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Publication date:
2019

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

sardinia_2019 17th INTERNATIONAL WASTE MANAGEMENT AND LANDFILL SYMPOSIUM / 30 SEPT - 04 OCT 2019
Forte Village / Santa Margherita di Pula (CA) / Italy

CLOSING THE METHANE MASS BALANCE FOR AN OLD DANISH LANDFILL

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Keywords: Horizontal landfill gas migration, methane oxidation efficiencies, methane generation, gas recovery, tracer gas dispersion method, oxidation in landfill cover soil

ABSTRACT

Climate change is on the political agenda worldwide, and abatement strategies for greenhouse gas emissions are a necessity. One source of greenhouse gas emissions is landfills, as the degradation of organic carbon in landfilled waste generates methane (CH_4). Landfill gas emission patterns show high spatial and temporal variability, but the development of innovative technologies for both monitoring and mitigation will help in the much-needed conceptual understanding of governing gas transport and emission processes. A CH_4 mass balance can be established based on the individual migration pathways for the generated CH_4, including CH_4 recovery for energy utilisation or flaring, lateral migration to neighbouring plots, CH_4 oxidation by microorganisms in the cover and emissions seeping into the atmosphere. A CH_4 mass balance forms a good conceptual framework for setting up a mitigation strategy for a landfill.

In this study, a CH_4 mass balance was established for Hedeland landfill located near Roskilde, Denmark. Hedeland landfill was established in 1979 in a former gravel pit and approximately 2.9 million tonnes of mainly non-combustible waste and soil has been landfilled there until operations were terminated in 2009. The landfill was constructed with a polymer liner on the bottom and the lower parts of the side slopes, while the upper part of the side slopes consisted of a clay liner. Leachate is drained from the whole landfill into a single leachate well. Gas recovery systems are installed in two sections of the landfill but do not cover the total site. The recovered gas is utilised in a dual-fuel engine producing electricity, with diesel oil as a support fuel. The landfill top cover consists of at least one metre of soil with no polymer liner, and seven residential houses are situated within a radius of fewer than 100 metres from the edges of the landfill. Many years of investigation in the area have uncovered laterally migrating landfill gas at a level posing a risk of explosion for five of the seven houses. To protect the residents in the five houses, three remediation systems have been installed, pumping the migrating landfill gas from some of the monitoring wells installed in the soil compartment adjacent to the site.

Figure 1 shows the methane mass balance for Hedeland landfill. CH_4 generation rates were modelled using a multiphase first-order decay model (Afvalzorg) and determined at between 57 and 79 kg h^{-1}. The modelled generation rate corresponded reasonably well with pumping tests from the waste

body, estimating CH_4 generation at between 92 and 148 kg h^{-1}. The CH_4 emission rate was quantified at between 2 and 14 kg h^{-1}, using the tracer gas dispersion method and the CH_4 gas recovery efficiency was between 8 and 21%. About 0.76 kg h^{-1} of CH_4 was extracted from three remediation wells placed along the perimeter of the landfill. Using a carbon mass balance for the lateral migrating landfill gas showed a fractional oxidation of about 78%, which corresponded to an oxidised CH_4 flux of 3.5 kg h^{-1} from the three remediation systems. The CH_4 flux (un-oxidised) from the remaining landfill perimeter was estimated at between 6.9 and 10.4 kg h^{-1}. CH_4 oxidation efficiency in the landfill cover soil, determined from stable carbon isotope analyses, was found to be between 12% and 92%. This resulted in an average CH_4 oxidation rate of 32 kg h^{-1}, using an average CH_4 emission rate of 8 kg h^{-1}. CH_4 surface screenings and surface flux measurements supported the hypothesis that oxidation efficiency was in the higher range and that oxidation could close the CH_4 mass balance.

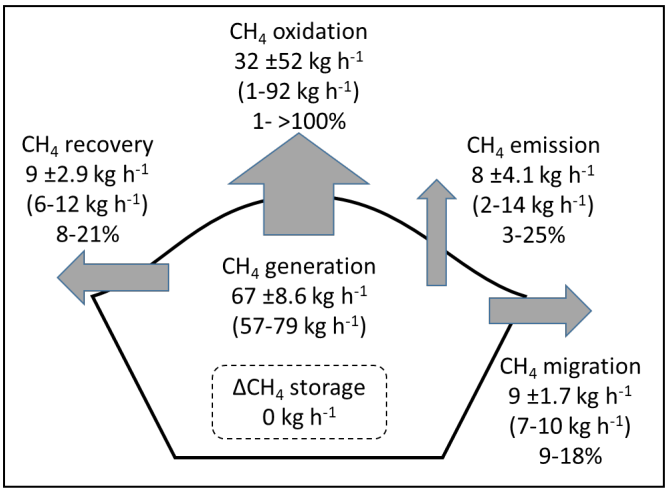

Figure 1. Methane mass balance for Hedeland landfill. Lateral CH_4 migration includes CH_4 oxidised in the soil compartment in the area between the side liner and the monitoring wells.

The results of this study are presented in the following paper to be published in Waste Management. Please cite the original paper:

Fjelsted, L., Christensen, A.G., Larsen, J.E., Kjeldsen, P., Scheutz, C. 2019. Closing the methane mass balance for an old Danish landfill. *Waste Management*.