# Chapter 7

## Waste

### 7.1 Introduction

The waste sector represented approximately 3% of all greenhouse gas emissions in 2001 and there was a decrease of 2.9% from 2000. Emissions are now 20% below the 1990 baseline in this sector. The majority of this reduction has occurred in the solid waste disposal on land source, which has decreased by 23.4%.

In New Zealand, managing solid wastes has traditionally meant disposing of them in landfills. Based on the results of the 1995 National Landfill Census that was conducted by the Ministry for the Environment, there were 327 legally operating landfills, or solid waste disposal sites (SWDSs), in New Zealand that accepted approximately 3,180,000 tonnes of solid waste.

Since that time there have been a number of initiatives to improve solid waste management practices in New Zealand. These have included preparing guidelines for the development and operation of landfills, the closure and management of landfill sites, and for consent conditions for landfills under the Resource Management Act 1991. As a result of these initiatives, a number of poorly located and substandard landfills have been closed and communities increasingly rely on modern regional disposal facilities for disposal of their solid waste.

Recently, the national focus has been towards waste minimisation and resource recovery. In March 2002, the Government announced its New Zealand Waste Strategy. The strategy sets targets for a range of waste streams as well as for improving landfilling practices by the year 2010.

Wastewater from virtually all towns in New Zealand with a population over 1,000 people is collected and treated in community wastewater treatment plants. There are approximately 317 municipal wastewater treatment plants and around 50 government or privately owned treatment plants serving more than 100 people.

While most of the treatment processes are aerobic and therefore produce no methane, there are a significant number of plants that use partially anaerobic processes such as oxidation ponds or septic tanks. Small communities and individual rural dwellings are generally served by simple septic tanks followed by ground soakage trenches.

Very large quantities of high-strength industrial wastewater are produced by New Zealand's primary industries. Most of the treatment uses aerobic treatment, or if anaerobic treatment is used, all the methane is collected and burned. There are however a significant number of anaerobic ponds that do not have methane collection, particularly serving the meat processing industry. These are the major sources of industrial wastewater methane.

## 7.2 Country-specific approaches different from the IPCC methodology

Both IPCC Tier 1 and Tier 2 methods have been applied for emissions from solid waste. A country-specific Degradable Organic Carbon factor (DOC) and methane generation potential ($L_o$) have been estimated. An oxidation correction factor of 0.1 is used consistent with IPCC Good Practice Guidance. A country-specific Methane Generation Rate Constant (k) has been derived based on conditions at New Zealand landfills, including a generally wet climate.

Methane emissions from domestic and industrial wastewater handling have been calculated using a refinement of the IPCC methodology. An adjusted value for Biological Oxygen Demand (BOD) has been used. The treatment of sludge is described in the methodologies section below. A modification of the IPCC methodology was used for calculations of nitrous oxide emissions from wastewater handling.

Negligible quantities of waste are incinerated and emissions from this were not estimated.

## 7.3 Emissions calculation methodologies

The details of both $CH_4$ and $N_2O$ emissions from the waste sector, as summarised below, are reported in *National Greenhouse Gas Inventory from the Waste Sector 1990 - 2020 (*SCS Wetherill Environmental and Bruce Wallace Partners, 2002). Both Tier 1 and Tier 2 approaches have been used for solid waste emissions estimates and the results compared[5]. The data reported in the CRF is from the Tier 2 approach.

### Solid waste disposal sites

Data on Municipal Solid Waste (MSW) generation rates, waste composition and the percentage of MSW disposed to SWDS was obtained from the National Waste Data Report (1997) and Waste Analysis Protocol (WAP) surveys for the period 1993 to 1995. Based on the 1995 data, each person sends approximately 1.08kg of residential waste per day. Industrial waste that is landfilled reportedly averages approximately 1.31kg per person per day. As a result, it is estimated that the total quantity of solid waste that is landfilled in New Zealand is 2.39kg per person per day[6].

[5] This was a recommendation from the technical review of New Zealand's greenhouse gas inventory conducted in May 2001.

[6] It has been noted that the results for New Zealand are higher than for other OECD nations. The residential result for New Zealand includes "bulky waste" associated with garden and home renovations. In addition, the industrial result for New Zealand includes construction and demolition waste. These two categories are counted separately by most other OECD nations.

The calculation of methane emissions from MSW entering landfills follows the IPCC methodology. The proportion of waste for each type of SWDS was obtained from the 1995 National Landfill Census. Based on a review of that information it is estimated that 90% of New Zealand's waste is disposed to managed SWDS, and 10% to "uncategorised" sites. The IPCC default methane correction factors were applied. The fraction of DOC was estimated using a knowledge of waste composition in New Zealand, and applying the default values for each fraction of the waste stream. In addition an estimate was made of the quantity of wood waste in the construction and demolition waste stream, and an allowance for this material was included in the NZ DOC Estimate Worksheet.

The fraction of DOC that actually degrades (50%) and the methane oxidation factor (10%) are drawn from the Topical Workshop on Carbon Conversion and Methane Oxidation in Solid Waste Disposal Sites, held by the IPCC Phase II Expert Group on Waste on 25 October 1996. These figures are consistent with IPCC Good Practice Guidance.

The recovered methane rate per year was estimated based on information from a previous survey of SWDSs that serve populations of over 20,000 in New Zealand. The survey information was updated based on local knowledge and experience (SCS Wetherill Environmental and Bruce Wallace Partners, 2002).

### Wastewater treatment - methane

Methane emissions from domestic and industrial wastewater handling have been calculated using a refinement of the IPCC methodology. For each municipal treatment plant in New Zealand a population has been assessed. Where industrial wastewater flows to a municipal wastewater treatment plant then an equivalent population for that industry has been assessed based on a BOD loading of 70g per person per day. Populations not served by municipal wastewater treatment plants have been estimated and their type of wastewater treatment assessed.

The plants have each been assigned to one of nine typical treatment processes with a characteristic emission factor. The emission factor is the proportion of incoming BOD to the plant that is anaerobically degraded multiplied by the methane conversion factor (MCF).

For industrial wastewater methane emissions, after reviewing the available information, the IPCC maximum methane-producing capacity, Bo of 0.25 for Chemical Oxygen Demand (COD) and an adjusted value of 0.375 for BOD were adopted (SCS Wetherill Environmental and Bruce Wallace Partners, 2002).

### Sludge

For larger treatment plants in New Zealand where sludge is handled anaerobically the methane is almost always flared or used. Smaller plants generally use aerobic handling processes such as aerobic consolidation tanks, filter presses and drying beds.

Sludge from wastewater treatment plants is typically landfilled and so any methane produced is accounted for under solid waste disposal.

Oxidation ponds accumulate sludge on the pond floor. In New Zealand these are typically only desludged every 20 years. The sludge produced is well stabilised and with an average age of approximately ten years. It has a low biodegradable organic content and is unlikely to be a significant source of methane.

Sludge from septic tank clean-out, known as septage, is often removed to the nearest municipal treatment plant. In those cases it has been included in the inventory for that plant. Where sludge is landfilled the methane production has been included under solid waste disposal. There are a small number of treatment lagoons specifically treating septage. These lagoons are likely to produce a small amount of methane and their effect is included in the calculations.

### Wastewater treatment – nitrous oxide

The IPCC does not offer a methodology for estimating of $N_2O$ emissions from industrial wastewater handling. The BOD load from the $CH_4$ emission calculations was adopted, a ratio of BOD to nitrogen in the wastewater was assessed for each industry and total nitrogen loads calculated. An emission factor giving the proportion of total nitrogen in the wastewater converted to $N_2O$ was used to calculate total $N_2O$ emissions from industrial wastewater.

### Human waste

The IPCC method calculates nitrogen production based on the average per capita protein intake. Raw sewage nitrogen data is available for many New Zealand treatment plants and it has been calculated that the per capita New Zealand domestic nitrogen production is 13g/day, and this has been used to derive a per capita wastewater N figure of 4.75kg/person/year.

## 7.4 Changes since the last inventory submission

There have been no changes introduced to the methodology for estimating greenhouse gas emissions from the waste sector since the last submission in 2002. That inventory (for the first time) used a Tier 2 approach for estimating methane emissions from solid waste disposal. That shift in approach also involved a change to the DOC value used (changed from 0.1582 to 0.1531) as a result of using more recent population data. The DOC value of 0.1531 is consistent with the waste statistics value of 2.39kg per person per day identified above.

As in last year's submission, the calculations for methane emissions from industrial wastewater handling are based on COD rather than BOD as was done previously, as COD is the preferred IPCC measure, and reliable COD measurements were available from the meat industry, which is the largest source of industrial wastewater methane emissions.

## 7.5 Uncertainty

### Solid waste disposal

**Tier 1:** Although the IPCC model has been updated and more current data has been used in the estimates for this inventory, the primary areas of data uncertainty include waste statistics, quantity of methane generated, quantity of methane which is emitted to the atmosphere, and recovered methane rate. Due to the unknown level of uncertainty associated with the accuracy of some of the input data, it is not possible to perform a statistical analysis to determine uncertainty levels. As a result, it is estimated that the level of uncertainty remains at the level of ±35% previously reported.

**Tier 2:** Given that the input data for the Tier 2 method is the same as the Tier 1 method, the uncertainty value is assumed to be the same – i.e. at a level of ±35% previously reported.

### Methane from domestic wastewater

The primary sources of inaccuracy in the data are biases due to collection methods, thus it is not possible to perform rigorous statistical analyses to determine uncertainty levels. The uncertainty for all wastewater figures is based on an assessment of the reliability of the data and the potential for important sources to have been missed from the data. Domestic wastewater methane emissions have an estimated accuracy of -40% to +60%.

### Methane from industrial wastewater

Because of the method used in estimating methane emissions a statistical analysis of uncertainty is not possible. However, based on assessed levels of uncertainty in the input data, the total methane production from industrial wastewater has an estimated accuracy of -30% to +40%.

### Nitrous oxide from wastewater

Nitrous oxide emissions from anaerobic ponds are not well quantified. There may also be significant nitrous oxide emissions from downstream treatment processes in aerobic plants. There are very large uncertainties associated with nitrous oxide emissions and no attempt has been made to quantify this uncertainty. The IPCC default emission factor, $EF_6$, has an uncertainty of -80% to +1,200%. The estimates only have an order of magnitude accuracy.

## 7.6 References


Hauber G, 1995, Wastewater Treatment in New Zealand: Evaluation of 1992/93 Performance Data, *Water and Wastes in New Zealand*, Auckland, New Zealand.

NRB, 1995, *Landfill Census*, report by the National Research Bureau Limited for the Ministry for the Environment, New Zealand.

Royds, 1994, *Estimates of Methane Production from New Zealand Landfills*, report by Royds Consulting Limited for the Ministry for the Environment, Wellington, New Zealand.

Savage, E, 1996, *Methane Emissions from Wastewater in New Zealand*, report for the Ministry for the Environment, Wellington, New Zealand.

SCS Wetherill Environmental and Bruce Wallace Partners Ltd, 1998, *New Zealand's National Greenhouse Gas Inventory from Wastes 1990 - 2020*, report for the Ministry for the Environment, Wellington, New Zealand.

SCS Wetherill Environmental and Bruce Wallace Partners Ltd, 2002, *National Greenhouse Gas Inventory from the Waste Sector 1990 – 2020*.

# Appendix to Chapter 7:
# Waste sector calculation table 2001

**Module** 2001 Waste (New Zealand)
**Submodule** **Methane emissions from solid waste disposal sites**
**Worksheet** **6.1A (supplemental)**

| Total population[1] | MSW generation rate[1] (kg/cap/day) | Annual MSW generated (Gg/yr) | Fraction of MSW to SWDs | Total MSW to SWDSs (Gg) |
|---|---|---|---|---|
| 3,859,000 | 2.39 | 3,363 | 1.00 | 3,363 |

1 SCS Wetherill 2002

**Module** 2001 Waste (New Zealand)
**Submodule** **Methane emissions from solid waste disposal sites (tier 2)**
**Worksheet** **6.1**

| Total annual MSW disposed to SWDs (Gg MSW) | Methane generation potential ($L_o$) | Methane Generation rate constant (k) | Gross annual methane generation (model output) | Total annual MSW disposed to SWDs with LFG systems (Gg MSW) | Percentage of MSW with LFG systems (%) | Estimated average LFG system collection efficiency (%) | Recovered methane per year (Gg $CH_4$) | Net methane generation (Gg $CH_4$) | One minus oxidation correction factor | Net methane emissions (Gg $CH_4$) |
|---|---|---|---|---|---|---|---|---|---|---|
| 3,363 | 73.43 | 0.06 | 157.5 | 1,708.0 | 50.79 | 0.65 | 51.9990 | 105.5 | 0.9 | **95.0** |

Information in this table based on SCS Wetherill 2002

**Calculations of DOC and $L_o$**

**New Zealand DOC Estimate Workshet**

| Waste category (NZ WAP) | Waste Quantity (tonnes) | Waste composition (% by weight) | Fraction DOC (by weight) |
|---|---|---|---|
| Paper | 586,710 | 18 | 0.4 |
| Plastic | 222,600 | 7 | 0 |
| Glass | 60,420 | 2 | 0 |
| Metal | 208,290 | 7 | 0 |
| Organic | 1,135,260 | 36 | 0.17 |
| C&D[1] non wood | 330,720 | 10 | 0 |
| C&D wood | 197,160 | 6 | 0.3 |
| Other | 162,180 | 5 | 0 |
| Pot Haz | 276,660 | 9 | 0 |
| Total | 3,180,000 | | |

1 Construction and demolition

**Methane Generation Potential Calculation by Using Waste Type Data in 1995**

| Methane correction factor (MCF) | Degradable organic carbon (DOC) GgC/Gg waste | Fraction of DOC dissimilated ($DOC_F$) | Fraction by volume of $CH_4$ | Conversion from C to $CH_4$ | Methane Generation Potential ($L_o$) $GgCH_4/Gg$ waste | Methane Generation Potential ($L_o$) $m^3CH_4/Mg$ waste |
|---|---|---|---|---|---|---|
| 0.96 | 0.1531 | 0.50 | 0.50 | 1.3333 | 0.0490 | 73.43 |

**Module** 2001 Waste (New Zealand)
**Submodule** **Methane emissions from domestic and commercial wastewater treatment**
**Worksheet** **NZ 6.2**
**Sheet** **Estimation of emission factor for wastewater handling systems**

| Wastewater handling system[1] | Fraction of wastewater treated by the handling system[1] (percent) | Methane conversion factor for the handling system | Product | Maximum methane producing capacity (kg $CH_4$/kg BOD) $B_o$ | Emission factor for domestic/ commercial wastewater (kg CH4/kg BOD) |
|---|---|---|---|---|---|
| Anaerobic pond | 1.7 | 0.65 | 0.01105 | 0.375 | 0.00415 |
| Imhoff tank | 0.3 | 0.55 | 0.00186 | 0.375 | 0.00070 |
| Septic tank | 7.4 | 0.40 | 0.02974 | 0.375 | 0.01115 |
| Oxidation pond | 10.7 | 0.20 | 0.02131 | 0.375 | 0.00799 |
| Facultative aerated pd | 1.8 | 0.10 | 0.00181 | 0.375 | 0.00068 |
| Fully mixed aerated pd | 1.6 | 0 | 0 | 0.375 | 0 |
| Activated sludge | 31.2 | 0 | 0 | 0.375 | 0 |
| Other aerobic plant | 12.6 | 0 | 0 | 0.375 | 0 |
| Milliscreening[2] | 24.0 | 0 | 0 | 0.375 | 0 |
| Aerobic[3] | 8.4 | 0.10 | 0.00836 | 0.375 | 0.00313 |
| Aggregate MCF | | | | | 0.0278 |

1 SCS Wetherill 2002
2 Milliscreening or no treatment
3 Methane from sludge

**Module** 2001 Waste (New Zealand)
**Submodule** **Methane emissions from domestic and commercial wastewater and sludge treatment**
**Worksheet** **NZ 6.2**
**Sheet** **Estimation of methane emissions from domestic/commercial wastewater and sludge**

| | Total organic product[1] (kg BOD/yr) | Emission factor (kg $CH_4$/ kg BOD | $CH_4$ emissions without recovery/ flaring (kg $CH_4$/yr) | $CH_4$ recovered and/or flared[2] (kg $CH_4$/yr) | Net $CH_4$ emissions (Gg $CH_4$/yr) |
|---|---|---|---|---|---|
| Wastewater | 143,033,614 | 0.0278 | 3,976,137 | 0 | 4.0 |
| Sludge[2] | | | | | 0.0 |
| Total | | | | | 4.0 |

1 SCS Wetherill 2002
2 Almost all CH4 generated from aerobic sludge handling is collected therefore does not contribute to methane emissions, thus emissions from sludge have not been estimated; after methane recovery net emissions of methane from sludge are zero.

**Module** 2001 Waste (New Zealand)
**Submodule** **Indirect nitrous oxide emissions from human sewage**
**Worksheet** **6.4 (adapted)**

| Per capita wastewater N (kg/person/ year)[1] | Total Population[2] | Emission factor ($EF_6$) (kg $N_2O$-N/kg sewage-N produced) | Total $N_2O$ emissions (Gg) |
|---|---|---|---|
| 4.75 | 3,975,600 | 0.01 | **0.30** |

1 SCS Wetherill 2002
2 Statistics New Zealand.

**Module** 2001 Waste (New Zealand)
**Submodule** **Methane emissions from industrial wastewater and sludge handling**
**Worksheet** **NZ 6.3 (modified)**

| | Total industrial output (tonne product/year) | Degradable organic component (kg COD/ tonne product) | Total industrial organic wastewater (kg COD/yr) $TOW_{ind}$ | Proportion of industry using anaerobic treatment (without $CH_4$ collection) | Proportion of incoming COD degraded anaerobically in anaerobic plant | Maximum $CH_4$ producing capacity (kg $CH_4$/kg COD) $B_0$ | Emission factor (kg $CH_4$/ kg incoming COD) | $CH_4$ emissions (Gg/year) |
|---|---|---|---|---|---|---|---|---|
| Meat industry | | | | | | | | |
| beef | 571,857 | 50 | 28,592,850 | 43% | 55% | 0.25 | 0.059 | 1.69 |
| sheep/lambs | 539,014 | 50 | 26,950,700 | 33% | 55% | 0.25 | 0.045 | 1.22 |
| pigs | 48,338 | 50 | 2,416,900 | 40% | 55% | 0.25 | 0.055 | 0.13 |
| venison | 27,081 | 50 | 1,354,050 | 40% | 55% | 0.25 | 0.055 | 0.07 |
| goats | 1,285 | 50 | 64,250 | 40% | 55% | 0.25 | 0.055 | 0.00 |
| poultry | 111,000 | 123 | 13,653,000 | 20% | 55% | 0.25 | 0.028 | 0.38 |
| Leather and skins | 85,000 | 180 | 15,300,000 | 0% | 70% | 0.25 | 0.000 | 0.00 |
| Pulp and paper | | | 56,889,552 | 100% | 2% | 0.25 | 0.005 | 0.28 |
| Wool scouring | 183,000 | 22 | 4,026,000 | 9% | 29% | 0.25 | 0.007 | 0.03 |
| Wine[1] | | | | | | | | 0.02 |
| Beverages | | | | 0% | | | 0 | |
| Dairy processing | 1,714,363 | 5.8 | 9,943,305 | 0% | | | 0 | |
| Food processing | | | | 0% | | | 0 | |
| Metals and minerals | | | | 0% | | | 0 | |
| Petrochemical | | | | 0% | | | 0 | |
| Plastics | | | | 0% | | | 0 | |
| Textiles | | | | 0% | | | 0 | |
| Iron and steel | | | | 0% | | | 0 | |
| Non-ferrous metals | | | | 0% | | | 0 | |
| Fertiliser | | | | 0% | | | 0 | |
| Total | | | | | | | | **3.83** |

1 Emissions estimate for wine from Savage 1997. All other data from SCS Wetherill 2002