Measurement of Landfill Methane Emissions

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Waste Management

THINK GREEN.

NAS Committee on Anthropogenic Methane Emissions in the US
Webinar
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Introduction

WM and partners have invested significant resources in the quantification and modeling of methane emissions and methane oxidation at landfills.

As landfill owner or operator we are interested in developing methods to:

1. Investigate and evaluate impacts of operational and regulatory changes on emission rates.
2. Produce data that inform, refine and calibrate emissions models.
Landfill Methane Mass Balance:

3 main pathways for methane generated in a landfill

\[ \text{CH}_4 \text{ generated} = \sum (\text{CH}_4 \text{ recovered} + \text{CH}_4 \text{ emitted} + \text{CH}_4 \text{ oxidized}) \]
First-order Decay Model of Methane Generation

\[ G_{\text{CH}_4} = \sum_{x=S}^{T-1} \left\{ W_x \times \text{MCF} \times \text{DOC} \times \text{DOC}_F \times \frac{16}{12} \times \left( e^{-k(T-x-1)} - e^{-k(T-x)} \right) \right\} \]
\[ G_{\text{CH}_4} = \sum_{x=S}^{T-1} \left\{ W_x \times \text{MCF} \times \text{DOC} \times \text{DOCF} \times F \times \frac{16}{12} \times \left( e^{-k(T-x-1)} - e^{-k(T-x)} \right) \right\} \]
Landfill Emissions are Challenging to Quantify

- spatially variable
- temporally variable
- large spatial extent
- topography
## EREF Method Comparison Study (2008)

<table>
<thead>
<tr>
<th>Participant</th>
<th>Method</th>
<th>Country</th>
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</thead>
<tbody>
<tr>
<td>WM ARCADIS US</td>
<td>Vertical Radial Plume Mapping (VRPM)</td>
<td>USA</td>
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<tr>
<td>Finnish Meteorological Institute</td>
<td>Micrometeorological Eddy-Covariance</td>
<td>Finland</td>
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<tr>
<td>WM/Landfill+ Inc./Florida State University</td>
<td>Static Flux Chamber</td>
<td>USA</td>
</tr>
<tr>
<td>National Physical Laboratory</td>
<td>Differential Absorption LiDAR (DiAL)</td>
<td>UK</td>
</tr>
<tr>
<td>FLUXSENSE AB</td>
<td>Mobile Tracer Plume FTIR spectroscopy</td>
<td>Sweden</td>
</tr>
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</table>
Controlled Methane Release
**Whole Landfill Emission Method Comparison**

**Metro**

<table>
<thead>
<tr>
<th>Method</th>
<th>Global Emission (kgCH4/h)</th>
<th>Associated coefficient of variation</th>
<th>Landfill area analyzed</th>
<th>Time of data collection during campaign (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRPM</td>
<td>1325</td>
<td>28%&lt;cv&lt;84%</td>
<td>~15%</td>
<td>4.5</td>
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<tr>
<td>Chamber</td>
<td>295</td>
<td>175%&lt;cv&lt;400%</td>
<td>~3%</td>
<td>4</td>
</tr>
<tr>
<td>MicroMet</td>
<td>1005</td>
<td>&gt;30%</td>
<td>~30%</td>
<td>6</td>
</tr>
<tr>
<td>Tracer</td>
<td>916</td>
<td>5%&lt;cv&lt;8%</td>
<td>Whole landfill</td>
<td>4</td>
</tr>
<tr>
<td>DiAL</td>
<td>659</td>
<td>28%&lt;cv&lt;43%</td>
<td>Whole landfill</td>
<td>3</td>
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</tbody>
</table>
Methane Emission Vary by Landfill Cover Type
20 Landfill OTM-10 Study

Methane (g m\(^{-2}\) d\(^{-1}\))

<table>
<thead>
<tr>
<th>Type</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily</td>
<td>5</td>
</tr>
<tr>
<td>Intermediate</td>
<td>27</td>
</tr>
<tr>
<td>Final (soil)</td>
<td>19</td>
</tr>
<tr>
<td>Final (synthetic)</td>
<td>2</td>
</tr>
</tbody>
</table>
Intermediate Cover Emission by Climate
20 Landfill OTM-10 Study

Methane (g m\(^{-2}\) d\(^{-1}\))

- Mediterranean
- Semiarid
- Humid Subtropical
- Humid Continental Warm Summer
- Humid Continental Cool Summer

Climate Types:
- Semiarid
- Mediterranean
- Humid Continental Cool Summer
- Humid Continental Warm Summer
- Humid Subtropical
Comparing Measurements to Models: TCA Measurements at Closed Landfills

Four closed landfills in Indiana and Ohio

- Passively vented, no LFG collection.

- Received waste in from late 1960s and early 1970s, ceased waste acceptance by 1995.

- Range in area from 44 to 56 acres.

- Estimated to have received between 1.7 and 2.2 million tons of waste.
Measured vs. Model Emissions at Passively Vented Closed Landfills

- South Wells
- Springfield
- Seneca East
- Center Point

**GHGMRR Modeled Emission**

**SWICS Modeled Emission**

**CRDS Emission**

Methane emission (g m⁻² d⁻¹)
Comparing Measurements to Models: TCA Measurements at a New Landfill

Opened in 2010
WIP=2,801,041 metric tons
Area= 145,287 m²

Modeling Parameters
k=0.057 (yr⁻¹)
DOC =0.2 (tons C/ ton waste)
IPCC DefaultLit Review 2009

% Methane Oxidation

- WM Study
- Lit Review 2009
- IPCC Default
Results from Recent Field Studies on Methane Oxidation at Low Methane Flux
Summary

• Methods have measurement error in the range of 20-50%.
• Field measurements indicate models tend to overestimate landfill methane emissions.
• Uncertainty remains around the extrapolation of episodic measurements to annual emission estimates.
• Whole landfill measurement approaches are limited by meteorological conditions.
• Impacts of the landfill and surrounding topography on airflow and the accuracy of measurements is not well understood.