Assessing Short-Term Temporal Variability in Global Methane Emissions from Landfills: Annual Estimates 1980 - 1996

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Background and Research Issues

Methane (CH_4) is an important greenhouse gas: the total positive climate forcing attributed to CH_4 over the last 150 years is 40% that of carbon dioxide. Moreover, CH_4 has a relatively short atmospheric lifetime (about 10 years), so that short term changes in CH_4 sources affect atmospheric concentrations during decadal time frames. In situ measurements of atmospheric CH_4 since 1983 show large interannual variations, including a declining growth rate after 1990. The atmospheric CH_4 burden grew by 25-40 Tg yr^{-1} in the 1980's (1 Tg = 10^{12} g) and continued at a slower rate of <20 Tg yr^{-1} during the 1990's, except for large increases in 1991 and in 1998. Although climate-related variations in wetland emissions can explain most of the large annual anomalies, the cause of the declining growth rate during the 1990's is not understood. Since the atmosphere reflects the net balance of all sources and sinks, any changes in the growth rate must be the result of changing sources, changing sinks, or both. Methodologies are needed to quantitatively address these changes on an annual basis.

Deciphering the interannual to decadal dynamics of the global CH_4 cycle requires an understanding of the temporal behavior of individual sources and sinks. Terrestrial CH_4 sources include natural wetlands, rice production, ruminant animals, termites, wastewater treatment, fossil fuel production and consumption, biomass burning, and landfills. The non-wetlands sources collectively account for approximately half of the annual atmospheric input of 500-600 Tg, and there is considerable uncertainty with respect to their individual magnitude and short-term variability.

This is especially true for landfills: global CH_4 emissions estimates have ranged from 9 to 70 Tg yr^{-1}. Estimates are based on national solid waste generation data and the fraction landfilled, the degradable organic carbon (DOC) content of the waste, the fraction of the DOC that will anaerobically decompose to biogas, the CH_4 content of the biogas product, and, for some developed countries, subtractions for CH_4 oxidation and CH_4 recovery via pumped systems. In general, solid waste data are lacking for many countries, the reliability of existing data for many countries is questionable, and interannual variability is not well quantified. Unlike some of the other CH_4 sources, there have been no regional multi-year field campaigns for landfill emission measurements, so that empirical models do not currently exist which are capable of predicting seasonal or annual emissions.

New Methodology for Annual Global Methane Emissions from Landfills

In this paper we develop and apply a new proxy method to reconstruct historical estimates for annual global CH_4 emissions from landfills for the period 1980-1996. This study was part of a broader effort by NASA-GISS to assess short-term variations in emissions from all CH_4 sources. The current study relies on calculated annual per capita solid waste generation based on a surrogate variable (per capita energy consumption). A major problem with calculating annual landfill emissions is obtaining solid waste data that are reliably referenced to a given base year, especially for developing countries. Using composited per capita solid waste from 1975-1995, we developed simple linear regression models for prediction of per capita solid waste generation using per capita energy consumption. This surrogate reflects population and general level of affluence—the major determinants of national solid waste generation rates.

These models were applied to estimation of annual solid waste generation for all countries for the period 1980-1996 using either total population (developed countries) or urban population (developing countries). Annual landfill CH_4 emissions were estimated using a modified Intergovernmental Panel on Climate Change (IPCC) methodology. Methane recovery was modeled by fitting historic data on total global and U.S. landfill CH_4 recovery to time-dependent linear relationships. Two scenarios for global landfill CH_4 emissions using the energy surrogate were compared to two scenarios using an IPCC standard methodology. The resulting annual estimates from all four scenarios fall into similar ranges as previous estimates (overall range of 17 - 57 Tg yr^{-1} for the period 1980-1996). However, the energy surrogate scenarios result in lower overall emissions, are characterized by larger interannual variations, and document both positive and negative annual changes. The energy surrogate approach was validated using independent international data for solid waste generation from Europe, N. America, and Japan from 1990-1996, and the calculated emissions compare favorably to recent compilations of emissions from the EU15 reported to IPCC. The use of the surrogate variable provides a reasonable methodology for a large number of countries where data do not exist, a consistent methodology for both developed and developing countries, and a procedure that facilitates annual updates using readily available data.

Reference:

Bogner, J., and E. Matthews, Global methane emissions from landfills: new methodology and annual estimates 1980-1996. Submitted *to Global Biogeochemical Cycles*, April, 2002.