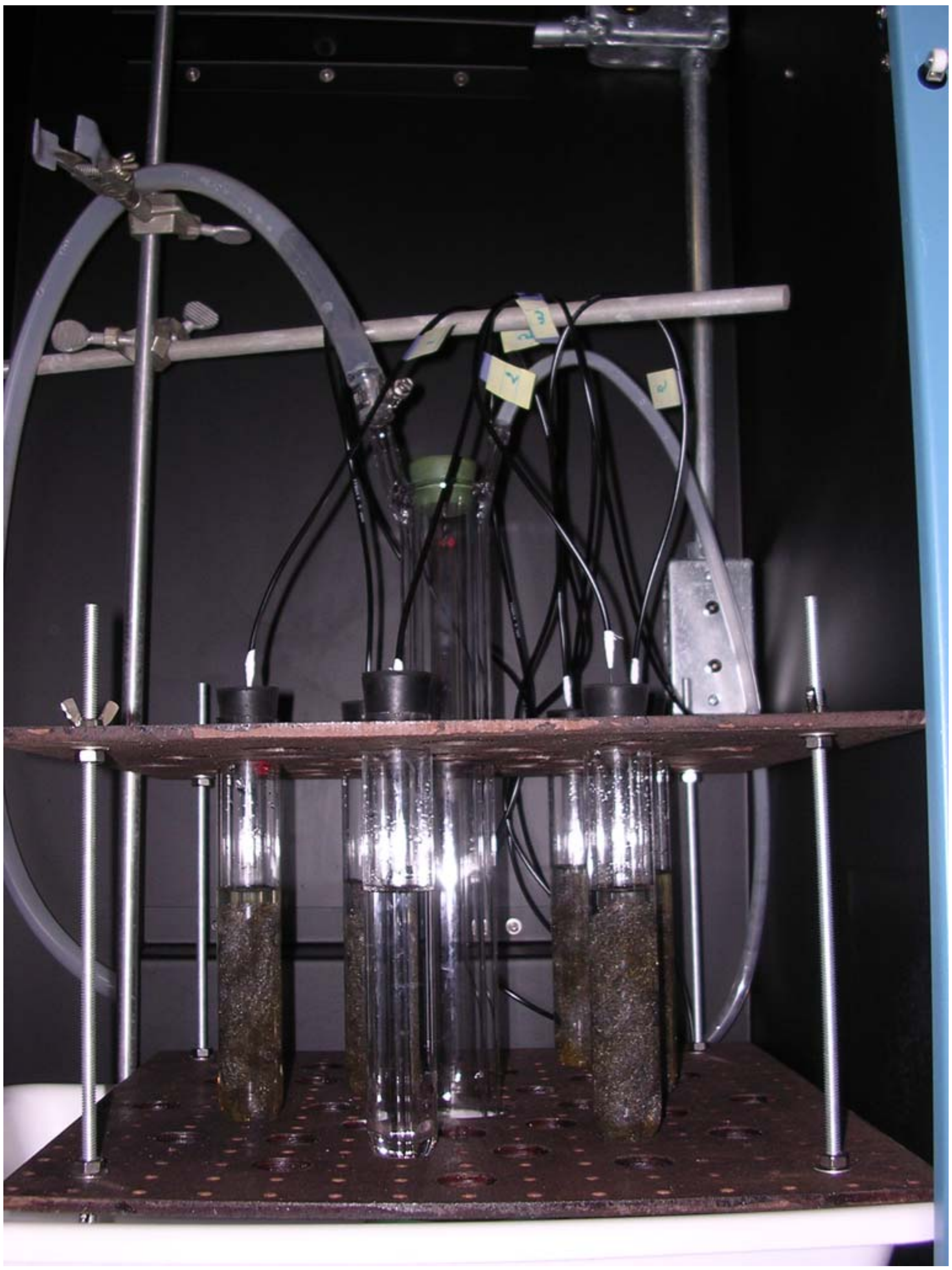

Figure 1: PIMA process reactor

Figure 2: Experiments to validate the ammonia meter.

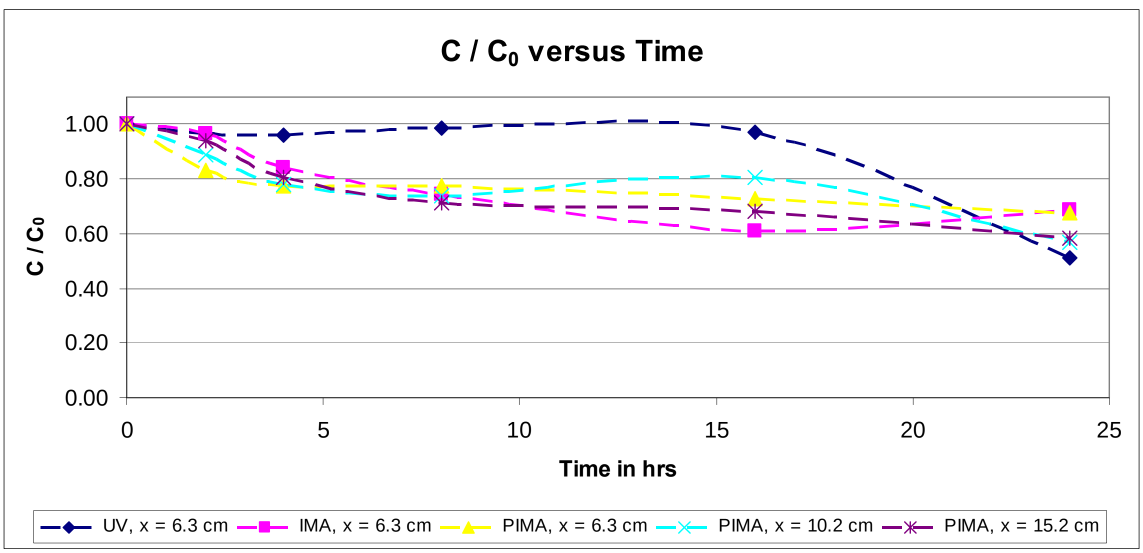

Figure 3: COD removal efficiency

Significant results:

- PIMA reactor is operational and performance data is being collected. The reactor is able to handle eight different samples simultaneously. One of the samples is an IMA process control, a second sample is a UV control without iron and the six remaining samples are the PIMA process with 3 different UV intensities possible. This setup allows for the research team to collect multiple replicates during the same experiment.
- The aeration system has been upgraded, and the air flow rate is checked and recorded using a volumetric displacement method prior to each experiment. Figure 4 and 10 shows pictures of the aeration system and the flow meter, respectively.
- Each of the following parameters is evaluated: aeration, temperature, pH, iron dose, time, and UV intensity. Table 2 below summarizes the results obtained for UV intensity measurements.

Table 2: UV intensity measurements and calculations

	Distance from the UV lamp cm	Irradiance mW/cm^2	Intensity mW
Close Circle	6.3	56.73	2251.48
Middle Circle	10.2	21.64	2251.48
Far Circle	15.2	9.75	2251.48

- COD: the highest initial removal efficiency recorded was 40%, with an initial concentration of approximately 10,000 mg/L.
- Conductivity: the initial removal efficiency was low; only one sample showed a removal of 14%, while the others showed an increase in the conductivity due to dissolved iron.
- Ammonia: an initial removal efficiency of 14% was recorded. More experiments are needed on this component to validate the measurement procedures.

Next step:

- Conduct our first TAG meeting and evaluate comments.
- Pursue the literature review to complete the leachate treatment alternatives ranking.
- Continue scoping tests with simulated leachates prior to the testing of actual leachate collected from the Solid Waste Authority of Palm Beach County.
- Evaluate the iron concentration in the effluent.
- Update the project website.

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

Figure 4: Upgraded aeration system.

Figure 5: Laboratory bench scale ammonia analyses.

Figure 6: Disposal of the hazardous waste collected during NH_3 testing.

Figure 7: Preparation of the COD tests.

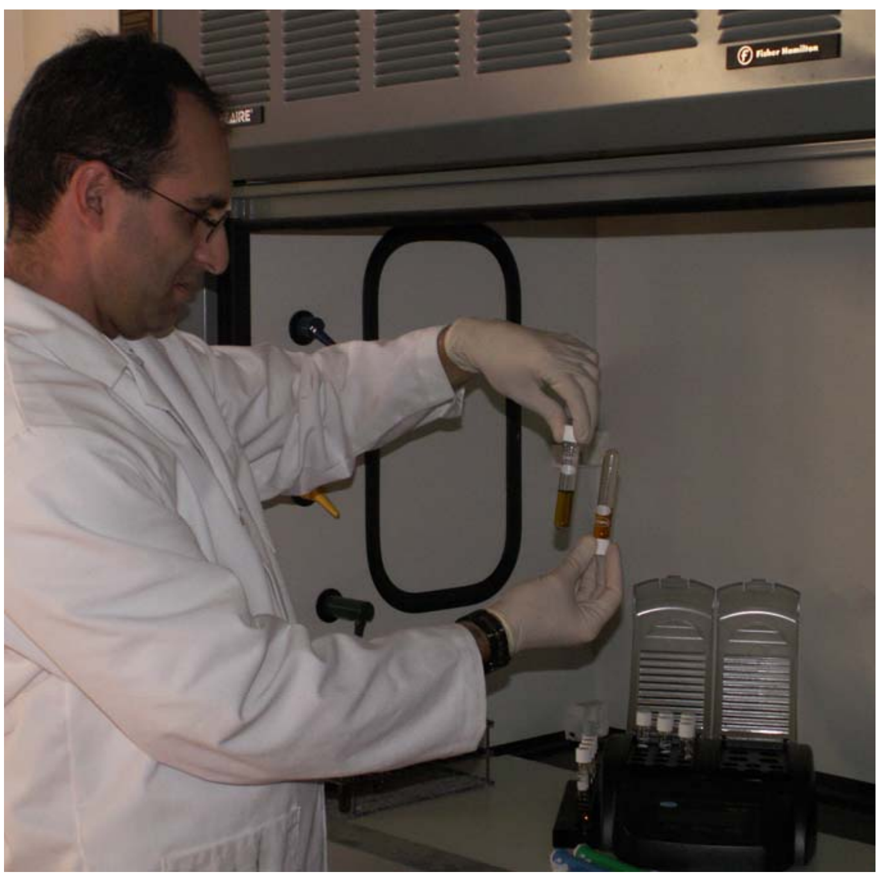

Figure 8: Dr. Meeroff performing chemical oxygen demand tests

Figure 9: Checking the light sensitivity of the new PIMA photoreactor.

Figure 10: Measurement of the air flow rate.