Outer Loop Landfill
EPA/WMI Bioreactor Research

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Presentation Content

◆ EPA Bioreactor CRADA with Waste Management, Inc.
  » Initial Data from Research Project
◆ Supporting Research
◆ Discussion Questions
Bioreactor Fundamentals

- In simplest form, leachate reintroduced to the waste mass
- In more complex forms, sequenced addition of liquids, air or other combinations performed with aim of controlled, accelerated degradation
Bioreactors – Potential Benefits

- Bioreactors reduce long-term environmental risk
- Bioreactors act as on-site leachate pre-treatment systems, produce less potent leachate
- New bioreactors require relatively few physical modifications compared to traditional landfills
- Bioreactor techniques may be applicable to landfill remediation
- Bioreactors produce the same amount of methane, but at a faster rate corrective actions.
Key Performance Objectives

- As a research effort: identify key operating parameters and develop guidance on operation and monitoring
- Demonstrate environmental protection benefits of bioreactor operational technique via enhanced control of leachate and gas
Bioreactors – Research Challenges

- How can bioreactors enhance environmental protection?
- Which bioreactor operational techniques most efficiently degrade waste?
- How can operators distribute leachate and collect gas efficiently?
- Is an interim cover necessary to cover a waste mass that is settling?
- How do operators ensure physical stability over time?
- How much moisture addition is optimal for degradation?
- What limitations exist for natural degradation?
- When can the landfill be “switched off” and closed?
- Can post-closure care be reduced?
ORD Bioreactor Research

◆ Bioreactor CRADA
  » Cooperative Research and Development Agreement with Waste Management Inc.
  — Share tasks and information
  — Signed in 2000 designed to end in 2005

◆ Supporting and Related Research Projects
  » State-of-the-Practice of Bioreactor Landfills
  » Microbial Temporal Analysis of Waste Degradation
  » Liner/GCL Interaction with MSW Leachate

◆ Upcoming EPA Bioreactor Workshop in February 2003
CRADA Project Objectives

- To determine the parameters and trends that should be monitored to control and assess the performance of a bioreactor landfill.
  - Leachate
  - Gas Management/Fugitive Emissions
  - Solids Decomposition
- Two primary sites
  - Area 7 – New fill
  - Area 5 – Existing fill to be retrofitted, and will use nitirified leachate to control ammonia levels
  - Shared experimental control area
Unit 5
Retrofit Anaerobic

Unit 7.3
Control

Unit 7.4
New Aerobic/Aerobic Sequence

Outer Loop Landfill, Louisville, KY
Experimental Design

- Facultative Landfill Bioreactor (FLB) and Aerobic-Anaerobic Landfill Bioreactor (AALB) treatments
- Conventional (no leachate addition) landfill control
- Treatment and control units composed of independent, paired cells

Source: Jim Markwiese, Neptune and Co.
Critical measures were selected to capture waste stabilization

Example: Volatile Organic Acids

Source: Jim Markwiese, Neptune and Co.
Critical Measures

◆ **Leachate**
  » BOD, COD, Temperature, pH, VOA’s

◆ **Municipal Solid Waste/Solids**
  » Biochemical Methane Potential, Organic Solids, Temperature, Settlement (GPS), Density, pH, Moisture Content

◆ **Gas**
  » Methane, Carbon Dioxide, Oxygen, Volume

Source: CRADA Quality Assurance Project Plan Final 21 SEP 2001
Facultative Bioreactor

Gas Collection to Generate Energy

Groundwater Monitoring

Leachate / Liquids Addition

Leachate Nitrification Treatment

Gas Collection

Figure Courtesy of Waste Management, Inc.
Outer Loop
Unit 5
Unit 5 Trench Schematic

Figure Courtesy of Waste Management, Inc.
Unit 5 Trench Infiltration/Gas Collection Gallery

Figure Courtesy of Waste Management, Inc.
Unit 5 Sub Cell Arrangement
Gas Monitoring

- North metering station
- South metering station
- 5.1a and 5.2b (South)
- 5.2a and 5.2b (North)
- To flare
Aerobic-Anaerobic Bioreactor

- Gas Collection to Generate Energy
- Air Injection
- Groundwater Monitoring

- Leachate / Liquids Addition
- Gas Collection
- Air Injection

Figure Courtesy of Waste Management, Inc.
Outer Loop Unit 7
Initial Results
Unit 5
Gas
Unit 5.1 Gas Composition vs. Time

Figure Courtesy of Neptune, Inc.

Leachate Injection Begins

-%w/w

CH4
CO2
O2
Respective Lab Result

Date
11/01 01/02 03/02 04/02 06/02 08/02 09/02
Unit 5.2 Gas Composition vs. Time

Figure Courtesy of Neptune, Inc.

Leachate Injection Begins

- CH4
- CO2
- O2
- Respective Lab Result

Date

EPA

Figure Courtesy of Neptune, Inc.
Modeled v. Actual Methane Production
Unit 5

MODEL ASSUMPTIONS:
- 2,085,748 tons (1995-2001)
- $L_0 = 1.6$ ft$^3$/lb
- Collection efficiency = 100%

Figure Courtesy of Waste Management, Inc.
Modeled v. Actual Methane Production
Unit 5

methane production (ft³/min)

k=0.03
k=0.05
k=0.07

Figure Courtesy of Waste Management, Inc.
Initial Results
Unit 5
Leachate
Outer Loop Unit 5 Leachate Sampling

6/10/2002
Outer Loop Unit 7 Leachate Sampling
Unit 5
Cumulative Liquid Addition and AUF vs. Time

Figure Courtesy of Waste Management, Inc.
Unit 5
Liquid Addition and Leachate Removal vs. Time

Figure Courtesy of Waste Management, Inc.
Unit 5 Leachate
BOD/COD vs. Time

Figure Courtesy of Neptune, Inc.
Unit 5.1A Leachate Composition vs. Time

Figure Courtesy of Waste Management, Inc.
Initial Results
Unit 5
Solids
Baseline Waste Sampling
Baseline Waste Sampling
Solids Analysis
Unit 5.1A
Waste and Ambient Temperature and Leachate Addition vs. Time

Figure Courtesy of Waste Management, Inc.
Unit 5 Waste Density vs. Time

Figure Courtesy of Waste Management, Inc.
Unit 5 Waste Volume vs. Time

Figure Courtesy of Waste Management, Inc.
Unit 5 Airspace Recovery vs. Time

Figure Courtesy of Waste Management, Inc.
Static FTIR - Background
Scanning FTIR
Summary

◆ Project is in the initial stages of a multiyear study
  » This project, coupled with supporting research will enhance understanding of bioreactors
    — Project XL
    — Assessment of Bioreactor Performance Study
◆ Early bioreactor results are as expected
CRADA Next Steps

◆ Continue Monitoring
  » Revise Monitoring Plan as Needed
◆ Issue Interim Report in 2003
◆ Issue Detailed Technical Report in 2005
Q. How effective is bioreactor technology in achieving desired aims?
A. Too early to tell at this project, but beneficial trends as expected.

Q. What research gaps exist?
A. Which monitoring parameters needed at working fills to maintain control.

Q. What challenges were faced?
A. Continuity of operations, retrofitting of system to existing fill, changing waste stream, daily operations, permit proceedings.
Discussion Questions (cont’d)

Q. What recommendations can be made for future design and operation?
A. Waste placement planning, gas collection timing

Q. How were instruments used in process control?
A. Parameter control is direct for some parameters, delayed for others, data management is a concern