DTU Library

Quantifying Gas Emissions from Landfills – Which Methodologies Can Be Used?

Kjeldsen, Peter

Publication date:
2012

Document Version
Publisher's PDF, also known as Version of record

Quantifying Gas Emissions from Landfills – Which Methodologies Can Be Used?

Peter Kjeldsen[1]

BACKGROUND

Landfills are significant sources of methane (CH_4) that contribute to climate change due to emission of large quantities of landfill gas (LFG) containing CH_4. Worldwide, CH_4 emission from the waste sector is about 18% of the global anthropogenic CH_4 emission, with landfills being the main source. LFG generation models are used to evaluate site-specific emissions from whole landfills incorporating default values for CH_4 oxidation in landfill covers. LFG generation models have only been compared to observations in a few cases, and often large discrepancies between model results and observations have been seen.

In order to obtain better – and validated – modeling results of LFG emission, there is a need to develop robust methodologies for measurement of whole landfill gas emissions. In the future, the competent authorities will probably also demand landfill owners to report emissions based on measurements. Besides, there is a need for documentation of LFG mitigation facilities (gas extraction efficiencies for LGF utilization systems as well as efficiencies of passive biological CH_4 oxidation in biocovers systems).

OVERVIEW OF MEASUREMENT METHODOLOGIES

Several methods have been suggested for whole landfill emission measurements. The most used methods are the traditional static flux chamber method, the tracer dilution method, micro-meteorological methods, and laser methods using open-path CH_4 measurements, but also a few other methods have been used to quantify CH_4 emissions from landfills. Table 1 gives an overview of the most used methods with references to reported studies where the methods have been used (Kjeldsen & Scheutz, 2011).

EXPERIENCES USING THE MEASUREMENT METHDOLOGIES

<u>Flux chamber methodologies.</u> Flux chambers are probably the mostly used methodology to evaluate CH_4 emissions from landfills, especially the simple-to-use static flux chamber. The method was originally developed to measure diffusion-controlled emission from natural fields, but has also been used at landfill surfaces where the emissions may be controlled by pressure differences. In order not to influence the basic emission by the presence of the chamber, measurements are often performed over very short time periods – optimally within a few minutes.

Table 1 Overview of methodologies used for measuring CH_4 emissions from landfills.

Methodology	Description
Static flux chambers	Single point measurements on the ground surface. Concentrations are measured in an air space confined by the chamber installed on the ground. Measurements are usually carried out over a short time period. Several point measurements are integrated to represent larger surface areas.
Dynamic flux chambers	As above, however the chamber is continuously flushed with air to avoid errors by build-up of pressure/high concentrations in the chamber. Several point measurements are integrated to represent larger surface areas.
Tracer dilution method	Rely on simultaneous measurement of atmospheric CH_4 and a tracer, which is released at a known rate from the landfill surface. The CH_4 release is then determined from the ratio of CH_4 to tracer in the downwind plume.
• Stationary plume methods	A tracer dilution method relying on measurement in one or more single points located in the downwind plume
– Point release	A tracer dilution method developed to measure releases from a single point source such as a gas vent or a leachate well (Fredenslund et al, 2010).
– Whole landfill with field measurements	CH_4 and tracer are measured in the field using highly sensitive analytical instruments (Galle et al, 2001).
– Whole landfill with field sampling	Gas samples are taken in the field using canisters or gas bags. Samples are brought to the laboratory and analyzed for CH_4 and tracer (Scharff and Hensen, 2009).
• Dynamic plume methods	
– Whole landfill – single source	Concentrations of CH_4 and tracer are continuously measured across the downwind plume from a single landfill using a highly sensitive instrument installed in a vehicle.
– Whole landfill – multiple sources	As above but releasing two or more tracers from different sources in order to differentiate the contribution to CH_4 emissions from the multiple sources.
Micrometeorological methods	A group of methodologies measuring the turbulent flux of gases between the land surface and the atmosphere. Fast-response sensors mounted on towers are needed to measure vertical gradients of wind speed and CH_4 concentrations, Lohila et al., 2007).
Vertical Plume Mapping	Measures CH_4 emission from area sources using ground-based optical remote sensing. The method uses open-path spectroscopic instrumentation to obtain path-integrated CH_4 concentrations along several optical paths. The data are used together with simultaneously measured wind data to yield the CH_4 emission from the area source using a computer algorithm (Babilotte et al., 2010).
Differential absorption LiDAR method	This technique uses pulsed tuneable laser radiation which is transmitted into the atmosphere. The amount of backscattered radiation is measured. By tuning the laser wavelength on and off the CH_4 concentration can be determined. This is done along several lines-of-sight. Combined with wind information, emission CH_4 fluxes can be calculated (Babilotte et al., 2010).

The methodology has been suggested for measuring whole landfill emissions. However, several comparisons to other methods have shown that it is not adviseable to measure whole landfill emissions by use of any flux chamber based methodology, since it would almost certain lead to a strong underestimation of the CH_4 emission.

Tracer dilution methods. The use of tracer releases for measuring CH_4 emissions from landfills was first introduced in the early nineties. As shown in Table 1 the method has been developed for quantifying emissions from smaller point sources (Fredenslund et al., 2010) as well as whole landfills. The method has been used in both a stationary and a dynamic setup. Lately a method using multiple traces has been used (Figure 1) to differentiate between several adjacent sources.

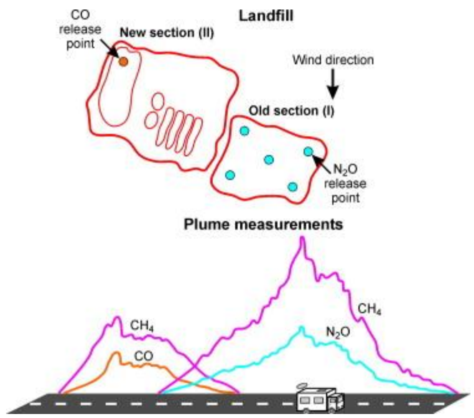

Figure 1. Dynamic plume measurements using a double tracer approach to quantify emissions from two different landfill sections (Scheutz et al., 2011).

<u>Field comparison of methods.</u> As shown in Table 1 also other methodologies for landfill gas emission measurements have been developed and tested. The reported comparisons show that methods relying on measurements at the landfill surface or close to the landfill (such as chamber techniques, micrometeorological methods and vertical plume mapping) have a tendency to underestimate the whole landfill gas emission due to the often heterogenous nature of emission patterns. Especially the use of chamber techniques will in almost all cases lead to significant underestimation of the true landfill gas emission because gas releases through hot spots in the cover or leachate wells will not be adequately represented in the measurements. The vertical plume mapping method has difficulties in covering emissions along the slopes and perimeter of the landfill, while the micrometeorological methods in most cases only include emissions from a fraction of the landfill area. Babilotte et al. (2010) report from the most recent comparison study that only mass flux methods (such as the tracer dilution methods and the LiDAR method) "can provide a global landfill measurement with an associated confidence interval". The LiDAR method makes use of highly sophisticated equipment and is at the moment the less cost-efficient of the two mass flux methods.

CHALLENGES IN EMISSION MEASUREMENTS

As already stated, measuring CH_4 emissions from a landfill could have different objectives. Independently of whether the objective is to obtain better data for validating and tuning landfill gas generation models, to document emissions to the competent authorities, or to document mitigation efficiency of a gas extraction/utilization or biocover system, a representative value for the annual emitted CH_4 is what is needed in most cases. Basically, a measured whole landfill emission is only valid for the emission at the time the measurement was carried out. So to obtain an estimate of the average annual CH_4 emitted from the landfill, a procedure to get from the few measuring campaigns to an annual estimate needs to be developed (incorporating questions like "when should I measure?" and "how many times a year do I need to measure?"). This is obviously not straight-forward, since the CH_4 emission from a landfill (for instance measured in kg/hour) is in most cases highly time-dependent, both on a short time basis (barometric pressure effects, operational proceedures) and on longer term (seasonal effects). As already stated, many studies have shown that emissions changes rapidly with changes in barometric pressure. Also wind effects have been observed. For larger landfills seasonal changes in landfill gas generation is minor especially since environmental factors such as moisture and temperature of the waste do not change a lot over the year. However, in cases where the gas emission is highly regulated by on-going CH_4 oxidation in the cover (especially in the case of implementation of a biocover system), seasonal changes may be seen in temperate climate due to seasonal changes in ambient temperatures.

As described in the previous section, methods based on the tracer dilution approach are at the moment the most promising approach for measuring whole landfill emission. However, still some development is needed to obtain a cost-efficient method which can give a sufficiently precise estimate of the annual average CH_4 emission from a landfill. Cheaper and more easy-to-use instruments are now commercial available, which will make dynamic plume measurements more straightforward. Simpler methods based on stationary plume measurements are also under development and may – with further development efforts – lead to an even simpler approach than dynamic plume measurement using field instruments. For tracer dilution methods in general, also basic method development is needed in respect to differentiating multiple emitting sources, selection of the number and location of tracer release points, optimal measuring/sampling distance, and acceptable wind speed range.

REFERENCES

Babilotte, A. Green, R., Hater, G., Watermolen, T. and Staley, B. 2010. Field intercomparison of methods to measure fugitive methane emissions. Proceedings of the Global Waste Management Symposium 2010, October 3-6, 2010, JW Marriott San Antonio Hill Country Resort & Spa, San Antonio, Texas, USA.

Fredenslund, A.M., Scheutz, C. and Kjeldsen, P., (2010). Tracer method to measure landfill gas emissions from leachate collection systems. *Waste Management*, 30, 2146-2152.

Galle, B., Samuelsson, J., Svensson, B.H. and Börjesson, B., 2001. Measurements of methane emissions from landfills using a time correlation tracer method based on FTIR absorption spectroscopy. *Environmental Science and Technology* 35, 21–25.

Kjeldsen, P. & Scheutz, C.(2011). Evaluating Gas Emissions From Landfills – Which Methodologies Can Be Used? In: Proceedings Sardinia 2011, Thirteenth International Waste Management and Landfill Symposium. Italy : CISA, Environmental Sanitary Engineering Centre, 2011.

Lohila, A., Laurila, T., Aurela, M., Thum, T., Tuovinen, J.-P., Pihlatie, M., Rinne, J. and Vesala, T. (2007). Micrometeorological measurements of methane and carbon dioxide fluxes at a municipal landfill. *Environmental Science and Technology* 41, 2717–2722.

Scharff, H. and Hensen, A. 2009. Further development of a cheap and simple methane emission measurement method. Proceedings Sardinia 2009, Twelfth International Waste Management and Landfill Symposium S. Margherita di Pula, Cagliari, Italy; 5 - 9 October 2009. ©2009 by CISA, Environmental Sanitary Engineering Centre, Italy.

Scheutz, C., Samuelsson, J., Fredenslund, A.M., Kjeldsen, P., (2011). Quantification of multiple methane emission sources at landfills using a double tracer approach. *Waste Management*, 31, 1009-1017.

---

[1]Professor, Department of Environmental Engineering, Technical University of Denmark, DK-2800 Kgs. Lyngby, Denmark, pk@env.dtu.dk.