Bioreactors & 
Landfill Gas Emissions

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Landfill Technology Conference
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Presentation Outline

- Potential Issues & Environmental Concerns
- Ongoing Field Test Evaluations
- Updates & Next Steps
Landfills are identified for evaluating residual risk under CAA Section 112 (f)
- EPA has identified ~30 hazardous air pollutants (HAPs) in landfill gas (LFG)
- Persistent bioaccumulative toxics (PBTs) include Hg and dioxins/furans and are linked to LFG

Existing emission factors are for conventional landfilling operation and do not reflect bioreactor operations

Data being collected through ongoing field test programs will help in
- Updating existing AP42 LFG emission factors
- Developing LFG emission factors for bioreactors (to include in AP42) and
- Evaluating residual risk.
Potential Issues In Regard to Air Emissions

- Bioreactor operation can result in increased environmental impact if –
  - There is no LFG collection & control
  - There is a delay in installation & operation of LFG collection & control from onset of liquid additions
  - No cover material in place to help contain the gas
  - Presence of cracks & fissures in existing LFG cover and/or cap

- Bioreactor operation can result in decreased environmental impact if LFG collection and control is designed to minimize fugitive emissions
Potential Issues In Regard to Air Emissions (Cont.)

- Existing requirements are for sites that contain at least 2.5 millions tons of waste
  - No Clean Air Act LFG collection/control requirements for smaller sites

- Potential increase in air toxic emissions?
  - Sewage sludge is often part of liquid additions; transport & fate of mercury in sludge and potential formation of organo-mercury is not understood
  - If a landfill fire were to occur, cause for concern for dioxin/furan emissions and other impacts to local air and water sheds
Potential Issues In Regard to Air Emissions (Cont.)

- Must closely monitor to ensure that landfill fires do not occur
  - Aerobic Operations
  - May be more of an issue because of the high temperatures that are experienced within the site (will also need adequate supply of liquid/water for length of time that site is operated as aerobic bioreactor)
  - Anaerobic/Hybrid Operations
  - Air intrusion can lead to landfill fires; operators must balance maximizing LFG control while avoiding air intrusion
Potential Issues In Regard to Air Emissions (Cont.)

◆ Tradeoff in maximizing liquid infiltration and minimizing fugitive emissions
  » Operators typically want to delay installation of cap or cover material to allow for more infiltration
  » Often substitute materials for cover are chosen because of their permeability and ability to maximize airspace

◆ Leaky caps typically result in higher level of fugitive gas emissions
  » Is compost effective in minimizing LFG emissions for any fugitive LFG?
  » Are there geo-textiles that could be used that would allow for infiltration while minimizing LFG emissions?
  » Are there data available to compare effectiveness of alternative cover material (over short term and long term)?
Potential Issues In Regard to Air Emissions (Cont.)

◆ Lack of long-term data to help characterize LFG emissions
  » Very limited data exist for anaerobic operations
  » Even less data available for aerobic/hybrid operations
Technology for Measuring Area Source Emissions

- Beam Configuration: Open-path Fourier Transform Infrared Spectroscopy (OP-FTIR) multiple beams to determine vertical and horizontal gradients
  - Uses radial scanning technique to locate potential hot spots
  - Vertical gradient measurements used for determining mass flux rates
- Smooth basis function minimization (SBFM) algorithm to directly reconstruct the mass equivalent plume downwind from the source
- No need for tracer release or inverse dispersion modeling approach for plume characterization (although we have included this as part of QA/QC)
- (Plane-integrated concentration) times (wind speed) yields emission flux

EPA
Schematic of OP-FTIR Technology

- IR beam executing a single “monitoring event” (5 events make up a complete “plume traverse”)
- Retroreflectors mounted above the ground
- Wind Direction
- Source
- Directly measured plume component
- FTIR on scanner
- Ground measured retroreflectors
Scanning OP-FTIR
OP-FTIR Measurement Paths at Swine Waste Lagoon
OP-FTIR Determined Ammonia Fluxes from Hog Waste Lagoon

Jacksonville 7/11/00 Flux = 0.35 g/s; CCF = 0.984
concentrations are in microgram/m³

Jacksonville 8/16/00 Flux = 0.079 g/s; CCF = 0.999
concentrations are in microgram/m³
Major advantage of this technology is that emissions are being measured rather than modeled.

Successful demonstration of open-path optical technique to conduct radial scans and measure emission fluxes for multiple pollutants.

Successful application of this technology at different large-area sources including coal mines, landfills, poultry, swine farms, and wastewater treatment facilities.
Overview of Research to Evaluate LFG Emissions from Bioreactors

- Characterizing emissions from 2 different types of landfill “bioreactors” as part of partnership with Waste Management for large-scale operation in Kentucky [CRADA w/ Waste Management, Inc. (WMI)]
  - Evaluating fugitive emissions & mercury
    - One round of sampling was completed in 2002;
      Two rounds planned for 2003
      - Sampling header pipes (raw LFG) for total, elemental, and organo-mercury
      - Using open-path Fourier Transform Infrared (OP-FTIR) Spectroscopy for measuring fugitive emissions including speciated VOC, methane, HAPs, NH₃
  - WMI is sampling header pipes for methane, carbon dioxide, NMOC, and speciated organics including list of “AP42” LFG constituents
Overview of LFG Field Tests - Bioreactors

- Considering sampling other types of bioreactors using OP-FTIR including aerobic
- Results from field tests will be documented in EPA reports and summarized in peer-reviewed journal publications
- Gathering all available LFG data for bioreactors (D. Reinhart) to develop appropriate defaults/models for bioreactors
Organization Chart for CRADA Bioreactor Research

- Waste Management Biosites Group
  - Gary Hater
  - Roger Green

- WM Site Personnel

- Contractor Support

- David Carson
  - Containment

- Wendy Davis-Hoover
  - Solids Decomposition

- Fran Kremer
  - John Martin
  - Project Coordination

- Susan Thorneloe
  - Bruce Harris
  - Landfill Gas

- Jennifer Goetz
  - Solids Sampling

- Contractor Support
  - In House
  - D. Reinhart
  - R. Hashmonay

- Larry Wetzel
  - Solids Sampling
Plot Plan of Bioreactor Field Test

- Retrofit Area
- Compost Area
- Biocover Area
- AALB Area
Preliminary Results for Radial Scanning – Methane Concentrations for Unit 5

Concentrations are in ppm
Preliminary Results of Vertical Scan of North Side of Unit 5 – Methane Flux

Concentrations are in ppm
Flux = 19 g/s
Preliminary Results of Vertical Scan of South Side of Unit 5 – Methane Flux

Concentrations are in ppm
Flux = 18 g/s

Height [meters]
Crosswind Distance [meters]
Preliminary Results from OP-FTIR Measurements on South Side of Active Site - Methane Flux
Update to EPA’s Landfill Gas Emission Factors (AP 42)

◆ Plans to have update by Spring 2004; will include emission factors for bioreactor operations in addition to updated data for conventional landfilling operations for
  » Use in State emission inventories and obtaining air permits
  » Use in MSW Decision Support Tool (includes conventional and bioreactor landfills)
◆ Results will also be used in evaluating residual risk for landfills as specified in CAA Section 112 (f)
Update to EPA’s Municipal Solid Waste Decision Support Tool

- Municipal Solid Waste Decision Support Tool (MSW DST) provides holistic approach to evaluation of solid waste management
  - Evaluates life-cycle environmental tradeoffs (multi-media, multi-pollutant) including potential benefits of recycling and energy recovery
  - Includes analysis for all waste management processes – collection, transportation, recycling, composting, combustion, landfilling
  - Includes capability for evaluating full costs of existing program and options to minimize costs and/or environmental burdens
  - Helps communities to evaluate new technologies and have basis of comparing them to existing technologies in use
- Software is set up to enable states/communities/others to evaluate existing infrastructure and options for environmental and economic improvements
- Used in over 30 studies in various states, communities, and regions

EPA
Types of Questions Answered Using the MSW-DST

- What are the cost and environmental benefits of a municipality’s recycling programs?
- Which strategy best minimizes GHG emissions for a given budget?
- What is the difference in cost and environmental tradeoffs using a landfill bioreactor (or other technology) versus what is currently used?
- What are the cost and environmental aspects of recycling versus composting corrugated containers?
Complex Solid Waste Decisions Being Evaluated

How do we ensure

- Cost efficient waste management?
- Meeting state mandated recycling goals?
- Continued improvement of the environment?
- Fast, objective analysis of options?
- Best privatization bids?

Environmental Aspects

- Local air quality impacts
- Energy consumption and offsets
- Greenhouse gas emissions
- Benefits from materials recycling

Economic/Social Aspects

- Municipal budgets
- Need for new facilities
- Household convenience
Case Studies Using MSW DST*

- Anderson County, South Carolina
- Atlanta, Georgia
- Great River Regional Waste Authority, Iowa
- Lucas County, Ohio
- Madison, Wisconsin
- Minneapolis, Minnesota
- Portland, Oregon
- Seattle, Washington
- Spokane, Washington
- State of California
- State of Georgia
- State of Washington
- State of Wisconsin
- Subbor – ETV GHG Center
- U.S. Conference of Mayors – U.S. GHG Study
- U.S. Navy Region Northwest
- Vancouver, Canada

*Many other case studies are under consideration and are being funded through participating organizations……
Conclusions

◆ Ongoing research to evaluate bioreactors to document potential environmental benefits and/or burdens
◆ Will result in credible, objective, and peer-reviewed data and information
◆ Will use results to update –
  » AP42 LFG emission factors for use in State emission inventories and obtaining air permits
  » Defaults in MSW DST for conventional landfilling and bioreactor operations
◆ Results will also be used in evaluating residual risk for landfills as specified in CAA Section 112 (f)