Assessing Options for On-site Leachate and Groundwater Management Strategies at Florida Landfills

Timothy Townsend, Professor
Department of Environmental Engineering Sciences
Engineering School for Sustainable Infrastructure and the Environment
University of Florida
Box 116450
Gainesville, Florida 32611-6450
352-92-0846
ttown@ufl.edu
http://pages.ees.ufl.edu/townsend/

ABSTRACT

Despite increases in solid waste recycling and resource recovery, landfills remain an integral part of the infrastructure in Florida’s solid waste management landscape. Landfills used for the disposal of municipal solid waste (MSW) and MSW combustion residue (WTE ash) require liners and leachate collection systems. While the benefits to the environment resulting from the incorporation of liners and leachate collection systems are obvious, their use does create new challenges for modern landfill operators, design engineers, and regulators. The leachate that is collected must be managed appropriately, but some operators have difficulty in finding local treatment options and are thus required to transport leachate long distances. At some locations, the construction of a liner inadvertently results in the mobilization of naturally occurring soil elements, resulting in detrimental impacts on groundwater quality. Research is proposed to assess options for addressing current issues facing landfill operators in Florida.

First, the research will involve a critical review of current options for on-site leachate management at Florida landfills. The objective of this phase of the work will be to produce technical guidance for Florida landfill operators concerning what options are available for on-site leachate treatment and when these options are favorable relative to off-site treatment. An engineering tool will be developed that allows site specific assessment of the cost, energy, and treatment efficiency of different leachate treatment operations. This work will benefit operators faced with problematic leachate elements and concentrations (e.g., chloride and other salts at WTE ash landfills) and operators looking for alternative treatment methods for on-site leachate management (e.g., wetlands treatment).

Second, the research will evaluate engineering and construction alternatives to mitigate the release of naturally occurring elements resulting from landfill liners (and other site infrastructure) causing reductive dissolution. Current Hinkley Center work by the investigator is developing a tool for predicting when such problems are expected to occur and predicting the spatial and temporal extent of expected elevated concentrations. The new work proposed here will assess several engineering solutions to prevent or minimize the occurrence of reductive dissolution, such as the introduction of soil venting underneath the liner system. Similar to the first phase of this research project, the assessment will involve and economic and energy analysis, and will be coupled with porous media fluid flow modeling.

INTRODUCTION AND BACKGROUND

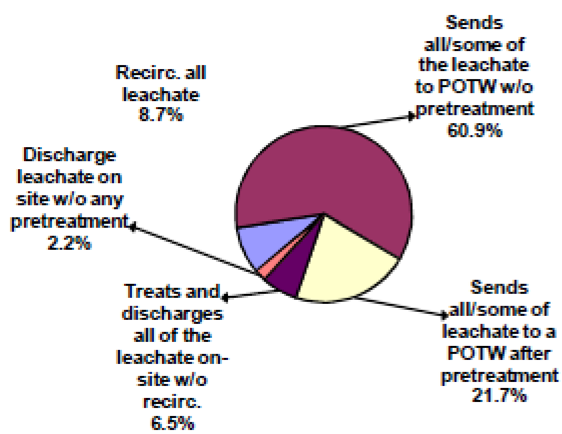
Research Agenda Items Addressed

The proposed research addresses several items listed in the Hinkley Center Research Agenda for FY 2013-2014. Agenda item 7 specifically addresses the following questions: "What measures can be taken to prevent "reductive dissolution" of iron and arsenic beneath existing lined landfills? What are some low-cost design and construction options for getting oxygen into the soils? What are the options for new landfills that have not yet been constructed?" Some of these questions are being addressed in an ongoing Hinkley Center project. The current proposal will assess engineering options for preventing reductive dissolution such as venting the zone underneath the liner.

Agenda items 12 and 13 both address on-site leachate treatment, addressing specific questions on the use of wetlands (item 12) and the management of high salt leachates from facilities that dispose of combustor ash (item 13). The current proposal will address both of these as part of developing the tool for assessing on-site leachate treatment cost, energy and performance.

Background on On-Site Leachate Treatment

The investigator previously examined leachate treatment strategies at Florida landfills for the Hinkley Center (Townsend et al., 2007; see this reference for additional references on the topic). The assessment included a technical review of many on-site management options, including on-site treatment plants, leachate recirculation, leachate evaporation and wetlands treatment. As seen in the following figure, the majority of landfills manage their leachate using off-site publically owned treatment works (POTWs).



Leachate Management Survey Results for Florida Landfills
(results based 46 of 60 landfills responding to the survey; Townsend et al., 2007)

Leachate treatment can be challenging because of the diversity of chemical constituents requiring treatment. Major classes of leachate treatment targets include organic matter (both biodegradable and biologically recalcitrant organic compounds), nutrients (primarily ammonia), salts (chloride and sodium are primary examples), and trace constituents (both heavy metals and volatile organic compounds). In some cases, off-site leachate treatment for landfill operators has become more difficult or expensive because of reluctance of POTW operators to accept leachate as well as specific constituent concerns in some leachates. An example of this problem is the high level of salts in waste combustor ash landfills.

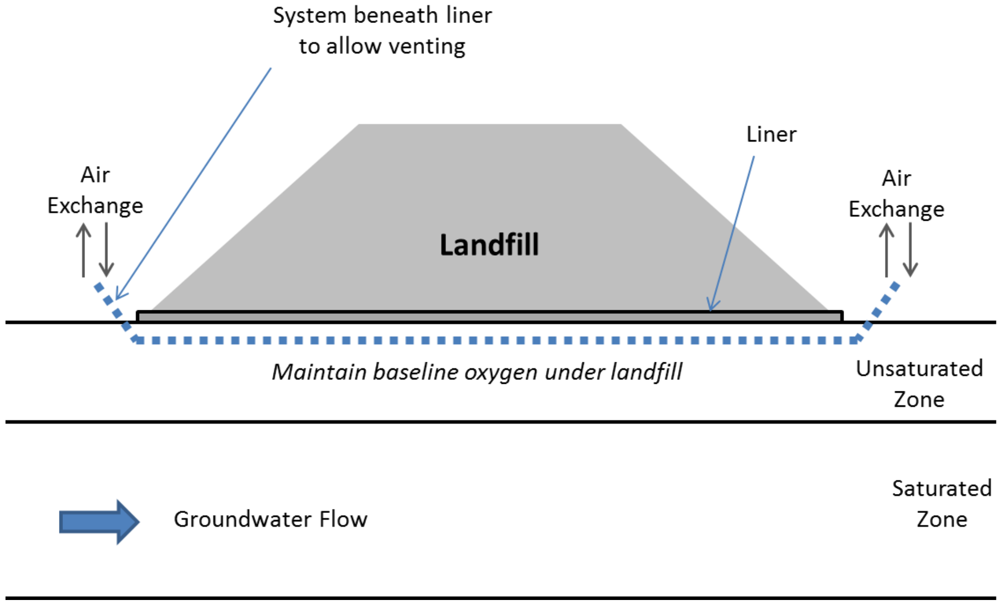
When MSW is combusted, the remaining residual is elevated in inorganic constituents. Such leachate is typically not amenable to conventional biological wastewater treatment that a POTW would use. POTW operators have concerns regarding the effect of high salt levels on the biota of the treatment plant, as well as on effluent water quality. Treatment options for salts in the leachate are limited. Some approaches attempt to separate a treated low-salt effluent from the leachate, leaving behind a salt-concentrated solution or sludge. Techniques include leachate evaporation (Birchler et al., 1994) and membrane processes (Ahn et al., 2002; Chianese, 1999). Another approach is to dilute the salts sufficiently in the receiving water body, either groundwater or surface water. This practice occurs at several Florida landfills.

Wetlands have been proposed for leachate treatment in a number of applications (Aluko and Sridhar, 2005; Bulc et al., 1997; Debusk, 1999; Maehlum, 1995, 1999). Wetlands have the ability to assimilate organic matter, nutrients, and priority pollutants. In the wetland system, leachate contaminants can be removed by various natural processes. VOCs concentrations can be reduced by air-stripping occurring on surface of the wetland water; heavy metals can be removed by precipitation, cation exchange, and plant uptake; and Ammonium nitrogen can not only be volatilized like VOCs, but also can be reduced through nitrification and denitrification processes occurring in the aerobic and anaerobic zones, respectively. Organic materials can be biodegraded by various bacteria, either in the oxic surface zones or in the anoxic or anaerobic sediments (Kadlec 1999). Salts typically remain in the water and are ultimately managed via dilution in the receiving water body (and within the wetlands themselves). As more landfills reach closure and begin to look for long-term sustainable management solutions, use of natural systems such as wetlands will grow in interest.

Background on Reductive Dissolution

Reductive dissolution refers to the process where naturally occurring elements in the form of an oxidized mineral (e.g., Fe(III) in hematite) are reduced and in the process a soluble form of the element is released into the groundwater (Fe(II)). This process has been well documented at unlined landfills where iron is released into groundwater as a result of iron reducing bacteria using solid phase Fe(III) as an electron receptor resulting in the elevation of dissolved Fe(II); Hinkley Center research has documented this in laboratory studies (Wang et al., 2012; see this document for additional references). What has also been suggested is that even the construction of a landfill liner and the associated infrastructure can cause this phenomenon; this has been demonstrated in the field, and laboratory data suggest this as well. Current research at the Polk County North Central Landfill is examining this in a field study, and a current Hinkley Center project is developing a tool for landfill operators to predict whether or not iron mobilization will occur at a landfill site and the spatial extent of such occurrences.

As suggested in the Center's 2013-14 research agenda, newly constructed landfills could possibly be engineered to prevent or minimize this effect. One possible option would be to provide subsurface venting under the liner to maintain soil and aquifer conditions similar to starting conditions. A conceptual illustration of this idea is presented as follows:



Conceptual Illustration of Below-Liner Venting System

INVESTIGATOR

The principal investigator for the proposed research is Timothy G. Townsend, a Professor in the Department of Environmental Engineering Sciences at the University of Florida. Dr. Townsend's area of specialization is solid and hazardous waste management and engineering. He has done research on numerous areas of solid waste management in the last 15 years. Specific qualifications for the proposed research include:

- Served as PI on previous Hinkley Center research on iron reductive dissolution and landfill leachate management.
- Currently a PI on a Hinkley Center project that is looking at assessing reductive dissolution potential and landfill sites.
- Currently a PI on project funded by other agencies related leachate management issues at ash disposal landfills, on-site leachate treatment, and groundwater reductive dissolution impacts.

OBJECTIVES AND METHODOLOGY

The proposed research has two overriding objectives. One, information regarding on-site leachate treatment technologies will be compiled, assessed and presented in a manner that landfill operators and related professionals can easily use the information for decision making. Two, design strategies for the prevention of reductive dissolution at new landfill construction projects will be developed and critically examined, and recommendations will be produced for the Florida solid waste community. The following specific tasks will be conducted.

Task 1. Update of current state of practice for leachate management at Florida landfills. The previous Hinkley Center study on leachate management practices in Florida will be updated (Townsend et al., 2007). Additional sites will be identified. Contact information for the majority of the facility operators already exists from the previous work. A specific objective is to identify all facilities with on-site leachate treatment components; these will serve as probable data sources for economic, energy and treatment efficiency data.

Task 2. Critical review of ash landfill leachate management practices. Given the Center Agenda Item 13, an in depth critical review, beyond those facilities in Florida, will be conducted for ash landfill leachate management. Leachate quality data, treatment experience, economic data and energy consumption information will be gathered from facilities around the country (and internationally if appropriate). The investigator already has contacts with many of the major companies involved in the WTE industry.

Task 3. Development of an engineering cost model for on site leachate treatment. A spreadsheet economics model, one that includes energy consumption, will be developed for major on-site leachate treatment options. The source of the information will be from industry and facility contacts identified in Tasks 1 and 2, the scientific literature, communications with practicing engineers (included as part of the TAG), and consultation with equipment and technology vendors. The goal of the model will be to allow an interested party to enter site specific information, using defaults where necessary, and predict the costs of implementing various forms of on-site leachate treatment.

Task 4. Development of a dissemination tool for on-site leachate assessment. The resulting model and associated information will be used to produce a tool for use by interested parties. The exact nature of the tool will depend on feedback from the TAG, but candidate formats are a spreadsheet, an interactive website, or an app.

Task 5. Development of design options for sub-liner vadose zone venting. The investigator and his team will develop a set of potential design alternatives for meeting the objectives described earlier in this proposal. These design alternative are anticipated to include either air venting (forced aeration, induced soil venting, passive venting) or the addition of aerated water (possibly with amendments) using configurations/materials such as pipes, rock trenches, geonets, and high permeability soil layers. These configurations will be presented to the TAG for feedback before detailed simulation and costing.

Task 6. Vadose zone venting simulation and economic evaluation. Appropriate design configurations developed in Task 5 will be modeled with respect to the potential to maintain baseline oxygen conditions under a landfill liner system. This will be modeled with standard hydraulic engineering techniques as well as multimedia transport models currently used by the investigator for reductive dissolution research. Based on these results, an engineering economic analysis and energy evaluation will be conducted for those scenarios/designs that are believed to suitably meet the desired objectives. The results will be compared to more traditional remedial alternatives.

Task 7. Preparation of final report. A final report will be developed to describe the results of the entire project. This report will document all activities and results, but the tool described in Task 4 will be a separate deliverable.