**Biocovers at landfills for GHG mitigation – overview and whole site GHG monitoring**

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**Introduction**

- Landfills containing organic wastes produce biogas containing methane
- Landfills significant sources of methane which contributes to climate changes.
- Some landfills are not or cannot be utilized for landfill gas (LFG): gas is flared with risk of producing toxic combustion products, emitted to atmosphere
- Experiments have documented that a very high methane oxidation rate can be obtained in bio-covers, high enough to significantly reduce the methane emission from the landfill
- Bio-covers may also be a very cost-effective supplementary method at landfills with landfill gas utilization, since the efficiency of the gas extraction system often is in the range of 50-60 %.
- Documentation of the efficiency of bio-covers has so far not been carried out in full scale.

**Project objectives**

- to reduce the greenhouse gas emissions from landfills by improvement of the soil cover to better oxidize the methane produced within the landfill
- to demonstrate a method for documentation of the obtained emission reduction
- to analyze the economic viability of the technology
- to development guidelines on how to incorporate bio-covers in landfill gas management at European landfills and further disseminate the outcome of the demonstration project

**Methane oxidation in biocovers on landfills**

**Fakse Landfill**

- Section I (1981-1997):
  - 600,000 tonnes of mixed waste (incl. 25 % household waste, and 12 % sludge)
  - Leachate collection system, but no gas collection
  - Partly covered with a relatively thick layer of clay
- Section II (1998 →)
  - 140,000 tonnes of non-combustible waste
  - Various activities incl. storage of sludge, and a composting facility
  - New section (II)
  - Old section (I)

**Biocover system with biowindows**
Baseline study of methane emission - Actions

1. Measurement of spatial variability in emissions
2. Measurement of total methane emission

Main objective:
To identify main methane emission zones on the landfill

Purposes:
To enhance precision of total methane emission measurements
To provide partial basis for the cover improvement plan
Whole emission measurements methods tested

- Plume measurements:
  - Dynamic/mobile plume measurements
  - Stationary plume measurements using sampling canisters
  - Micrometeorological methods

Team for test of methods

- Charlotte Schuetz, Anders Frederiklund, & Peter Kjeldsen, Technical University of Denmark, Denmark
- Jerker Samuelsson, Chalmers University of Technology / FluxSense, Sweden
- Tuomas Laurila & Mika Aurela, Finnish Meteorological Institute, Finland
- Joeri Jacobs & Heijo Scharff, NV Afvalzorg, Netherlands
- Charlotte Scheutz, Anders Fredenslund, & Peter Kjeldsen, Technical University of Denmark, Denmark
- Tuomas Laurila & Mika Aurela, Finnish Meteorological Institute, Finland
- Joeri Jacobs & Heijo Scharff, NV Afvalzorg, Netherlands
- Charlotte Scheutz, Anders Fredenslund, & Peter Kjeldsen, Technical University of Denmark, Denmark
- Tuomas Laurila & Mika Aurela, Finnish Meteorological Institute, Finland
- Joeri Jacobs & Heijo Scharff, NV Afvalzorg, Netherlands

Dynamic plume measurements – double tracer approach

- Tracer release bottle and flow regulator
- Mobile FTIR (Fourier Transform Infrared) absorption spectroscopy instrument

General leak search at Fakse landfill

- October 2006

Field campaigns

- FTIR transects, Feb
- FTIR transects, Oct
- N2O release points
- O2 release points
- FTIR transects, Feb
- FTIR transects, Oct
- New source area
- Compost area and sludge pit
Results - example from the October campaign

The CH4/N2O-plume was continuously traversed 27 times from side to side whereas the CH4/CO-plume was traversed 7 times from side to side (driving speed was 2.8 m/s)

<table>
<thead>
<tr>
<th>Time</th>
<th>Emission CH4 (%)</th>
<th>Time</th>
<th>Emission CH4 (%)</th>
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<tbody>
<tr>
<td>12:36</td>
<td>37.5</td>
<td>12:52</td>
<td>38.3</td>
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<tr>
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<td>13:15</td>
<td>39.0</td>
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<tr>
<td>13:50</td>
<td>39.0</td>
<td>13:58</td>
<td>39.0</td>
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</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>Emission N2O (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>13:50</td>
<td>39.0</td>
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<tr>
<td>13:58</td>
<td>39.0</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>Emission CO (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>13:50</td>
<td>31.6</td>
</tr>
<tr>
<td>13:58</td>
<td>31.6</td>
</tr>
</tbody>
</table>

Whole landfill emission (kg h⁻¹)

<table>
<thead>
<tr>
<th></th>
<th>Field campaign</th>
<th>Model (2005)*</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>October</td>
<td>February</td>
</tr>
<tr>
<td>Whole landfill emission</td>
<td>43.4±5</td>
<td>35.9±5.3</td>
</tr>
<tr>
<td>Old landfill section (I)</td>
<td>31.2±5.5</td>
<td>30.5±2.2</td>
</tr>
<tr>
<td>New landfill section (II)</td>
<td>12.2±5.2</td>
<td>7.3±2.2</td>
</tr>
</tbody>
</table>

*The production of LFG was evaluated using four available gas production models; GasSim, Avfalzorg Multi Phase Model, and IPCC First Order Decay method.

Emission measurements from the compost area and a sludge pit

<table>
<thead>
<tr>
<th>Compound</th>
<th>Emission from compost area (kg h⁻¹) (± 50 %)</th>
<th>Emission from the sludge pit (kg h⁻¹) (± 25 %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH4</td>
<td>0.5</td>
<td>2.4</td>
</tr>
<tr>
<td>N2O</td>
<td>0.06</td>
<td>0.03</td>
</tr>
<tr>
<td>CO2</td>
<td>332</td>
<td>-</td>
</tr>
</tbody>
</table>

Conclusion

A project establishing a documented procedure for reducing methane emissions from landfills using a low-tech biocover solution is underway.

A baseline study is needed to establish a conceptual emission model and to quantify the baseline emission from the landfill.

A mobile plume FTIR tracer method was successfully used for quantification of the whole CH4 emission from Fakse landfill.

Using two different tracers it was possible to quantify the emission from different sections of the landfill as well as different on-site sources.

The measured methane emission from the old landfill section (30-31 kg CH4 h⁻¹) will be used as baseline for comparison with measurement campaigns after installation of the bio-cover.

Klintholm is a new project – Malaysia??