Assessing the Feasibility of Bioreactor Landfill Operation

Part 1:
Technical, Regulatory, and Site Opportunities and Constraints.
Making the Decision to Design and Operate a Landfill as a Bioreactor

• First let’s review:
  – Definition of a bioreactor landfill
  – Motivation for bioreactor operation
  – Concerns for bioreactor operation

• Then let’s evaluate the factors that should be considered when making this decision:
  – Regulatory considerations
  – Technical considerations
  – Site specific considerations
Bioreactor Landfill Definition

“A bioreactor landfill is a controlled landfill or landfill cell where liquid and gas conditions are actively managed in order to accelerate or enhance biostabilization of the waste. The bioreactor landfill significantly increases the extent of organic waste decomposition, conversion rates, and process effectiveness over what would otherwise occur with the landfill.”

SWANA Bioreactor Committee
Bioreactor Landfill Definition

“MSW landfill or portion of a MSW landfill where any liquid other than leachate …is added in a controlled fashion into the waste mass (often in combination with recirculating leachate) to reach a minimum average moisture content of at least 40 % by weight to accelerate or enhance the anaerobic …biodegradation of the waste…”

US EPA CAA Definition
Important Consideration

• What constitutes a bioreactor depends on who you ask.
  – A distinction is often made between landfills that practice leachate recirculation and bioreactor landfills.
  – Modern bioreactor landfills may also practice air addition.
Goal of Bioreactor Landfill Operation

• Actively treat the landfilled waste in a controlled manner.

• What would motivate a landfill operator to pursue this?
Waste Decomposes More Rapidly in a Bioreactor Landfills
Yard Trash from 20-yr Waste
Food Waste from Delaware Solid Waste Authority Test Cells

Excavated - Fall 1998

Test Cell #1  Test Cell #2

Chicken Leg  Chicken Leg

DSWA
Excavated Waste Methane Yield Data
(Alachua County, Florida)

Before Leachate Recirculation

After Leachate Recirculation (4 years)
Waste Decomposition Results in Volume Loss (Airspace Gain)
Landfill Settlement

Yolo County (Mehta et al., 2002)
Delaware (Morris et al., 2003) (Volume loss)
Mountain View (El-Fadel, 1999)
Test Cells – Yolo County
Gas Production is Increased

Yearly Methane Production (m$^3$)

Time Year

Bioreactor, $k = 0.48$ yr$^{-1}$

EPA Default, $k = 0.05$ yr$^{-1}$
Leachate Recirculation Provides a Method for Managing Leachate
Leachate Tank at Polk County
Leachate Quality is Improved More Rapidly
Rapid Stabilization Should Lead to Long-Term Savings in Post-Closure Expenses
Treating the Waste in a Bioreactor is a More Sustainable Practice than Disposal in Dry Tomb Landfill
 Concerns with Bioreactors

• Leachate and storm water issues
  – Seeps must be managed
  – Chances of storm water contamination are increased
Concerns with Bioreactors

- Excessive pore water pressures in a landfill can lead to instability problems.
- Strength of waste may become reduced following decomposition.

From: Dr. Robert Koerner
Slope stability concerns

Landfill Gas Well

LCRS

Liner
Concern: Increased Gas Emissions

• If uncontrolled, increased gas production from bioreactor operation will result in the increased gas emissions to the environment.

• Bioreactor landfills may require different types of gas collection systems compared to traditional landfills (wells can become flooded).
Concerns with Bioreactors

- Too difficult to permit

- Increased costs
  - More labor (operation and monitoring)
  - More capital (construction, pipe)
Concern: Fires and Explosive Gas Mixtures

- While aerobic bioreactor landfills can provide for greater waste stabilization rates, uncontrolled air addition can lead to the formation of fires.
- In an effort to maximize gas extraction from anaerobic bioreactors, air might be drawn into the landfill.
- Concern with oxygen in the landfill
  - Explosive gas mixtures
  - Spontaneous combustion
Is Your Site Appropriate for a Bioreactor?
Regulatory Feasibility

• At the federal level, leachate recirculation is allowed under Subtitle D if it is a Subtitle D liner system
• No bulk liquid waste disposal is permitted
• New gas rules require gas collection sooner for bioreactor landfills
Regulatory Feasibility

- Some states interpret the bulk liquid waste restriction to preclude water from being added to landfills (Florida does not).
- Some states only allow leachate recirculation if an exact Subtitle D liner is present (Florida’s liner requirements are viewed as equivalent to Subtitle D).
Regulatory Feasibility

• The biggest challenge with meeting the regulations have been:
  – Meeting the 1-ft of head on the liner requirement
  – Provide adequate operational and monitoring constraints to ensure that the environment will not be harmed
    • Seeps and storm water
    • Side slope stability
    • Gas emissions
Technical and Site Specific Flexibility

• Is the type of landfill suitable for bioreactor operations?
  – Is it an existing landfill unit or a new landfill unit?
  – What types of wastes are present?
Technical and Site Specific Feasibility

• Existing unit or new landfill unit
  – Different techniques can be used to recirculate liquids
  – The term “as-built” bioreactor is used to refer to landfills where the liquids addition devices are added to the landfill as it is constructed
  – The term “retrofit” bioreactor is used to refer to landfills where most of the waste has already been placed
Surface Methods: Pre-Cap

- Spray Irrigation
- Drip Irrigation
- Tanker Truck Application
- Infiltration Ponds
Surface Methods: Post-Cap

- Leach Field
- Trenches
- Drip Irrigation
Subsurface Methods

- Vertical Injection Wells
- Horizontal Trenches
- Buried Infiltration Galleries
1. Existing Landfill at Grade

Shallow Horizontal Trenches

MSW

Liner and Leachate Collection System
Shallow Horizontal Trenches

2. Excavate Trench and Install Bedding and Pipe

MSW

3 - 15 ft

Liner and Leachate Collection System
3. Backfill

Shallow Horizontal Trenches

MSW

Liner and Leachate Collection System
Shallow Horizontal Trenches

4. Additional Trenches

50 – 200 ft
Shallow Horizontal Trenches

5. Recirculate
Shallow Horizontal Trenches

5. Recirculate

MSW

Liner and Leachate Collection System
Deep Horizontal Trenches

1. Install Horizontal Trenches on Lower Lifts

- Install Horizontal Trenches on Lower Lifts
- Liner and Leachate Collection System
- 50 – 200 ft
- 15 ft
Deep Horizontal Trenches

2. Continue Installing

MSW

Liner and Leachate Collection System
Deep Horizontal Trenches

3. Continue Installing

Liner and Leachate Collection System
Deep Horizontal Trenches

4. Recirculate Leachate
Deep Horizontal Trenches

4. Recirculate Leachate
Technical and Site Specific Feasibility

- The biggest difficulty encountered in Florida with respect to implementing a bioreactor at an existing design or as part of a new design is the leachate and gas collection systems.

- In addition to head on the liner impacts, the additional weight of the waste caused by added moisture and increased densities can impact the foundation slope.
Technical and Site Specific Feasibility

• What types of waste are present?
  – Large amounts of C&D debris can result in hydrogen sulfide production
    • In some states, lined C&D debris landfills recirculate their leachate as a method of leachate disposal. This is believed to have resulted in greater odor problems.
  – If ash is present, it can create barrier layers that interfere with leachate flow and can cause seeps
Technical and Site Specific Feasibility

• Bioreactor landfills may be more feasible at sites where leachate disposal is an issue

• If leachate disposal is not a problem, this benefit goes away
  – Polk County NCLF → Leachate management = big benefit
  – NRRL NCLF → Leachate management = minor benefit
Technical and Site Specific Feasibility

- Savings due to increased landfill capacity is the most profound immediate costs savings to the landfill operator in most cases.
- This is a savings, however, if the site is operated in a manner where that additional space can be utilized
Technical and Site Specific Feasibility

- More rapid gas production is an advantage only if the landfill is in a position to collect and recover the methane.
Technical and Site Specific Feasibility

• Some of the concerns with bioreactors are minimized with certain site configurations as opposed to others.
• For example, in ground landfills are much less susceptible to problems from side slope seepage and slope stability problems.
Good Bioreactor Candidate Sites

• High leachate management/disposal costs
• Operations where capacity can be recovered at a later time
• Locations with good opportunity for gas recovery
• Sites with good designs for leachate collection and early gas collection
Existing Landfill vs New Landfill

• Most existing landfills can be re-engineered to serve as bioreactors. But they may not be as efficient as bioreactors that are designed and built with this purpose in mind.

• New bioreactors can put in placed systems to better manage leachate and gas, and to address concerns such as seepage and slope stability problems.
Bioreactor Landfill Feasibility

• Most sites can be operated as bioreactors.
• There are many possible direct short-term benefits, depending on site-specific conditions.
• There will be some additional costs to operate the landfill unit as a bioreactor.
• The big question is “are the savings resulting from the bioreactor greater than the cost of the bioreactor itself?”
Discussion