

Appendix G. Waste Management

Overview

Greenhouse gas (GHG) emissions from waste management include:

- Solid waste management – methane (CH₄) emissions from waste decomposition at municipal and industrial solid waste landfills, accounting for CH₄ that is flared or captured for energy production (this includes both open and closed landfills);
- Solid waste combustion – CH₄, carbon dioxide (CO₂), and nitrous oxide (N₂O) emissions from the controlled combustion of solid waste in incinerators or waste to energy plants or open burning of waste (e.g. at city dumps or in residential burn barrels); and
- Wastewater (WW) management – CH₄ and N₂O from municipal wastewater and CH₄ from industrial WW treatment facilities.

Inventory and Reference Case Projections

Solid Waste Management

Solid Waste Landfills. GHG emissions from municipal solid waste (MSW) landfills were estimated by Minnesota Pollution Control Agency (MPCA) from 1990 through 2004 using the United States Environmental Protection Agency's (US EPA) Landfill Gas Emissions Model (LandGEM) Version 3.02, with landfill input data (year opened, year closed, waste acceptance rate).¹ Emissions were modeled for the following landfill sites: Anoka; Burnsville; Flying Cloud; Pine Bend; Louisville; Woodlake; Elk River; and Spruce Ridge. For closed city dumps, emissions were estimated for three model scenarios: a low scenario (high rate of waste burning during the 1970's and 1980's); a high scenario (low burn rate during the 1970's and 1980's), and a medium scenario (average of the low and high scenarios).² For this inventory, in consultation with MPCA, estimates were taken from the medium scenario for the closed city dumps. Finally, emissions were also estimated for an "other" landfill category.

These estimates include CH₄ emissions from all MSW landfills, as well as CH₄ and N₂O estimates at sites where landfill gas was collected and combusted in either a flare or engine/turbine. In developing the landfill emission estimates, MPCA adjusted uncontrolled emissions estimated with LandGEM by subtracting CH₄ flared or used for energy production and by adding CH₄ produced by flares or engines.³ Emissions from the open burning of waste are described in the next section below.

Emissions from industrial paper pulp landfills were also estimated using LandGEM. Modeling of emissions from the Moonlight landfill was performed, and the results were extrapolated to the State level.⁴ Data on the annual amount of decomposable material landfilled was estimated by MPCA.⁵ Emissions from other industrial landfilled waste were assumed to be captured within the municipal landfill modeling described above.

¹ MPCA

² MPCA

³ MPCA

⁴ MPCA

⁵ MPCA

Growth rates were estimated by using the overall historic emissions for MSW landfills from 1995-2004. Throughout the U.S., many of the smaller and older unlined landfills were closed during the mid-1980's to mid-1990s as a result of new requirements for solid waste management. Hence, CCS believes that the period from 1995 onward better reflects recent landfilling practices and growth in waste emplacement. The annual growth rate for MSW landfills is -0.45%. For industrial landfills, the forecasted emissions are also declining. The growth rate (-1.6%/yr) was estimated based on emissions estimated from 1990 to 2004.

Solid Waste Combustion. GHG emissions from municipal and industrial solid waste combustion were estimated by MPCA from 1990 through 2004. Sources include solid waste burning in municipal and medical waste incinerators, rural open burning, and hazardous waste incineration. Emissions were estimated for CO₂ from the fraction of non-biogenic carbon in the waste. Emissions were also estimated for CH₄ and N₂O. Data on the amount of waste combusted by waste category and emission factors were obtained by MPCA.⁶ For the waste management sector, the emissions associated with waste combustion for the purposes of electricity generation and commercial steam/heat production are excluded. Emissions associated with residential burning of solid waste are not included in this inventory and are assumed to be negligible.

The growth rate for solid waste combustion was estimated based on emissions estimated from 1990 to 2004. The emissions trend during this period was declining at the rate of -2.5%/yr.

Wastewater (WW) Management

Municipal WW Treatment. GHG emissions from municipal WW and septic systems were also estimated by MPCA. Emissions from municipal WW and septic systems were calculated based on state population, biochemical oxygen demand (BOD), protein consumption per capita, and emission factors for N₂O and CH₄.⁷

Municipal WW management projections are based on the growth in emissions from 1990 to 2004. The growth rate is 1.5%/yr.

Industrial WW Treatment. No sources of data were identified to estimate emissions from industrial WW management. The US EPA's State Greenhouse Gas Inventory Tool (SGIT) software allows for the calculation of emissions from the following industry sectors, if data on production levels are available: pulp & paper; fruit & vegetable processing; and meat & poultry processing. Data on WW flow rates and chemical oxygen demand could also be used to develop emission estimates.

Results

Figure G1 shows the emission estimates for the waste management sector and Table G1 displays these results in tabular form. Overall, the sector accounts for 5.0 MMtCO₂e in 2005. By 2025, emissions are expected to decrease to 4.6 MMtCO₂e/yr. This decrease in emissions is driven by declining emissions in the solid waste management sector, in particular MSW landfills. While data were not available to verify this, CCS believes that the declining trend in MSW landfill

⁶ MPCA

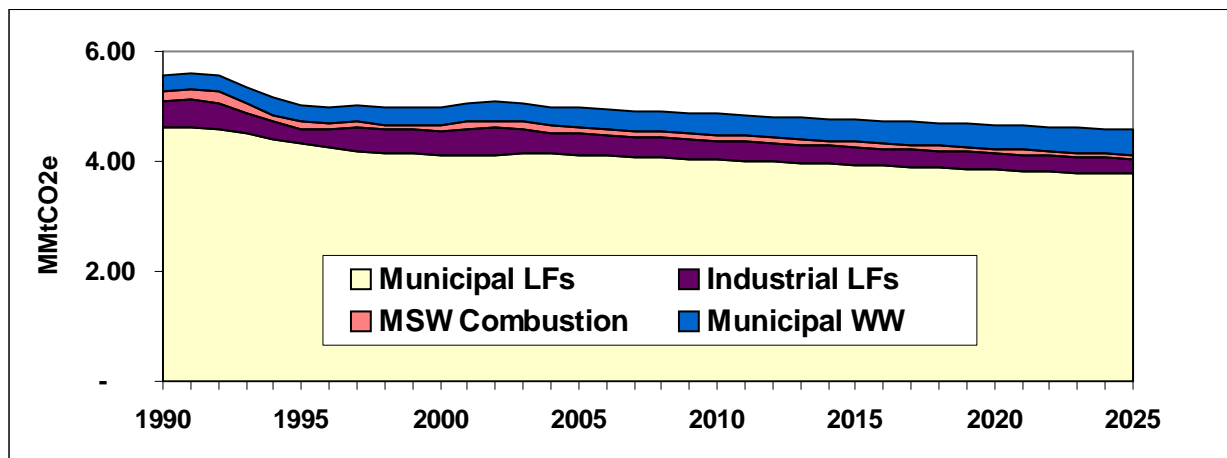
⁷ MPCA

emissions is due to more waste being emplaced into landfills that are collecting and controlling CH₄ emissions over time. From 2005 through 2025, the contribution of emissions from the MSW landfills sector is expected to remain about the same (about 82%).

In 2005, about 7% of the waste management sector emissions were contributed by municipal WW treatment systems. By 2025, municipal WW treatment is expected to contribute about 10% of the waste management sector emissions.

There were no readily-available sources of data identified to estimate emissions from the industrial WW treatment sector. If sources of data can be identified during the advisory group process for production levels or WW flow rates at pulp and paper mills, fruit and vegetable processors, and meat and poultry plants, then emissions for this subsector can be estimated and incorporated. CCS believes that this subsector would likely contribute only small amounts to the sector emissions.

Figure G1. Minnesota GHG Emissions from Waste Management (MMtCO₂e)



Notes: LF – landfill; WW – wastewater; MSW – municipal solid waste.

Table G1: Annual GHG Emissions from Waste Management (MMtCO₂e)

Year	1990	1995	2000	2005	2010	2015	2020	2025
Municipal LFs	4.62	4.32	4.10	4.12	4.03	3.94	3.85	3.76
Industrial LFs	0.47	0.28	0.44	0.37	0.34	0.31	0.29	0.27
MSW Combustion	0.18	0.13	0.11	0.12	0.11	0.10	0.09	0.08
Municipal WW	0.28	0.30	0.33	0.35	0.37	0.40	0.43	0.47
Industrial WW	0	0	0	0	0	0	0	0
Total	5.55	5.03	4.97	4.96	4.85	4.75	4.66	4.58

Key Uncertainties

The key uncertainties for the waste management sector are primarily associated with the MSW landfill emission estimates. Uncertainty stems from: the initial LandGEM modeling results at individual landfill sites, data from each site collecting and combusting landfill gas, and the

associated emission factors. For industrial (pulp and paper) landfills, the emission estimates are extrapolated from measurements at the Moonlight landfill. Hence, depending on how representative this site is to the overall population of pulp and paper landfills, emissions could be under- or over-estimated.

As mentioned above, the current inventory does not include estimates for the industrial WW treatment sector. These estimates will be added, if data can be identified during the advisory group process.