FAU
FLORIDA ATLANTIC UNIVERSITY
College of Engineering & Computer Science

Technical Advisory Group Meeting

"Investigation of Energized Options for Leachate Management"

By F. Bloetscher, F. Gasnier, (Florida Atlantic University)

Funded by the Florida Center for Solid and Hazardous Waste Management (FCSHWM)

DATE: **Thursday, May 24, 2006**

TIME: **11:00 am**

WHERE: **Solid Waste Authority**
7501 N. Jog Road, West Palm Beach, FL 33412

Sign-In Sheet

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	West Palm Beach, FL 33401
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Minutes

1. Opening address (11:10 AM) by Dr. Bloetscher

2. Introduction of landfill leachate project by Dr Bloetscher
   - Objectives
   - Overview

3. Discussion of study methodology by François Gasnier
   - Literature review: evaluation of leachate quality/quantity data and evaluation of management strategies
   - Discussion of Photochemical Iron-Mediated Aeration (PIMA) laboratory experiments
   - Presentation of the cost analysis and advantages/disadvantages tables

4. Discussion of photocatalytic nanoparticles by Dr. Bloetscher
   - Methodology of particle manufacturing
   - Application on leachate and future work by Swapnil Jain

5. Discussion of future work by Dr. Bloetscher
   - Summary of Energized Processes
   - Introduction of the grounding project.
   - Management Model
   - Broader Impacts
   - Project Website
   - Acknowledgements

6. Discussion of TAG input needs (open forum)
   - Tim Vinson proposed to use different forms of iron (nanoparticles) and testing another type of reactor where leachate and particles would circle around the UV lamp.
   - Richard Meyers volunteered to provide additional leachate samples from the Broward landfills but was not able to provide feedback concerning cost estimates.
   - A discussion regarding funding mechanisms to continue the work did not yield any suggestions to pursue further, although everyone was in agreement as to the value of continued support.

7. Adjourn (12:25 PM), thank you for participating

Investigation Of Energized Options For Leachate Management

Presentation to the Technical Advisory Group Meeting

May 24, 2007, Solid Waste Authority of Palm Beach County, West Palm Beach, FL

D.E. Meeroff, Ph.D., E.I.
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Director, Laboratories for Engineered Environmental Solutions
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Professor, Department of Mechanical Engineering, Florida Atlantic University
F. Gasnier
MSCE, Florida Atlantic University
Dr. Shaowei Chen
Post-Doctoral Researcher

Presentation Outline

- **Literature review**
  - Quality and quantity of leachate data collection
  - Review of available technologies
- **Experiments**
  - Design the PIMA reactor
  - Establish performances data in two steps

Literature Review

- **Leachate data:**

Parameters	Concentration: Wastewater, Medium strength	Concentration: Leachate, Average Value
Lead in mg/L	n/a	0.1
Conductivity in µS/cm	n/a	13,100
TDS in mg/L	500	11,000
TSS in mg/L	210	840
Ammonia in mg/L as N	25	830
COD in mg/L	430	10,300
BOD_5 in mg/L	190	4,000
pH	n/a	7.5

- **Leachate is a highly polluted waste stream that can not be treated as common wastewater.**

Literature Review

- **Available leachate treatment techniques:**
  - Municipal sewer discharge without pretreatment
  - Natural attenuation (Evaporation and Deep well injection
  - Hauling off-site
  - On-site treatment:
    - Biological treatment
    - Physical/chemical treatment (coagulation, flocculation, filtration, ion exchange, …)

Literature Review

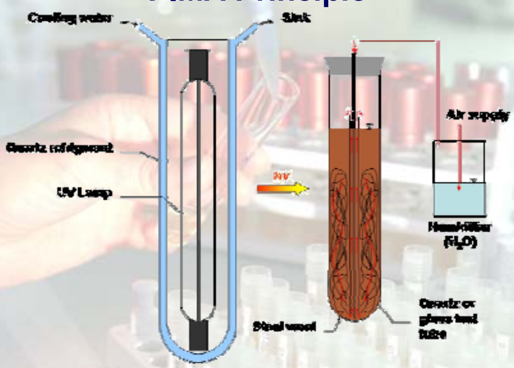
- **Alternative treatment techniques:**
  - Advanced Oxidation Processes
  - Energized Processes
- **PIMA is an EP based on the joined oxidation actions of hydroxyl radical and UV radiation and stripping potential of aeration**

Literature Review

	Technology	% COD removal	Source
	Coagulation and flocculation	23	Silva et al. (2003)
	Coagulation and flocculation	60	Wu et al. (2004)
	Reverse osmosis	68	Slater et al. (1983)
	Acclimated sludge	93	Anagiotou et al. (1993)
AOP	H_2O_2	16	Loizidou et al. (1993)
	Fenton	35	Loizidou et al. (1993)
	Ozone	35	Imai et al. (1998)
	H_2O_2	60	Shu et al. (2006)
	Fenton	61	Englehardt et al. (2005)
EP	UV / O_3	54	Ince (1998)
	UV / H_2O_2	59	Ince (1998)
	UV / H_2O_2	65	Shu et al. (2006)
	Photo-Fenton	70	Soo-M. Kim et al. (1997)
	UV / O_3 / H_2O_2	89	Ince (1998)
	TiO_2	73	Moraes and Bertazzoli (2005)
	IMA	56	Englehardt et al. (2005)
	PIMA	??	Present work

- **Currently working on the cost analysis and the pro/cons table of the treatment alternatives.**

PIMA Principle



PIMA principle

- **Reaction mechanism not completely known, but evidence suggests:**
  - The oxidation of $Fe_{(s)}$ to Fe^{2+}
  - The creation of hydroxyl radical according to the Photo-Fenton reaction
  - The oxidation action of hydroxyl radical
  - The co-precipitation action of ferric precipitates
  - The interaction with UV energy

Experiments - Phase I

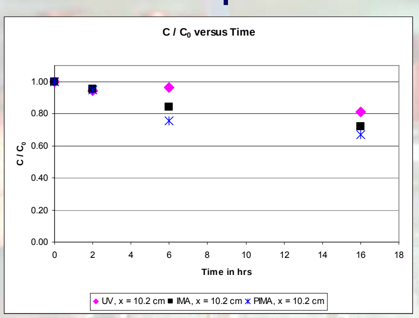
- **First phase, simulated leachate, 3 dose levels (low, medium and high):**
  - Individual scoping tests on ammonia, conductivity & TDS, COD, BOD_5 and lead
  - Mixture scoping tests

First phase completed

Experiments – Phase I

- **Individual and mixture scoping tests achieved similar treatment:**
  - PIMA is effective on COD, BOD_5 and lead.
  - PIMA is not effective on ammonia, TDS & conductivity.
  - A detention time of 16 hours is necessary to achieve treatment. Beyond this point, no significant treatment is achieve.
  - IMA results are, as expected, improved by the implementation of UV.
  - Safe sewer discharge limits are not reached by the PIMA leachate treatment process unless initial concentrations are at the low level.

Phase I - COD results of simulated mixture experiments



Phase I - COD results of simulated mixture experiments

- **COD removal up to 40% at the low level (C_0 = 750 mg/L) and 30% at the medium and high levels (C_0 = 3.8 and 11.6 g/L)**
- **Lead removal higher than 95% (C_0 = 0.3 mg/L), efficiency decrease if C_0 is lower)**
- **No removal of ammonia, TDS or conductivity**

Experiments – Phase 2

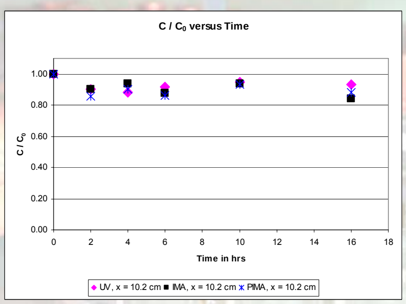
- **3 experiments completed on real leachate samples from the Class 1 landfill.**
  - Leachate collected are not concentrated (bottom part of the range observed during the literature review).
  - Preliminary results confirm the one obtained with simulated leachate:
    - PIMA remove portion of the COD, BOD_5, and lead (if initial concentration high enough, i.e. 600 mg/L for COD and BOD_5).
    - PIMA has no action on ammonia, TDS or conductivity.

Experiments – Phase 2

- **Concerning other parameters:**
  - PIMA removes the color of leachate.
  - PIMA does not reduce odors.
  - Initial pH was registered at a neutral value and remains stable over the treatment.

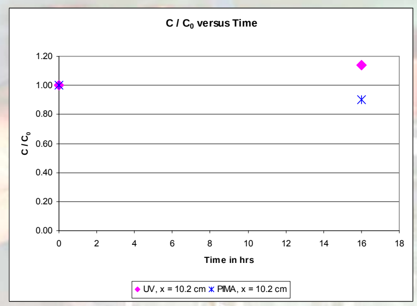
RAW UV PIMA PIMA PIMA

Phase 2 - COD results of real leachate experiments



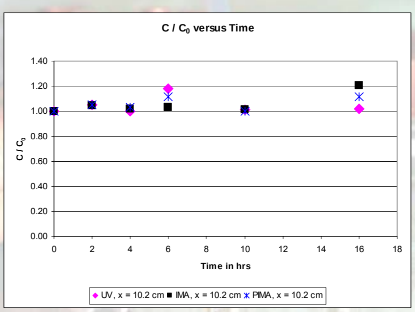
Initial concentration of 4,200 mg/L as O_2

Phase 2 - BOD_5 results of real leachate experiments



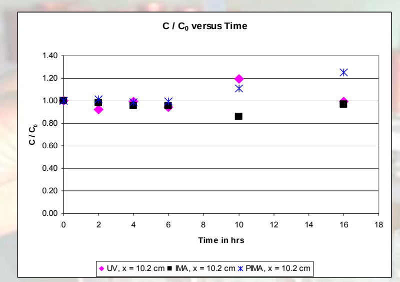
Initial concentration of 600 mg/L as O_2

Ammonia results of real leachate experiments



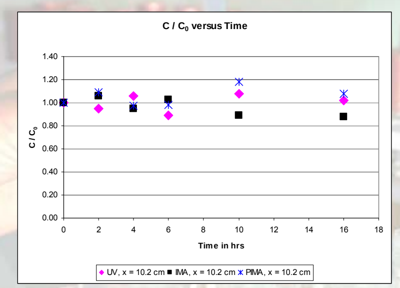
Initial concentration of 800 - 1900 mg/L as NH_3-N

TDS results of real leachate experiments



Initial concentration of 20,000 mg/L

Conductivity results of real leachate experiments



Initial value of 46,000 μS/cm^2

Lead results of real leachate experiments

- **Initial lead concentration is very low (less than 0.005 mg/L)**
- **Treatment not effective at such low level**
- **Level already in compliance with the discharge limit**

Real leachate experiments conclusion

- **Weak leachate collected:**
  - BOD_5, COD, Lead already in compliance with the sewer discharge limits.
- **Ammonia, TDS and Conductivity are not in compliance and not affected by the PIMA treatment.**

Next Steps

- **Literature review work:**
  - Refine the cost analysis and the pro/cons table
  - Establish the ranking
- **Experimental work:**
  - Continue the experiments with real leachate samples (3 more experiments).

Preliminary Cost Analysis

- **First order decay of COD: $C/C_0 = e^{-k}$**
- **Initial concentration assumed to be 10,000 mg/L (worst case scenario)**
- **Volume of leachate generated assumed to be 50,000 gpd**
- **For all technologies, the decay rate is calculated with the actual data from the research papers.**
- **Detention time is calculated as if leachate were to be discharged in the Boca Raton Sewer network with a COD less than 800 mg/L.**

Questions?

- **Feedback on the advantages and disadvantages table**
- **Cost analysis**
- **Suggestions and comments**

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Assistant Professor, Department of Civil Engineering, Florida Atlantic University
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MSCE, Florida Atlantic University
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Post-Doctoral Researcher

Individual scoping tests results

		COD			Conductivity			TDS		
		Low	Medium	High	Low	Medium	High	Low	Medium	High
Starting concentration or value		1.05	3.30	10.90	2,750	16,250	81,625	0.83	8.12	40.00
	IMA, x = 10.2 cm	21	53	39	-3	-14	-2	-	-3	0
	UV, x = 10.2 cm	-	11	3	3	-19	2	-	8	6
Process	PIMA, x = 6.3 cm	54	42	35	-26	-16	-9	-	38	-8
	PIMA, x = 10.2 cm	51	49	19	-12	-14	0	-	13	3
	PIMA, x = 15.2 cm	44	52	32	6	-12	-3	-	-8	-1
		concentrations in g/L as O_2			values in µS/cm			concentrations in g/L		
Remarks		Values after 24 hrs, no data available at 16 hrs	COD did not decrease between 16 and 24 hrs.	COD slightly decreased between 16 and 24 hrs.	Conductivity increased between 16 and 24 hrs.	Conductivity increased between 16 and 24 hrs.	Conductivity remained relatively stable between 16 and 24 hrs.	Sensitivity issue.	TDS highly increased between 16 and 24 hrs.	TDS slightly increased between 16 and 24 hrs.

		BOD_5			Ammonia			Lead
		Low	Medium	High	Low	Medium	High	Medium
Starting concentration or value		55	120	425	110	540	930	0.30
	IMA, x = 10.2 cm	38	-	28	-5	24	-8	99.96
	UV, x = 10.2 cm	-	100	-	-2	20	-12	53.33
Process	PIMA, x = 6.3 cm	-	-	-	-16	21	-4	99.97
	PIMA, x = 10.2 cm	39	55	44	-13	19	-3	99.97
	PIMA, x = 15.2 cm	-	-	-	-5	22	13	99.97
		concentrations in mg/L as O_2			concentrations in mg/L as NH_3-N			concentra-tion in mg/L
Remarks		BOD_5 was not monitored at 24 hrs.			Ammonia remained unchanged between 16 and 24 hrs.	Ammonia remained unchanged between 16 and 24 hrs.	Values after 24 hrs, no data availa-ble at 16 hrs.	Lead was not monitored at 24 hrs.

Mixture scoping tests results

		COD			Conductivity			TDS		
		Low	Medium	High	Low	Medium	High	Low	Medium	High
Starting concentration or value		0.74	3.83	11.60	3,915	28,250	78,750	0.17	13.34	43.75
	IMA, x = 10.2 cm	28	36	20	2	2	14	0	0	23
Process	UV, x = 10.2 cm	40	3	14	2	2	19	0	0	20
	PIMA, x = 10.2 cm	38	28	33	5	0	10	0	-2	19
		concentrations in g/L as O_2			values in µS/cm			concentrations in g/L		
Remarks								Sensitivity issue	Sensitivity issue	

		BOD_5			Ammonia			Lead		
		Low	Medium	High	Low	Medium	High	Low	Medium	High
Starting concentration or value		> 417	-	> 1,650	52.5	470	-	0.07	0.3	0.3
	IMA, x = 10.2 cm	> 37	-	-	-13	10	-	-	95	> 99.97
Process	UV, x = 10.2 cm	> 65	-	-	-25	12	-	-	3	79
	PIMA, x = 10.2 cm	> 48	-	> 860 *	-15	7	-	77	98	> 99.95
Remarks		concentrations in mg/L as O_2			concentrations in mg/L as NH_3-N			concentration in mg/L		

* This is not a percentage but the measured concentration: the actual percentage can not be estimated due to the double inequality.

- No results obtained (experiment not completed)