BIOREACTOR LANDFILLS

Theoretical Advantages & Research Challenges

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Bioreactor Landfills

- Municipal solid waste landfills that utilize bulk liquids in an effort to accelerate the degradation of solid waste.

- Bioreactor RD&D Rule allows approved states to issue variances for the introduction of bulk liquid waste and air to MSW landfills
- Liquid introduction in landfills with alternate liner systems (other than composite liners)

Benefits of Bioreactor Landfills

- Long-Term Risk Reduction
- Potential for energy generation from the increase in LFG production rate

*Monitoring Approach**

- Identifies key monitoring parameters to enhance operational control and assess environmental impacts
- Provides a template to enable evaluation of the technology nationally
- Uses parameters and techniques currently available to owner/operators, emphasis on waste stabilization, leachate management

** From U.S. EPA 600/R-04/301*

Monitoring Parameters

- Analytical monitoring parameters
  - Solids
  - Gas
  - Leachate
- Physical parameters
  - Geotechnical considerations
  - Head on liner
  - Mass balance
  - Moisture balance

Mass Balance

- Mass of MSW
- Mass of C&D
- Mass of soil (other than daily cover)
- Mass and type of daily cover
- Landfill volume
  - Conducting volume surveys on regular basis (GPS)
- Settlement

Moisture Balance

- Volume of leachate added
- Rainfall
- Volume of outside liquids added
- Volume of leachate generated
- Mass of sludge added
- Wet basis moisture content of sludge

Rationale for Solid Waste Monitoring

- Assess the acceleration in solid waste degradation in bioreactor landfills
- Moisture in the solid waste mass
  - Facilitates the movement of nutrients
  - Medium for Microbial growth
  - Acts as a seed

Solids Monitoring Parameters

- Average temp
- Average pH
- Average volatile solids content
- Average wet based moisture content
- Biochemical methane potential (BMP)
- Cellulose + hemicellulose to lignin ratio

Increase in Landfill Capacity (Settlement)

- Increase in the settlement rate
  - Primary settlement caused by the added weight of the liquids
  - Secondary settlement caused by the increase in the rate of organic degradation of organic matter

Rational for LFG Monitoring

- Increase in the rate of decomposition leads to an increase LFG generation rate
- Potential source of renewable energy if gas collected efficiently
- If not collected efficiently, the increase in LFG generation rate may result in an increase surface emissions of
  - CH4
  - CO2
  - NMOC

$$\text{Organic Matter} + H_2O \Rightarrow CH_4 + CO_2$$

Gas Monitoring Parameters

- Total Gas Flow
- Gas Composition (CO_2, CH_4, O_2, CO) at the flare
- Well head gas composition
- HAPs
- Fugitive gas emissions

Leachate Monitoring

- Temperature
- pH
- Conductance
- TDS
- Alkalinity
- Chloride
- Bromide
- Fluoride
- Sulfate
- BOD
- COD
- TOC
- Total Phosphorous
- Ortho Phosphate
- Ammonia
- Nitrite
- Nitrate

Leachate Monitoring (secondary)

- VOCs (40 CFR 258 Appendix I)
- SVOCs
- Volatile Fatty Acids
- Metals (As, Ba, Cd, Ca, Cu, Cr, Fe, Pb, Mg, Hg, K, Na, Se, Ag, Zn)

Potential Long-Term Risk Reduction

- Controlled short term decomposition rather than persistent long term emission

Economics

- Increase landfill capacity
- Industrial liquids
- Potential reduction in post closure care (PCC)
- LFG to Energy

Operational Concerns

- Potential for differential flow
- Potential increase in odor if no LFG collection
- Increase in the potential of standing water
- Fires in aerobic systems
- Data management

Design Considerations

- Slope stability
  - The increase of moisture content and the concurrent increase in gas generation may result in an increase in pore water pressure
  - High pore water pressure may lead to slope failure
- Perched liquids within the landfill
- Head on the liner
- Differential settlement
- Watering out of gas collection lines

Head on Liner

- Head on liner not to exceed 30 cm
- Leachate collection system needs to be design to handle the increase in leachate flow

Conclusion

- Monitoring approach presented earlier provides a practical method to assess landfill bioreactor operations and environmental impacts
- As more field data is accrued, monitoring strategy will be refined to reflect advances
- *Correctly* designed and operated bioreactor landfills *may* reduce liability and long-term risk to human health and the environment

Next Steps…

- EPA ORD, OSW and LMOP CRADA with
  - Waste Management;
  - Polk County Fl,
- Effects of Industrial Liquid and Various Sludge addition;
- Bioreactor Landfill State of the Practice (1st Quarter 2009);
- Design Criteria for Bioreactor Landfills (2st Quarter 2010);
- Project XL as well as other bioreactor landfills

Thank you…
Questions?

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