Development of a Mobile Tracer Correlation Method for Assessment of Air Emissions from Landfills and Other Area Sources

Tierney Foster-Wittig
tf29@duke.edu

Eben D. Thoma, Roger B. Green, Gary R. Hater, Nathan D. Swan, and Jeffrey P. Chanton

Duke UNIVERSITY
Background

- Large area sources like landfills present many emissions measurement challenges:
  - Large in extent, spatially variable emissions
  - Temporally variable, difficult to model
- Mobile tracer correlation is a simple approach for measuring large area source emissions
- Provides whole-facility emission measurements
# Field sites for testing

<table>
<thead>
<tr>
<th>Site Code</th>
<th>Location</th>
<th>Year</th>
<th>Studies (days)</th>
<th>Transects</th>
<th>Low/High</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA1</td>
<td>CA</td>
<td>2009</td>
<td>1(1)</td>
<td>26</td>
<td>High</td>
</tr>
<tr>
<td>CA2</td>
<td>CA</td>
<td>2009</td>
<td>1(1)</td>
<td>21</td>
<td>High</td>
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<tr>
<td>GA1</td>
<td>GA</td>
<td>2012</td>
<td>1(2)</td>
<td>9</td>
<td>High</td>
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<tr>
<td>GA2</td>
<td>GA</td>
<td>2011-2013</td>
<td>10(35)</td>
<td>443</td>
<td>Low</td>
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<tr>
<td>IL1</td>
<td>IL</td>
<td>2013</td>
<td>3(10)</td>
<td>163</td>
<td>Low</td>
</tr>
<tr>
<td>IN1</td>
<td>IN</td>
<td>2010-2011</td>
<td>5(9)</td>
<td>100</td>
<td>High</td>
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<tr>
<td>IN2</td>
<td>IN</td>
<td>2010-2011</td>
<td>6(8)</td>
<td>149</td>
<td>Low</td>
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<tr>
<td>IN3</td>
<td>IN</td>
<td>2009-2012</td>
<td>11(24)</td>
<td>331</td>
<td>High</td>
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<tr>
<td>KS1</td>
<td>KS</td>
<td>2012-2013</td>
<td>6(18)</td>
<td>321</td>
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<td>3(5)</td>
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<tr>
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<td>NM</td>
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<td>1(2)</td>
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<tr>
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<td>OH</td>
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<td>1(1)</td>
<td>20</td>
<td>Low</td>
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<tr>
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<td>OH</td>
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<td>2(4)</td>
<td>48</td>
<td>High</td>
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<tr>
<td>OH4</td>
<td>OH</td>
<td>2010</td>
<td>3(7)</td>
<td>139</td>
<td>High</td>
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</tbody>
</table>

15 sites 8 states 5 years 56(131) 1876 -
Equipment (CRDS and C$_2$H$_2$)
Tracer Setup

geometrical approach

two forms
GMAP-REQ-Tracer Correlation (TC)
Analysis Software
Equations

\[ Q_{CH_4,m} = (m)Q_t \frac{M_{CH_4}}{M_{C_2H_2}} \]

\[ Q_{CH_4,v} = (v)Q_t \frac{M_{CH_4}}{M_{C_2H_2}} \]

\[ ERD = \frac{|Q_{CH_4,v} - Q_{CH_4,m}|}{.5(Q_{CH_4,v} + Q_{CH_4,m})} \]

\( m \) – u slope
\( v \) – ratio
Analysis

- **Invalid Data**
  - Visual Inspection
  - Signal to Noise Ratio (SNR) < 3
  - Distance < 500 m
  - Before/after tracer release

- **1366 transects (73%)**
Analysis

- Acceptable Data - Method Quality Indicators (MQI)
  - Signal to Noise Ratio (SNR) > 10
  - Emission Rate Difference (ERD) < 20%
  - $R^2 > 80\%$
MQI 1: Signal to Noise Ratio (SNR)

\[ SNR = \frac{H}{0.5h} \]

a) High SNR: SNR > 10

b) Low SNR: SNR < 10
MQI 2: R-Squared

\[ R^2 = 0.34 \]
\[ ERD = 0.55 \]
MQI 3: Emission Rate Difference

CH₄ (ppm)

C₂H₂

R²=0.47
ERD=0.5

CH₄ (ppm)

C₂H₂

R²=0.88
ERD=0.26
Results: MQI Effects

ERD < 30%
Results: GA2 Emissions

- MQI: SNR > 10, dashed lines
- MQI: SNR > 10 and (80,20)

Graph showing data points for $Q_{CH_4}$ (g/min) from 06/11 to 11/13.
Field study data completes rates

- 1366 Valid Transects
  - SNR > 3
  - Distance > 500 meters

- 456 Acceptable Transects using the MQI's:
  - SNR > 10
  - $R^2 > 80\%$
  - ERD < 20\%

  - 456 transects (33\%)
  - SNR — 936 (69\%)
  - ERD — 731 (54\%)
  - $R^2$ — 751 (55\%)
Summary

- A more implementable form of mobile tracer correlation was successfully used to measure methane emissions in 56 real-world field studies in 15 landfills around the U.S.

- General quality assurance metrics including signal to noise ratio (SNR), emissions rate difference (ERD) and plume to tracer correlation ($R^2$) were developed.

- This information will be helpful in development of a standardized mobile tracer correlation method called OTM 33B.
THANK YOU
Background

- Large area sources like landfills present many emissions measurement challenges:
  - Large in extent, spatially variable emissions
  - Temporally variable, difficult to model

- Measurement tools such as flux boxes and EPA OTM 10 provide a “picture” of emissions from parts of a landfill

- A technique that provides whole-facility emission measurements is a valuable complementary tool
Background

- Mobile tracer correlation has been well-published in the literature using somewhat complex instruments (Quantum cascade lasers and FTIRs)

- Our project explores a more implementable form of the approach that uses high performance but simple to use instruments and a new tracer gas option (acetylene)

- This work supports development of an EPA preliminary method called OTM 33B and is based on real-world testing

- Waste Management and other Landfill companies through EREF are partnering with U.S. EPA to develop OTM 33B
This Talk

- Reviews the tracer correlation approach
  - Tracer setup
  - Equipment
  - Data analysis software
  - Emissions calculations

- Describes the field test sites

- Discusses preliminary method quality indicators (MQIs)

- Describes a few measurement scenarios and summarizes data completeness results
MQI 3: ERD

\[ R^2 = 0.94 \]
\[ \text{ERD} = 0.01 \]