

## **SUMMARY: INTERACTIVE DECISION SUPPORT TOOL FOR LEACHATE MANAGEMENT**

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According to Nabil Muhaisen (Florida Water Environment Association) and Patrick Victor (American Water Resource Association), today's need for technological innovation has sparked a technical information revolution of endless change and continuous discovery, threatening to encompass all aspects of our lives. How will busy environmental professionals keep up with the accelerated pace of technological advances and deal with the challenges of an ever-changing regulatory environment is the question that must be answered for Florida to remain at the leading edge of socially and environmentally responsible management of solid waste going forward. This proposal describes the development of web-based, internet-accessible municipal solid waste leachate management decision support tool for utilities, consultants, and regulators. The tool will address the need for: 1) improving the measurement and evaluation of current leachate management practices, 2) improving the design and implementation of new or upgraded systems, 3) improving the regulatory framework to adequately deal with changing technologies and lessons learned, and 4) enhancing access to vital information on leachate management strategies and applications.

The key component of the decision support tool will be the online database application that will house a Best Management Practice (BMP) guide. This guide will be constantly updated with information collected from the user profiles entered into the web-based decision support interface, allowing access to the latest information on the performance of new innovative technologies or new applications.

An exhaustive survey of existing decision support systems revealed that no system exists for identification of best management strategies and solutions for the solid waste industry. The strong motivation for the proposed tool is based on the need to meet two main objectives: 1) the solid waste industry must become better informed about the new technologies and strategies that are becoming available to address their long-term needs and 2) the proposed tool will provide a methodology to design, implement, evaluate, and modify user-specific leachate management programs.

The goal is to collect, analyze, and make available technical data for use in developing effective and sustainable long-term solutions for the solid waste management industry. At the heart of the system will be the four module components: 1) user interface, 2) profile module, 3) best management practice module, and 4) report module. The tool will be accessed through a user login screen. The utility will be asked to input a user profile. The user will be prompted to answer detailed questions about critical

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characteristics needed to assess alternatives. These will include climate conditions, generation rates, waste characteristics, customer characteristics, age of facilities, size, type of landfill, regulatory requirements, costs of operation, and current disposal practices. It will also ask for subjective inputs such as desired range of costs and technologies to exclude, for instance. During this consultation phase, the tool elicits the user's objectives, resources, preferences, constraints, etc. that must be factored into the selection of the appropriate strategies for a particular application. As a knowledge-based system, the tool balances the multiple criteria that need to be weighted and prioritized to choose the best strategies from the BMP guide. The user profile will interface with the BMP database and match the best fit technologies to generate a recommended set of alternatives. Once the appropriate technology has been selected by the user and implemented, its performance must be tracked against the initial goals set by the user profile. The user will continue to update the profile with specific measures to provide the feedback necessary to keep the BMP database and ranking system current, thus closing the loop. Performance measures can then be assessed against other participating utilities, which will allow the database to be continually refined and adjusted to be as realistic and as useful as possible.

This proposal tackles the major technological need for addressing the communication gap in bringing sustainable, economical options for routine leachate management into the hands of the end users in the solid waste management industry. The Florida Atlantic University research team is uniquely positioned to deliver the proposed decision support tool because we have experience in assessing engineering alternatives for long-term leachate management from our recently-completed HCSHWM-funded two-year study entitled, "Investigation of Energized Options for Leachate Management, Report #0632018" (Meeroff et al. 2008), and we have extensive expertise relating to developing decision support and knowledge-based systems for similar applications.

The objective of the proposed research is to identify viable options for leachate management and rank them according to sustainability, performance, risk, and cost criteria. The assessment will not be limited to current practices. Futuristic technologies, such as plasma arc or photocatalytic oxidation using iron-mediated aeration or TiO<sub>2</sub>-coated magnetite (under development at FAU), must also be evaluated to forecast which alternatives will be employed by the solid waste community in the years to come. Knowledge gained from these studies will also be included in the BMP database for the decision support tool. From the assembled matrix of engineering alternatives that are innovative, practical, and environmentally-sound, we propose to develop an interactive, web-based decision support tool to aid solid waste managers in long-term decision-making with regards to leachate management.

## **PROGRESS REPORT**

(November 2009)

**Project Title:** Interactive Decision Support Tool for Leachate Management

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### **Progress to Date:**

**Task 1.** A list of available and experimental long-term alternatives and rankings continues to be refined based on comments from TAG members and industry representatives. The ranking criteria are based on environmental sustainability, efficiency, risk, feasibility, and economic factors:

- Efficiency of treatment, regarding pollutant removal performance
- Residuals, regarding solids or liquids generated during treatment
- Footprint, regarding space needed for a unit process design for a capacity of up to 1.0 MGD
- Other parameters, included in this category are environmental impacts, odor generation, dependency on climate conditions, etc.
- Preliminary cost estimates

This work is underway and ongoing. Due to the hard work of Richard Reichenbach, Anthony Ruffini, and Andre McBarnette, the literature review of landfill leachate treatment process efficiency is complete enough to allow development of rule sets for the decision support tool. The information collection tool that was developed for determining bin sizes for user profile mapping has been populated with data obtained from record searches and surveys. It was suggested that the consultants on the FS/SWANA landfill committee contact their landfill clients on the list to help obtain the information missing for the user interface tool.

- Dan Schauer of Geosyntec volunteered to gather information from the Naples landfill in Collier County and we have successfully included his information.
- John Banks is still working on putting together an appropriate list of consultants and their landfill clients on the list to help the research team.

The working version of the BMP database, which is at the heart of the decision support tool, is posted on-line for public comment at <http://labees.civil.fau.edu/LeachateMatrix.pdf> (see Figure 1). Comments have been received (see above) and are in the process of being incorporated into a revised version of the BMP database.

"Interactive Decision Support Tool for Leachate Management"

Florida Atlantic University  
Daniel Meeroff, Ph.D.

Summary of Alternative Analysis Comparison Results

Technology	Efficiency		Preliminary Costs		Residuals		Footprint		Other		Total	
	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
<b>On-Site Management Options</b>												
Municipal Sewer Discharge without Pre-Treatment	2	10			4	8	5	5	4	16	15	30
Leachate Recirculation Bioreactor	4	20			2	4	3	3	3	12	12	39
Evaporation	2	10			2	4	1	1	3	12	8	27
Hauling Off-Site	0	0			5	10	5	5	0	0	10	15
Deep Well Injection (Natural Attenuation)	0	0			5	10	3	3	0	0	8	13
<b>On-Site Treatment Options</b>												
Photocatalytic Oxidation	4	20			4	8	3	3	4	16	15	47
Membrane Filtration	5	25			1	2	3	3	2	8	11	38
Iron-Mediated Aeration	4	20			1	2	3	3	3	12	11	37
Photochemical Iron Mediated Aeration	4	20			1	2	2	2	3	12	10	35
Hydrogen Peroxide	3	15			3	6	2	2	3	12	11	35
Ion Exchange	3	15			2	4	3	3	3	12	11	34
Physical/Chemical Processes (Coagulation, Flocculation, Precipitation, Sedimentation)	3	15			2	4	2	2	3	12	10	33
Fenton Process	3	15			1	2	2	2	3	12	9	31
UV and Hydrogen Peroxide	3	15			3	6	2	2	2	8	10	31
Photo-Fenton Processes	3	15			1	2	2	2	3	12	9	31
Carbon Adsorption	3	15			2	4	3	3	2	8	10	30
Ultraviolet Processes	2	10			4	8	3	3	2	8	11	29
UV and Ozone and Hydrogen Peroxide	3	15			2	4	2	2	2	8	9	29
UV and Ozone	3	15			2	4	2	2	2	8	9	29
Ozone	2	10			2	4	3	3	2	8	9	29
Aerobic and Anaerobic Biological Processes	2	10			2	4	2	2	2	8	8	24
Ozone and Hydrogen Peroxide	2	10			2	4	2	2	2	8	8	24
Air Stripping	1	5			3	6	3	3	2	8	9	23

Weighting Scale	
Efficiency	5
Costs	3
Residuals	2
Footprint	1
Other	4

Ranking Scale	
Best	5
Better	4
Average	3
Worse	2
Worst	1
N/A	0

Weighting Scale	
Max Score	75

Description of Ranking Criteria	
Efficiency	Pollutant removal performance for the major contaminants of interest in leachate.
Costs	Capital and O&M costs for the proposed treatment process. However, with only pilot-scale and no full-scale demonstration testing results, the determination of capital and operating costs for each of the selected landfill leachate treatment alternatives is preliminary at this stage.
Residuals	Solid or liquid by-products generated during treatment or as a consequence of treatment.
Footprint	Physical size requirements of the proposed treatment process.
Other	Catch-all criterion includes environmental impacts, odor generation, dependency on climate conditions, etc.

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Figure 1. Screenshot of the alternative analysis comparison results.

A meeting with Dawn K. Templin, P.E., Pretreatment Program Coordinator, Florida Department of Environmental Protection resulted in a list of all registered industrial sewer discharge limits for municipalities and county utilities in the state of Florida. This information was analyzed to help determine bins for treatment performance of landfill leachate technologies.

**TASK 2.** This task is complete. The system selected for the web-based portal is "expertise-2-go". A temporary web site hosted at FAU has been set up to test the rules (<http://www.civil.fau.edu/~ramesh/dss/dss.html>). The temporary web site uses "e2gLite Expert System Shell" with Java interface. Rule bases required for this shell are still being developed and modified. A simple interface for the web-portal is successfully tested and work is ongoing to refine the user-friendliness of the interface.

**Task 3.** Complete.

**Task 4.** The development of decision trees in their simplest forms is now completed based on available knowledge from the case studies, literature review, and laboratory performance testing (and also from the TAG member feedback). A set of questions are already prepared that relate to several alternative scenarios. The decision trees are developed in such a way that they can be used for knowledge base development for the envisioned decision support system. A matrix of alternatives along with a preliminary ranking scheme is in the process of being refined. Preliminary feedback will be collected at the SE District FDEP office of Joe Lurix in December, ahead of our planned TAG meeting in January 2010.

The prototype decision support system has been developed and will be completed on this web site <http://www.civil.fau.edu/~ramesh/dss/dss.html>. Figure 2 shows the screen shot of the system under development.



Figure 2. Screen shot of A typical web-based expert system/Decision support system being developed

The decision support/expert system is developed using a web-enabled expert system platform using the Java applets and already developed empty shell available from eXpertise2Go.com. The shell is referred to as “e2gRuleEngine Expert System Shell”. The expert system based rules developed will follow the below IF-THEN-ELSE structure.

#### **Leachate knowledge base – example rule**

**RULE [Best Management Option?]**

**If [] = "" or**

**[] = ""**

**Then [the recommended action] = "Option # 1"**

The development of rule-bases considering all management options with the help of decision tree is underway. The rule-base can be altered based on new knowledge and responses from TAG.

The status of the web-enabled decision support system is provided by the following constituents:

- Decision trees (draft completed)
- Knowledgebase for management options (draft completed)
- Rule-base development (currently under development, 40% completed)
- Development of Web Portal for hosting the decision support system (completed)
- Interface for Web portal – (under development)
- Experiment Testing of the Rules under decision support system platform (under development)

**Task 5.** Dr. Meeroff, Mr. Ruffini, Mr. MacBarnette, and Mr. Richard Reichenbach have assembled a list of questions that will be useful for the development of the user interface module. These questions are mapped into a database for Florida landfills that was developed during our previous two-year study. This database was constructed with the support of the TAG members and in particular the efforts of Joe Lurix, FDEP Southeast District Solid Waste Management Program Director. The database collects information from major Florida landfills regarding:

1. Facility name
2. Location
3. Contact information
4. Facility class
5. Capacity in tons/day of MSW and permitted acreage
6. Service area characteristics
7. Years of operation
8. Liner systems
9. Leachate management history
10. Volumes generated
11. Assessment of performance
12. Leachate water quality
13. Identification of issues

The draft user profile information list was approved by the university Institutional Review Board for the Institutional Animal Care and Use Committee (IACUC), which governs the collection of data from human subjects, on February 18, 2009 (h09-38xm).

The next TAG meeting is planned for January 2010 to divide participants into groups for evaluating the rule-base and alternative comparisons that have been developed thus

far. Using their input, we will develop a beta-test version of the decision support tool to perform a case study and help develop the user manual for the system.

**Research planned for the upcoming months:**

- Follow up with facilities on our list of 52 landfills that have not responded to our information collection tool. Data gaps for the user interface will be filled by contacting the consultants or landfill managers on our representative list directly, since the survey has been online for nearly 9 months and only very few responses have been received thus far using this format.
- After the January 2010 TAG meeting, we will map TAG/landfill manager responses to refine the matrix of technologies
- Solicit/compile comments and feedback from technical advisory group and other stakeholders
- Testing of photocatalysis with artificial leachates is underway to replicate the conditions of successful previous lab scale experiments in preparation for scale-up
- Testing of photocatalysis with actual leachates is underway
- Conceptual design of scale-up for pilot testing is underway

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