



Project Summary

Estimate of Global Methane Emissions from Landfills and Open Dumps

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Methane (CH_4) produced by the anaerobic decomposition of waste buried in landfills and open dumps is a significant contributor to global CH_4 emissions, with estimates ranging from 10 to 70 teragrams per year (Tg/yr or 10^{12} g/yr). Global anthropogenic sources emit 360 Tg/yr, which suggests that landfills may account for 3 to 19% of the total. The report presents an empirical model to estimate global CH_4 emissions from landfills and open dumps, based on data from landfill gas (LFG) recovery projects, developed by the U.S. Environmental Protection Agency's (EPA's) Air and Energy Engineering Research Laboratory (AEERL). The AEERL CH_4 estimates for 1990 range from 21 to 46 Tg/yr with a mid-point of 33 Tg/yr.

Many developed countries are encouraging incentive programs or regulatory requirements for municipal solid waste (MSW) landfills that could result in a reduction of CH_4 from landfills. The U.S. is scheduled to promulgate Clean Air Act regulations for MSW landfills by June 1995. This rule is estimated to reduce CH_4 emissions by 5 to 7 Tg/yr by the year 2000. Economical growth in newly industrialized countries (e.g., Taiwan) and overall population growth in developing countries are expected to increase total yearly waste generation. In developing countries, better solid waste management methods may increase the amount of waste that will be landfilled or dumped in the future and thus increase CH_4 emissions.

Substantial uncertainty in the global estimates from this source results from a lack of data characterizing (1) country-specific waste generation, (2) waste management practices, (3) CH_4 potential of the waste in place, and (4)

CH_4 that is emitted from waste piles and open dumps.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

AEERL has used U.S. LFG recovery data to develop an empirical model relating LFG flows to waste in place. LFG recovery flow rates (m^3/min) are converted to CH_4 emission rates (in g/min) by accounting for the average LFG density, the relative CH_4 concentration in LFG, the average efficiency of the gas recovery systems, and the estimated oxidation of CH_4 in the top soil cover of the landfill. CH_4 emissions (Tg/yr) from landfills equal

$$y = CF * R * X. \quad (1)$$

where CF is a conversion factor, R is the emission factor, and X is the estimate of waste in place (Tg/yr) decomposing under anaerobic conditions. For sanitary landfills, which are considered to be completely anaerobic, X is equal to total waste in place. CH_4 emissions are decreased by the amount of CH_4 that is currently recovered or flared (Y_R). It is estimated that worldwide there are about 270 sites in 20 countries where LFG is recovered.

Waste Generation

For most countries, data on X are not available and have to be developed from waste generation rates. The methodology distinguishes between rural and urban waste generation rates. To obtain X , the

total annual waste generation rate M (Tg/yr) is multiplied by the CH_4 generation time G (yr), which is the "lifetime" that a batch of waste continues to produce CH_4 (average 25 yr) in a landfill.

Per capita MSW generation rates range from 1.7 to 1.9 kg/day for the U.S. and Canada. Per capita MSW generation rates in other developed countries are about 1.2 kg/day. For developing countries, rates are about 0.8 kg/day for urban, and 0.3 kg/day for rural areas. MSW generation rates were multiplied with population data to obtain M .

Global Methodology

To adapt Equation (1) for other countries requires two modifications. The first modification concerns the fact that waste management practices in other countries differ considerably from the U.S. practice of sanitary landfilling. The second modification addresses the relationship between composition and CH_4 potential of waste in place. CH_4 potential is defined as the maximum amount of CH_4 that may be generated by a certain batch of waste.

In developed countries, not all waste that is generated is actually landfilled. Parts may be incinerated, composted, or recycled. In developing countries, part of the waste may be fed to animals or burned within the household. Also, much of the garbage is scavenged before it is collected. Refuse may also be dumped in

rivers, swept out onto the streets, or buried. In addition, garbage is often burned at the dump to reduce the volume. Finally, open dumps are often scavenged again by humans and animals. The methodology described in the report accounts for these practices by introducing a factor L to express the amount of generated waste that is eventually landfilled or dumped.

For U.S. landfills, which are considered to be completely anaerobic, X is equal to total waste in place. In other cases, for instance in open dumps, not all waste may be decomposing anaerobically. To account for this, a country-specific factor F is introduced to express the average degree in which anaerobic decomposition takes place within the dumps or landfills.

The emission factor used in this report is based on field measurements of CH_4 from U.S. waste. Compared to U.S. waste, waste in other countries will probably have a different composition and CH_4 potential. In the methodology, this difference is accounted for by relating the country-specific CH_4 potential to the U.S. potential.

By adjusting for L , F , and the relative CH_4 potential, the equation to estimate CH_4 emissions from landfills and open dumps for a certain country is

$$Y = L * F * \frac{P}{P_{Us}} * 47 * 10^{-3} * M - Y_R \quad (2)$$

Global estimates are obtained by summing country-specific emissions. Estimates of CH_4 emissions from global landfills

range from 21 to 46 Tg/yr, with a 33 Tg/yr midpoint. The U.S. is the biggest contributor, accounting for 39% of world emissions.

Trends and Uncertainties

In the future, plans by developed countries to place less waste in landfills in favor of recycling and incineration would help to reduce landfill CH_4 . Also, controls for LFG emissions are being considered by these countries. The U.S. is scheduled to promulgate Clean Air Act regulations for municipal solid waste landfills by June 1995. This rule is estimated to decrease CH_4 emissions by 5 to 7 Tg/yr by the year 2000. Economical growth in newly industrialized countries and overall population growth in developing countries are expected to increase total yearly waste generation. Also, in developing countries, there is a distinct intent to improve solid waste management methods for sanitation reasons. Better solid waste management methods may increase the amount of waste that will be landfilled or dumped in the future and thus increase CH_4 emissions.

Substantial uncertainty in the global estimates from this source results from a lack of data characterizing (1) country-specific waste generation, (2) waste management practices, (3) CH_4 potential of the waste in place, and (4) CH_4 that is emitted from waste piles and open dumps.

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The complete report, entitled "Estimate of Global Methane Emissions from Landfills and Open Dumps," (Order No. PB95-177002; Cost: \$19.50, subject to change) will be available only from

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