THE INFLUENCE OF ATMOSPHERIC PRESSURE ON WHOLE-LANDFILL METHANE EMISSIONS OBSERVED DURING A MULTI-SEASON STUDY

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ABSTRACT

Landfills are the largest sources of anthropogenic methane (CH_4) emissions to the atmosphere in the United States. We present the results of a multi-season study of whole-landfill CH_4 emissions using an atmospheric tracer method (Figure 1) at the Nashua, New Hampshire Municipal landfill. Measured emissions were negatively correlated with surface atmospheric pressure and ranged from 7317 to 21937 liters CH_4 min^{-1}. A simple regression model of these results was used to calculate an annual emission rate of 8.4 x 10^6 m^3 CH_4 $year^{-1}$. A reported gas collection rate of 7.1 x 10^6 m^3 CH_4 $year^{-1}$ and an estimated annual rate of CH_4 oxidation by cover soils of 1.2 x 10^6 m^3 CH_4 $year^{-1}$ resulted in a calculated annual CH_4 production rate of 16.7 x 10^6 m^3 CH_4 $year^{-1}$.

INTRODUCTION

Human activity contributes about 60 percent of the estimated 600 teragrams of CH_4 emitted each year to the atmosphere, and landfills are among the largest of the anthropogenic sources. Landfills are estimated to account for approximately 37 percent of annual anthropogenic CH_4 emissions in the United States and 10 to 19 percent of global anthropogenic emissions [*IPCC 2001; EIA 2000; USEPA 2000*]. However, there remains significant uncertainty associated with U.S. and international estimates. The objective of this study was to quantify the relationship between whole-landfill emissions and annual changes in physical environmental variables.

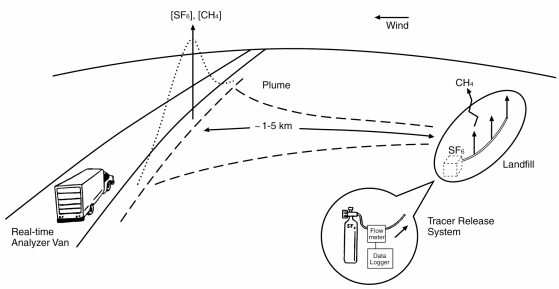

Figure 1: Landfill emissions measurements were conducted using an atmospheric tracer method. SF_6 tracer was released at the upwind edge of the landfill and CH_4 emissions were calculated by the ratio method as described by *Czepiel et al., 1996*. Samples collected in Aug. 1996, Feb., Mar., and Apr. 1997 were used to calculate whole-landfill emissions and oxidation rate. Samples collected in Sept. 1997 were used to calculate only oxidation rate.

SITE DESCRIPTION

- Located in the northeastern United States, subject to significant seasonal extremes.
- Opened in 1971 and was still accepting waste at the time of the study.
- Approximately 2.3 x 10^9 kg (by wet wt.) waste in place in 1997.
- Annual disposal peaked in 1988 at 1.3 x 10^8 kg, with 1.1 x 10^8 kg disposed in 1997.
- Waste composition: 36% MSW, 36% commercial, 13% C&D, 13% sludge (by wt.).
- Consists of 25 ha MSW, commercial, sludge site and adjacent 6 ha C&D site.
- Surfaces of completed areas covered by 1-2 m sandy-clay loam, no final cover.
- Gas recovery system installed in 1995, 60 vertical wells on a regular grid pattern.
- Gas recovery rate during measurement periods ranged from 25500-28300 l CH_4 min^{-1}.
- Recovered gas utilized for on-site electrical generation.

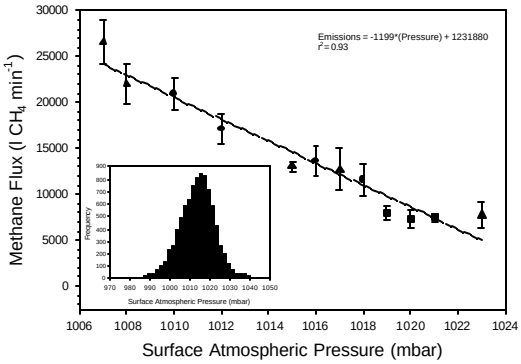

Figure 2: CH_4 emissions as a function of atmospheric pressure. Error bars represent the CV of each test. Squares are data from Aug. 1996, circles from Feb. 1997, triangles from Mar.- Apr. 1997. The inset shows hourly surface atmospheric pressure used as the independent variable in the annual emission model.

RESULTS

Emissions - Calculated emissions based on the measurements ranged from 7317 to 26542 liters CH_4 min^{-1}. Figure 2 presents calculated emissions as a function of the average atmospheric pressure measured during each test. This relationship was then utilized in a model to estimate total landfill emissions during 1997 using hourly average pressure values measured at a nearby weather station (Figure 2 inset). Simplifying assumptions were adopted to apply the model using pressures greater and less than our measured range. At pressures greater than 1020 mbar, a constant emission rate of 7000 liters CH_4 min^{-1} was assumed. At pressures less than 1005 mbar, a constant emission rate of 27000 liters CH_4 min^{-1} was assumed. The estimated annual emission rate during 1997 based on this model is 8.4 x 10^6 m^3 CH_4 $year^{-1}$.

Oxidation – The amount of CH_4 oxidized in cover soils during 1997 was estimated using measurements of stable carbon isotopes concurrent with emission measurements and additional measurements in September 1997 as described by *Chanton et al., 1999*. The reported oxidation rates (Figure 2) ranged from zero in March 1997 to 24% in October 1997. The average of the pooled "warm season" and "cold season" oxidation rates, 12%, was assumed to be representative of total annual oxidation or 1.2 x 10^6 m^3 CH_4 $year^{-1}$.

Collection – Approximately 7.1 x 10^6 m^3 CH_4 was collected for electricity generation in 1997 as reported by the operator.

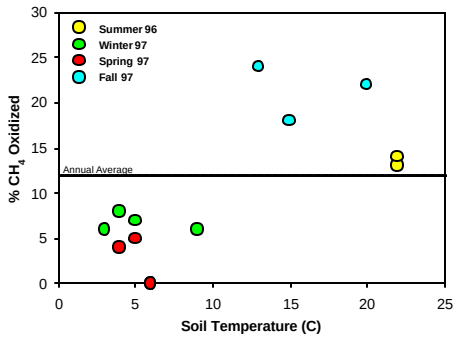

Figure 3: Fraction of whole landfill CH_4 emissions oxidized as a function of cover soil temperature at 5cm from *Chanton et al., 1999*. The estimated annual average oxidation rate, 12%, is represented by the dotted horizontal line.

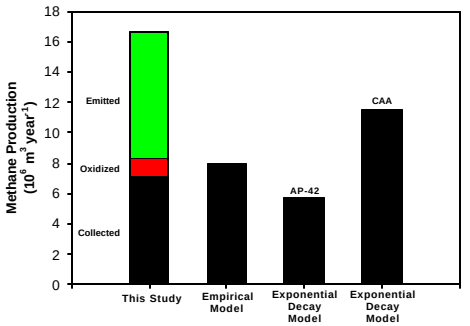

Figure 4: Estimated emissions from our study compared to emissions estimates based on the USEPA empirical model, from the study by *Peer et al., 1992*, and the USEPA LANDGEM exponential decay model (*Pelt et al., 1998*). The LANDGEM model was parameterized for two scenarios: the AP-42 (L_o=100m^3 Mg^{-1}, k=0.04 yr^{-1}) and the CAA (L_o=170m^3 Mg^{-1}, k=0.05 yr^{-1}).

CONCLUSIONS

- Emissions at this site are highly variable over short time periods (hours to days).
- Atmospheric pressure is responsible for the observed variability.
- Existing models inadequately represent emissions/production at this site.
- We need a better model!

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