Leachate Recirculation and Biogas Collection Methodologies in Bioreactors

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Leachate Recirculation Attributes

- Leachate quality becomes uniform over time
- Traditional leachate treatment postponed
- Heavy metal concentrations reduced over time
- Settlement rates accelerated
- Settlement enhanced
- LFG production enhanced in both quality and quantity

Leachate Recirculation Concerns:
- Bioreactor increases the complexity of analysis dictating a need for better information
- Instrumentation - moisture distribution, moisture control, decomposition indicators
- Increases slope stability concerns
- Potential for leachate breakout
Leachate Generation

• Begins with the placement of waste and does not cease until well after closure
• About 50% of the moisture infiltrating a landfill is not absorbed by the waste

Properties Affecting Hydraulic Conductivity

• Leachate properties
  – kinematic viscosity
  – density
• MSW properties
  – moisture content
  – degree of biodegradation
  – composition
  – compaction
  – depth within the landfill
  – degree of processing
  – landfill age
**Biogas Collection Issues**

- Must reflect from outset, the considerable quantities of biogas which will be developed
- Relying upon the collection system when it is most capable

**Landfill Gas**

- Odors/potential carcinogens
- Explosion, asphyxiation and toxicity hazards
- Release of greenhouse gases
- Adverse effects on local air quality
Gas Collection Effectiveness in Bioreactors

- Significantly higher rates of gas production
- Require significantly higher gas collection capabilities
- Not uncommon for gas trenches and wells to accumulate liquid

Issues with Gas Collection

- Air intrusion through point of entry into the bioreactor - an ongoing issue
- Care needed regarding bottom/dragdown effect on bioreactor equipment
- Must avoid providing a conduit for transfer of leachate vertically through the refuse
Gas Collection Methodologies

• Collection methodologies include:
  – Drive point wells
  – Drilled extraction wells
  – Horizontal gas collection wells
Drive Point Extraction Wells

- 50 mm iron pipe, no granular
- Modest radius of influence of collection (e.g. 4 m)
- Examples of installation Hagby, Sweden; Grudziadz, Poland; Getlini, Latvia

Driven steel pipes at 24 ft spacing

Mechanism of Gas Collection
Concerns with Drive Point Methodology

- Tightening required around surface to prevent air intrusion
- Vertical migration opportunity for leachate
- Subsidence and proximity of perforations to surface
- Dragdown and possible puncture of bottom liner
- Plastics “wrapping” around well column during installation, thereby interfering with biogas collection

Drilled Extraction Wells

- Similar to traditional landfill gas extraction wells - drilled, surrounded by granular
- Implementation possible after placement of wastes is completed
- Shortcircuiting of leachate being recirculated
Horizontal Gas Collection Wells

- Concern with ingress of fines
- Can be added during development of biocell and/or after cell virtually completed
- Concern with filling with condensate and/or recirculated leachate

Horizontal Gas Collection Wells

- Pipe strength and materials and maintaining of integrity
- Transmissivity of bedding system
- Perforation pattern and spacing
Condensate Management in Biogas Collection System

- An absolutely major issue - surging, blockage, “gumming up”

- Uncertainty in gas - very moist waste (approaching field capacity) may produce gas at rates that are more than double the rate of production from dry wastes, all other factors being equal
Part II: Leachate Recirculation

Issues

Leachate Recirculation

- Objectives
  - Elevate moisture levels in refuse to maximize degradation rate
  - Introduce moisture, microorganisms and nutrients
  - Considerations must include leachate collection methodology to be employed
Recirculation provides

- Opportunities for pH buffering, nutrient addition, moisture additions
  (optimum pH 6.8-7.2)
  young leachates pH<6.5
- To accelerate decomposition (little if <20%, maximum at >40%)

Purposes of Moisture Introduction

- Leachate recirculation has long been known to enhance biodegradation because
  - increases in situ moisture content accelerate decomposition,
  - maintains moisture flow through the waste,
  - improves the distribution of microbes and nutrients in the waste stream
  - organics introduction
  - bacterial seeding
  - pH buffering
  - nutrient content
Moisture Addition Can be Accomplished by:

- Recirculation of leachate
- The addition of water
- The addition of other, bulk liquids

Major consideration:

- Difference between bioreactors and leachate recirculation landfills
- Bioreactors increase the complexity, dictating need for better information (moisture distribution, moisture control and decomposition indicators)
Concerns During Recirculation, for Bioreactor Performance

• Must ensure the recirculation elements are not entry points for air intrusion
• Evenness of injection essential for success
• Odor prevention
• Freezing in winter
• Cost
• Accessibility of the controls
• Hydraulic blocking problems

Alternatives for Leachate Recirculation

• A number exist – surface and subsurface; retrofit as opposed to as-builts
• Most appropriate is dependent on size of bioreactor
• Pre-cap versus post-cap
Surface Application Methods

- Constrains waste disposal operations
- Nuisance odors
- Health and safety concerns
- Limited amount of liquid that can be introduced
- Unevenness of introduced moisture

Infiltration Ponds

- Many of the problems of surface application methods
  - Odors
  - Spatially limited/Unevenness of moisture introduction
  - Reasonable experience at this approach
Vertical Injection Wells

• Examples include:
  – 2 inch diameter steel rods, perforated over bottom 2 ft
  – 12 ft wells used by DSWA, filled with baseball-sized granular
• Individual delivery points for recirculated leachate
• Injection under pressure

Fig. 1. Waste placement, leachate recirculation, and leachate settlement at Area A/B.
Fig. 3. pH and conductivity of leachate from Area A/B.

Fig. 4. BOD concentration and BOD/COD ratio in Area A/B leachate.
Cross-section of Bioreactor, Latvia

Mechanism of Leachate Injection, Latvia
Vertical Injection Points

- Concerns
  - Doesn’t take much to freeze &/or clog
  - Monitoring to get even injection - individual controls that are accessible
  - Clear PE - if no UV protection, may fail
  - If too long, tendency is for leachate to find some easy route to the bottom of the biocell
  - Adjustments are difficult because of number of locations

Infiltration Pipe Galleries
Infiltration Pipe Galleries

- Higher costs but are effective at delivering higher quantities of liquid
- Can be negatively influenced by settlement
- Uncertainty regarding pipe spacing & lengths, pipe perforation patterns and bedding materials
- Can be gravity drainage trenches

Horizontal Pipes Per Dendritic Drainage Pattern
Dendritic Pattern for Leachate Recirculation

Horizontal Injection Pipes in Dendritic Pattern

- Better distributional pattern but harder to control where the recirculated leachate is actually entering the refuse
- Greater tendency for failure post-closure than for horizontal pipe galleries
Alternatives for Leachate Recirculation
Methods to Energy Cells

• Surface spray application systems
  – spray irrigation at the waste tipping face
  – Tanker truck
• Drip irrigation
• Infiltration ponds
• Individual vertical injection wells
• Horizontal injection galleries
• Horizontal injection pipes in dendritic pattern

Capillary Wicking Layers

• Applied as a daily cover (to overcome the potential for channeled flow of leachate through the waste)
• Improves overall moisture dispersal
• Examples e.g. pulp sludges
• Some bioreactors are highly stratified
• High lateral hydraulic conductivity as compared to vertical conductivity
• Influenced by degree of waste compaction

The Leachate Recirculation Operations Plan should include
• Both application and rest periods
• a monitoring plan which includes recording, precipitation, application rate, total leachate applied
**Elapsed Time for Generation of LFG - Effect of Bioreactor Acceleration**

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<thead>
<tr>
<th></th>
<th>Conventional Landfilling (years)</th>
<th>Bioreactor Landfilling (years)</th>
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<tbody>
<tr>
<td>Time to get 50% of LFG generated</td>
<td>28.8</td>
<td>1.3</td>
</tr>
<tr>
<td>Time to get 95% of LFG generated</td>
<td>125</td>
<td>5.8</td>
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</tbody>
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• Questions?