# MODULE 6
# WASTE

# 6. WASTE

## 6.1    Introduction

This module provides methodologies for estimating emissions of methane ($CH_4$) from solid waste disposal sites, $CH_4$ emissions from wastewater handling and $N_2O$ from human sewage.

## 6.2    Land Disposal of Solid Waste

This section covers estimation of methane emissions from solid waste disposal sites.

### 6.2.1 Introduction

Anaerobic decomposition of organic matter by methanogenic bacteria in solid waste disposal sites results in the release of $CH_4$ to the atmosphere. This source is estimated to account for about 5 to 20 per cent of global anthropogenic $CH_4$ emissions (US EPA, 1994; IPCC, 1992).

The methodology provides a classification of 'solid waste disposal site' (SWDSs) into "managed" and "unmanaged" sites through a knowledge of the extent and type of active site management carried out.    The classification is used to apply a methane correction factor (MCF) to account for the methane generation potential of the site.

### 6.2.2 Data Sources

Countries are encouraged to use their own data where available.  Default values, given in the tables, should be used when such data are not available.

**Population statistics**: Countries that include areas where no organised waste collection or disposal takes place (usually rural areas) should use values for the urban population only, when asked to provide population data.  Waste in rural areas is typically scattered on the land rather than in SWDSs and hence it tends to decay aerobically generating extremely low, if any, $CH_4$ emissions.

**Waste statistics**: Data on Municipal Solid Waste (MSW) generation rates and on the percentage of MSW disposed to SWDSs are available for many countries, and these should be used when available.  Default values are given in Table 6-1.

The different waste types that are here included in MSW are:

1   Household Waste;

2   Yard/Garden Waste; and

3   Commercial/Market Waste

In some countries, significant quantities of organic industrial solid waste is generated.  The default values provided in Table 6-1 should not include

industrial solid waste.  If a significant quantity of organic industrial solid waste  is generated and disposed of in SWDSs, care should be taken to determine the appropriate *per capita* solid waste generation rate and Degradable Organic Carbon value.

**The Degradable Organic Carbon** (DOC) content of the waste is here defined as the carbon content of paper and textiles; garden and park waste and other (non-food) putrescibles; food waste; and other organic biodegradable waste.  DOC content may be determined by one of three methods:

- By using your own national data;

- By calculation from a knowledge of your country's waste composition and using the default DOC values given in Table 6-3 for each type of waste; or

- By using the default values given in Table 6-1.

Note that values given in Tables 6-1 and 6-3 are, in general, for wet (or fresh) waste.

It is critical that the DOC value corresponds to the waste generation/disposal rate on which the methane estimate is based.  For example, a country that includes industrial waste in its MSW estimate should ensure that the DOC value used reflects this component of the waste stream.

**Categories of waste disposal sites**: Sites are classified as managed or unmanaged SWDSs.  A managed solid waste disposal site must have controlled placement of waste (i.e., waste directed to specific deposition areas, a degree of control of scavenging and a degree of control of fires) and will include at least one of the following: cover material; mechanical compacting; or levelling of the waste.  All other solid waste disposal sites that do not fall into the above category are defined as unmanaged sites.  Unmanaged sites are further divided as deep ($\geq$5m depth) or shallow (<5m depth), to allow for their $CH_4$ generation potential.

The methodology requires countries to provide data or estimates of the quantity of waste that is disposed to each of the three categories of SWDSs.  It is acknowledged that some countries may find it difficult to provide this information.  In such cases, *Guidelines* users are encouraged to consult with national waste experts to come to a reasoned consensus on the status of waste management in a country.

Note that the information requires data on the quantity (mass) of waste deposited in each of the categories, and not the number of waste disposal sites in each of the categories.  If the breakdown of waste in each category is not known, the default value given in Table 6-1 should be used.

## 6.2.3 Methodology

The default methodology allows for the calculation of $CH_4$ emissions based on:

A)      the amount of waste deposited in the different categories of SWDSs;

B)      the fraction of degradable organic carbon and the amount which actually degrades; and,

C)      the fraction of $CH_4$ in landfill gas.

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**EQUATION 1**

Methane emissions (Gg/yr)

=

$$(MSW_T \times MSW_F \times MCF \times DOC \times DOC_F \times F \times 16/12 - R) \times (1-OX)$$

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where:

MSW_T    =    total MSW generated (G/yr)

MSW_F    =    fraction of MSW disposed to solid waste disposal sites

MCF    =    methane correction factor (fraction)

DOC    =    degradable organic carbon (fraction)

DOC_F    =    fraction DOC similated

F    =    fraction of $CH_4$ in landfill gas (default is 0.5)

R    =    recovered $CH_4$ (Gg/yr)

OX    =    oxidation factor (default is 0)

## Completing the Worksheet

Use WORKSHEET 6-1 METHANE EMISSIONS FROM SOLID WASTE DISPOSAL SITES to enter data for this submodule.

### STEP 1   ESTIMATE TOTAL MUNICIPAL SOLID WASTE GENERATED AND DISPOSED OF IN SOLID WASTE DISPOSAL SITES

• If your country has detailed statistics on Total Annual MSW Disposed to SWDSs (in gigagrams of MSW), enter these data into column A of the main Worksheet (Worksheet 6-1), then go directly to Step 2.

Otherwise use Worksheet 6-1A or 6-1B to estimate the quantity of MSW disposed of in SWDSs in your country using the following steps.

Worksheet 6-1A (Supplemental)**:**  COUNTRY WASTE GENERATION/DISPOSAL DATA

1   For the inventory year, define the Population whose Waste goes to SWDSs. For developed countries this figure is likely to be the total country population. For developing countries and countries with economies in transition, this may be the total urban population only, because the rural population is assumed to dispose of waste in such a

way that $CH_4$ emissions are extremely low.  Enter this value (number of persons) into column A.

2    Enter the Municipal Solid Waste (MSW) Generation Rate (in kg/capita/day) into column B.

MSW is here defined as:

*    household waste;

*    yard/garden waste; and

*    commercial/market waste.

If your country MSW contains significant quantities of other organic waste, such as industrial organic solid waste, then care should be taken to select an appropriate *per capita* waste generation rate.

You should provide your own data if available.  Default values (for MSW as defined above) for some specific countries are given in Table 6-1.

3    Multiply the value in column A with the value in column B.  Multiply the result by 365 to convert from the daily rate to give the Annual Amount of MSW Generated.  Divide the total by $10^6$ to convert kg to Gg and enter the result in column C.

4    Enter the Fraction of MSW Disposed of to SWDSs into column D.  Use your own data if available, otherwise use the default values that are given in Table 6-1.

5    Multiply the value in column C by the value in column D to give the Total Annual MSW Disposed to SWDSs.  Enter the result in gigagrams of MSW in column E.

6    Enter the figure from column E into column A of the main Worksheet (Worksheet 6-1).

Worksheet 6-1B (Supplemental):  COUNTRY WASTE DISPOSAL DATA

Use Worksheet 6-1B if country or default data are not available on MSW Generation Rate or Fraction of MSW Disposed to SWDSs .

1    Define the Population whose Waste goes to SWDSs for the inventory year.  Enter the result in column A.  For developed countries this figure is likely to be the total country population.  For developing countries and countries with economies in transition, this may be the total urban population only, because the rural population is assumed to dispose of waste in such a way that $CH_4$ emissions are extremely low.  Enter this value (number of persons) into column A.

2    Enter the appropriate annual MSW Disposal Rate to SWDSs (kg/capita/day) from Table 6-1 into column B. If a default value for your country is not available, choose the most appropriate default value provided in the Table.  Choose a default value from a country that most closely reflects your country's waste disposal practices and prevailing environmental conditions.   (This may be the country that is geographically closest to your country.)

3  Multiply the value in column A with the value in column B.  Multiply the result by 365 to convert from the daily rate to give the Total Annual MSW Disposed to SWDs.  Divide the total by $10^6$ to convert kg to Gg and enter the result in column C.

4  Enter the figure from column C into column A of the main Worksheet (Worksheet 6-1).

## STEP 2   DETERMINE METHANE CORRECTION FACTORS

Worksheet 6-1C (Supplemental):  METHANE CORRECTION FACTOR

1  Estimate the Proportion of Waste (by weight) of Each Type of SWDSs for the Total Annual MSW Disposed to SWDSs (i.e., the value in column A of Worksheet 6-1).  These types of site are listed and defined in Table 6-2.

   Enter these values into column W of Worksheet 6-1C to correspond with the values x, y and z shown in Table 6-2.  **[Check that x+y+z=1].** If you do not know values for x, y and z, then assume that all the waste is disposed to unmanaged sites and <u>do not</u> enter any values for x, y or z. Instead, enter the default value of 1 in the bottom of column W (as shown in Table 6-2).

2  Enter the  Methane Correction Factors in column X for managed and unmanaged sites to correspond with the values a, b and c shown in Table 6-2.

3  Multiply the value in column W by the value in column X to give the Weighted Average MCF for Each Type of Solid Waste Disposal Site. Enter the result in column Y.

   If country specific values are not available, use default values provided in Table 6-2.  If you do not know values for a, b and c, enter the default value of 0.6 (Table 6-2) in the bottom of column X.

4  Sum up the three values in column Y to give the total Weighted Average MCF for Each Type of SWDS.   Enter the result in the bottom of column Y.

   If you have used the default value of 1 in column W, and the MCF default value of 0.6, the Weighted Average MCF for Each Type of SWDS is 1 x 0.6 = 0.6.  Enter 0.6 in the bottom of column Z.

Enter the total value in the bottom of column Y into column B of the main Worksheet (Worksheet 6-1).

| TABLE 6-1 COUNTRY WASTE GENERATION, COMPOSITION, AND DISPOSAL DATA | | | | |
|---|---|---|---|---|
| Region/Country | MSW Generation Rate (kg/cap/day) | Fraction of MSW Disposed to SWDs | Fraction of DOC of MSW | MSW Disposal Rate (kg/cap/day) |
| **North America** | | | 0.18-0.21 | |
| USA | 2.0 | 0.62 | | 1.24 |
| Canada | 1.81 | 0.75 | | 1.35 |
| **Oceania** | | | | |
| Australia | 1.26 | 1.00 | 0.15 | 1.26 |
| New Zealand | 1.33 | 1.0 | 0.19 | 1.33 |
| **UK/Western Europe/Scandinavia** | | | 0.08-0.19 | |
| UK | 1.9 | 0.9 | 0.10 | 1.7 |
| Ireland | 0.85 | 1.00 | | 0.85 |
| Austria | 0.92 | 0.40 | | 0.36 |
| Belgium | 1.10 | 0.43 | | 0.47 |
| Denmark | 1.26 | 0.20 | | 0.25 |
| Finland | 1.70 | 0.77 | | 1.3 |
| France | 1.29 | 0.46 | | 0.60 |
| Germany | 0.99 | 0.66 | | 0.65 |
| Greece | 0.85 | 0.93 | | 0.79 |
| Italy | 0.94 | 0.88 | | 0.83 |
| Luxembourg | 1.34 | 0.35 | | 0.47 |
| Netherlands | 1.58 | 0.67 | 0.14 | 1.06 |
| Norway | 1.40 | 0.75 | | 1.05 |

Note: The values in Table 6-1 represent the best data available to the Expert Group. Note that all values may not reflect identical assumptions regarding MSW composition (and hence corresponding DOC values). Where updated national data are available corresponding to the definitions used here, they should be used for comparison instead of the values given in Table 6-1.

See *Volume 3, Reference Manual* for References.

| TABLE 6-1 (CONTINUED) COUNTRY WASTE GENERATION, COMPOSITION, AND DISPOSAL DATA | | | | |
|---|---|---|---|---|
| Region/Country | MSW Generation Rate (kg/cap/day) | Fraction of MSW Disposed to SWDs | Fraction of DOC of MSW | MSW Disposal Rate (kg/cap/day) |
| Portugal | 0.90 | 0.86 | | 0.78 |
| Spain | 0.99 | 0.85 | | 0.83 |
| Sweden | 1.01 | 0.44 | | 0.44 |
| Switzerland | 1.10 | 0.23 | | 0.25 |
| **Eastern Europe** | | | | |
| Poland | | | 0.15 | 0.54 |
| Russia | 0.93 | 0.94 | 0.17 | 0.87 |
| **Asia** | | | | |
| Japan | 1.12 | 0.38 | | 0.43 |
| India | 0.33 | 0.6 | 0.18 | 0.2 |
| China | | | 0.09 | 0.84 |
| Indonesia | | | 0.17 | 0.51 |
| **Central America** | | | | |
| Guatemala | | | 0.13 | 0.46 |
| **South America** | | | | |
| Brazil | | | 0.12 | 1.47 |
| Peru | | | 0.15 | 0.98 |
| Chile | | | 0.18 | 0.59 |
| **Africa** | | | | |
| Egypt | | | 0.21 | 0.40 |
| Nigeria | | | 0.11 | 0.40 |
| South Africa | | 1.00 | | |
| Note: The values in Table 6-1 represent the best data available to the Expert Group.  Note that all values may not reflect identical assumptions regarding MSW composition (and hence corresponding DOC values).  Where updated national data are available corresponding to the definitions used here, they should be used for comparison instead of the values given in Table 6-1. | | | | |
| See *Volume 3, Reference Manual* for References | | | | |

| | W | X | Y | Z |
|---|---|---|---|---|
| **TABLE 6-2** **CALCULATION OF METHANE CORRECTION FACTOR** | | | | |
| Type of site | Proportion of Waste (by weight) in Each Type of Site | Methane Correction Factor (MCF): Default Values | Methane Correction Factor (MCF): Country-Specific Value | Weighted Average MCF for Each Type of SWDS |
| | | | | $Z = W \times X$ (or $W \times Y$) |
| Managed | x | 1.0 | a | = x or (a x x) |
| Unmanaged - deep (> or = 5m waste) | y | 0.8 | b | = 0.8y or (b x y) |
| Unmanaged - shallow (< 5m waste) | z | 0.4 | c | = 0.4z or (c x z) |
| Total | Check x+y+z=1 | - | - | $Z_{total}$ (= sum of values in shaded boxes above) |
| Default values | 1 | 0.6 | - | 0.6 |

Definitions:

A managed solid waste disposal site must have controlled placement of waste (i.e., waste directed to specific deposition areas, a degree of control of scavenging and a degree of control fires) and will include at least one of the following: cover material; mechanical compacting; or levelling of the waste.

All other solid waste disposal sites that do not fall into the above category are defined as unmanaged sites.

## STEP 3 ESTIMATE METHANE PRODUCTION RATE PER UNIT OF WASTE

1 Estimate the Fraction of Degradable Organic Carbon (DOC) in the Municipal Solid Waste (MSW) which is disposed of in SWDSs. This can be done:

- by using your own national data;

- by calculation using a knowledge of waste composition in your country and the default DOC values of each fraction of waste given in Table 6-3; or,

- by using the default values given in Table 6-1.

Use local data where these are available, and document your sources if you do so.

| TABLE 6-3 DEFAULT DOC VALUES FOR MAJOR WASTE STREAMS | |
|---|---|
| Waste Stream | Per cent DOC (by weight) |
| A.   Paper and textiles | 40 |
| B.   Garden and park waste and other (non-food) organic putrescibles | 17 |
| C.   Food waste | 15 |
| D.   Wood and straw waste[1] | 30 |

[1] excluding lignin C

Source: Bingemer and Crutzen, 1987.

Using the values in Table 6-3, the DOC of your country's waste could be calculated using Equation 2.

| EQUATION 2 |
|---|
| Per cent DOC (by weight) = 0.4(A) + 0.17(B) + 0.15(C) + 0.30(D) |

where:

A   =   per cent MSW that is paper and textiles

B   =   per cent MSW that is garden waste, park waste or other non-food organic putrescibles

C   =   per cent MSW that is food waste

D   =   per cent MSW that is wood or straw

If the default values from Table 6-1 are used, choose the default value which most closely corresponds to conditions in your country.

Enter the result in column C of the main Worksheet (Worksheet 6.1).

2   Enter the Fraction of DOC which Actually Degrades into column D. This is the fraction of the total DOC which actually degrades in a waste disposal site. The decomposition of DOC does not occur completely and some of the potentially degradable material always remains in the site even over a very long period of time. Dissimilation is currently under review, but the default value of 0.77 should be entered until further information is available.

3   Enter the Fraction of Carbon Released as Methane in column E. The default value is 0.5. If you have locally available data for this fraction then it should be used. Document your sources if you do so.

4   Calculate the Potential Methane Generation Rate per Unit of Waste by multiplying together the values in columns C, D, and E with the Conversion Ratio which converts carbon to $CH_4$ in column F (16/12). Enter the result into column G.

5   Calculate the Realised (Country-specific) Methane Generation Rate per Unit of Waste by multiplying together the values in columns B and G. Enter the result into column H.

## STEP 4   ESTIMATE TOTAL NET ANNUAL METHANE EMISSIONS

**METHANE CORRECTION FACTOR**

The Methane Oxidation Correction Factor is given as 0. This value may be changed in future versions of the Workbook to reflect new data arising from improvements in understanding of the effects of $CH_4$ oxidation in waste disposal sites.

1   Multiply the values in columns A and H to give the Gross Annual Methane Generation. Enter the result into column J.

2   Enter the amount of Recovered Methane per Year, in gigagrams $CH_4$, either through gas flaring or through energy recovery schemes. Enter the result in column K.

No default data are available. Use locally available figures for the amounts recovered if these are available. Document your sources if you do so.

Further details about factors to take into account and ways of calculating methane oxidised by flaring or use are given in the *Reference Manual*.

3   Subtract the values in column K from the values in column J to give Net Annual Methane Generation. Enter the result in column L.

4   Enter the value One Minus the Methane Oxidation Correction Factor in column M. (The default value is 1-0=1).

5   Multiply the values in columns L and M to give the Net Annual Methane Emissions. Enter the result, in gigagrams of $CH_4$, into column N.

## 6.3    Methane Emissions from Wastewater Handling

### 6.3.1 Introduction

The handling of wastewater streams with high contents of organic material, including domestic and commercial wastewater and some industrial wastewater streams, can emit significant amounts of methane (Table 6-4). Methane emissions from industrial wastewater are estimated to range from 26 to 40 Tg, while domestic and commercial sources emit approximately 2 Tg/yr.  Together, they account for 8 to 11 per cent of global methane emissions (IPCC, 1995).

There are two basic types of wastewater handling, emissions from which should be calculated separately.  These are:

- Domestic and commercial wastewater

- Industrial wastewater

The principal factor that determines methane generation potential of wastewater is the amount of organic material in the wastewater stream. For domestic and commercial wastewater and sludge, this is indicated by the Biochemical Oxygen Demand (BOD); for industrial wastewater, the Chemical Oxygen Demand (COD) is used.  The BOD indicates the amount of carbon that is aerobically biodegradable, whereas the COD indicates the total amount of carbon, biodegradable and non-biodegradable, that is available for oxidation.  This is a change from the previous methodology (IPCC, 1995), which used BOD as the organic material parameter in both domestic/commercial and industrial wastewater streams.

An important addition to the previous methodology (IPCC, 1995) is the incorporation of emissions from sludge.  Sludge is produced as a by-product of certain wastewater handling systems, and can produce methane under anaerobic conditions.

### 6.3.2 Data Sources

Countries are encouraged to use their own data where available. Otherwise, default values are given in the Tables.

**Population**: If wastewater produced in rural areas is managed without formal handling and/or treatment systems, then countries may consider only the urban population in estimating this emissions source.

**Degradable Organic Component**: If national or source-specific BOD and COD output values are not available, the regional default values (Table 6-5) should be used.  Consultation with national wastewater experts is suggested.

| TABLE 6-4 METHODS OF WASTEWATER HANDLING | |
|---|---|
| Handling Method | Exceptions to Expected $CH_4$ Production |
| **Mostly aerobic disposal and handling methods (little or no $CH_4$ production)** | |
| Developing countries <br><br> • Open Pits/Latrines <br><br><br> • Aerobic shallow ponds <br><br><br> • River Discharge | <br><br> • Pits/latrines may produce methane when temperature and retention time are favourable <br><br> • Aerobic shallow ponds over 3 metres deep may produce methane <br><br> • Stagnant, oxygen-deficient rivers may allow for anaerobic decomposition |
| Developed countries <br> • Sewer systems with aerobic treatment | <br> • Poorly designed or managed aerobic treatment systems produce methane |
| **Mostly anaerobic disposal and handling methods (high $CH_4$ production)** | |
| Developing countries <br> • Anaerobic deep ponds <br> • Sewer systems with anaerobic treatment | <br> • Poorly designed or managed anaerobic systems may allow for aeration and reduced methane production |
| Developed and developing countries <br><br> • Septic Tanks | <br><br> • Frequent solids removal reduces methane production |
| **Anaerobic Methods with Methane Recovery** (mainly for sludge handling) | |
| Primarily developed countries | |

| TABLE 6-5 ESTIMATED $BOD_5$ VALUES IN DOMESTIC WASTEWATER BY REGION | | |
|---|---|---|
| Region | $BOD_5$ Value (kg/cap/day) | $BOD_5$ Value (kg/1000 persons/yr) |
| Africa | 0.037 | 13,505 |
| Asia, Middle East, Latin America | 0.04 | 14,600 |
| N. America, Europe, Former USSR, Oceania | 0.05 | 18,250 |
| Source: IPCC (1994) | | |

<u>**Industry Output**</u>: National Data may be available.  Specific industries can also be contacted for output information.

<u>**Industry Wastewater and Sludge Production**</u>: If data are unavailable, default values are provided in Table 6-6.

<u>**Handling Systems**</u>: National data on wastewater and sludge handling system utilisation practices should be used if it is available.  Consultation with national wastewater experts is suggested.

## 6.3.3 Methodology

The methodology considers emissions from wastewater and from sludge. For each the method consists of three parts: total organic material; emission factors; and emissions estimates.  The organic material in the wastewater or sludge, measured as BOD or COD, is multiplied by an average emission factor for each wastewater or sludge source to arrive at an emissions estimate.

## DOMESTIC AND COMMERCIAL WASTEWATER

### Completing the Worksheets

Use WORKSHEET 6-2 FOR DOMESTIC AND COMMERCIAL WASTEWATER AND SLUDGE to enter data for this submodule.

### STEP 1 ESTIMATING TOTAL ORGANIC WASTEWATER AND SLUDGE

1   Enter the City or Region in column A.  If regional data do not exist, use national data.

2   Enter total Population or urban population for the inventory year in column B, in 1000 persons.  Developing countries may choose to use only the urban population if wastewater produced in rural areas receives little or no handling or treatment.  See Table 6-4 for a list of anaerobic and aerobic handling methods.

3   Enter the Degradable Organic Component in column C for each region/city in kg BOD/ 1000 persons/year.  Default values by region are shown in Table 6-5.

4   Enter the Fraction of Degradable Organic Component Removed as Sludge in column D for each region/city.  The default value is 0.

5   Multiply the values in columns B, C, and one minus the value in column D.  Enter the product in column E. This is the Total Domestic/Commercial Organic Wastewater for the city/region.

6   Multiply the values in columns B, C, and D.  Enter the product in column F.  This is the Total Domestic/Commercial Organic Sludge for the city/region.

7 Repeat 1-6 above for each region or city as necessary, using the next row.

8 Sum the values in column E. Enter the sum at the bottom cell, labelled "Total." Repeat for column F. The summed values are the total domestic and commercial organic wastewater and sludge for the country.

## STEP 2 ESTIMATE EMISSION FACTORS FOR DOMESTIC/COMMERCIAL WASTEWATER AND SLUDGE HANDLING SYSTEMS

Determine the Aggregate methane conversion factor (MCF) for domestic/commercial wastewater.

1 In column A, enter the types of Wastewater Handling Systems used for domestic wastewater.

2 In column B, enter the Fraction of Wastewater Treated by the Handling System in column A.

3 In column C, enter the Methane Conversion Factor for the Handling System in column A.

4 Multiply the values in columns B and C. Enter the Product in column D.

5 Enter the sum of the products in the bottom of column D.

6 Enter the Maximum Methane Producing Capacity for the wastewater in the bottom of column E. The default (theoretical) value for $B_o$ is 0.25 kg $CH_4$/kg BOD.

7 Calculate the average Emission Factor for the Domestic/Commercial Wastewater by multiplying the value in the bottom of column D by the value in the bottom of column E. Enter the product in the bottom of column F.

## STEP 3 ESTIMATE EMISSION FACTORS FOR DOMESTIC/COMMERCIAL SLUDGE HANDLING SYSTEMS

Determine the Aggregate MCF for domestic/commercial sludge.

1 In column A, enter the types of Sludge Handling Systems used for domestic wastewater.

2 In column B, enter the Fraction of Sludge Treated by the Handling System in column A.

3 In column C, enter the Methane Conversion Factor for the Handling System in column A.

4 Multiply the values in columns B and C. Enter the Product in column D.

5 Enter the sum of the products in the bottom of column D.

6   Enter the Maximum Methane Producing Capacity for the sludge in the bottom of column E.   The default (theoretical) value for $B_o$ is 0.25 kg $CH_4$/kg BOD.

7   Calculate the average Emission Factor for the Domestic/Commercial Sludge by multiplying the value in the bottom of column D by the value in  the bottom of column E.   Enter the product in the  bottom of column F.

## STEP 4   ESTIMATE METHANE EMISSIONS FROM DOMESTIC/COMMERCIAL WASTEWATER AND SLUDGE

1   In column A, rows 1 and 2, copy the Total Domestic/Commercial Organic Wastewater value from the bottom of column E of Worksheet 6-2, Sheet 1 and the Total Domestic/Commercial Organic Sludge value from the bottom of column F of Worksheet 6-2, Sheet 1.

2   In   column   B,   copy   the   average   Emission   Factor   for Domestic/Commercial Wastewater value from column F of Worksheet 6-2, Sheet 2 and the average Emission Factor for Domestic/Commercial Sludge value from column F of Worksheet 6-2, Sheet 3.

3   Multiply the values of columns A and B.   Enter the product in column C.

4   Enter the total amount of Methane Recovered and/or Flared from domestic/commercial wastewater or sludge in column D in kg $CH_4$.   If no data are available, the default value is zero.

5   Subtract the value in column D from the value in column C.   Multiply by $10^{-6}$ to convert emissions to gigagrams.   Enter the difference in column E.

6   Sum the values in both rows of column E at the bottom of the column. This is the Net $CH_4$ Emissions from domestic/commercial wastewater and sludge.

| TABLE 6-6 INDUSTRIAL WASTEWATER DATA BY REGION | | | |
|---|---|---|---|
| Industry Type and Region | Wastewater Produced ($m^3$/tonnes of product) | COD Value (kg COD/$m^3$ wastewater) | Country |
| **Beverage-Distilled & Industry** | | | |
| Generic - ethanol | 13 $m^3$/ $m^3$ ethanol | 40 | |
| Generic - ethanol | NAV | 5,000 kg/ $m^3$ ethanol | |
| South America | NAV | 22 | Brazil |
| Western Europe | NAV | 4.0 - 5.0 | Netherlands |
| **Beverage - Malt & Beer** | | | |
| Generic | 5 $m^3$/ $m^3$ beer | 17 | |
| Generic | 5-9 $m^3$/ $m^3$ beer | 2.0 - 7.0 | |
| Western Europe | NAV | 1.0 - 1.5 | Netherlands |
| **Food - Meat & Poultry** | | | |
| Generic | 1.4 $m^3$/animal | NAV | |
| Western Europe | NAV | 2.9 | Netherlands |
| North America | NAV | 15.0 | USA |
| **Food - Fish** | | | |
| North America | NAV | 2.5 | USA |
| **Food - Coffee** | | | |
| North America | NAV | 3.0 - 14.0 | USA |
| **Food - Dairy Products** | | | |
| Generic | 2.8 | NAV | |
| Western Europe | NAV | 1.5 | Netherlands |
| **Food - Fruits & Vegetables** | | | |
| Generic (cannery) | 26 | NAV | |
| Generic Tomato processing | 26 | NAV | |
| North America, potatoes | NAV | 3.0 | USA |
| Western Europe, bean blanching | NAV | 5.2 | Netherlands |
| Western Europe, sauerkraut | NAV | 10.0 - 20.0 | Netherlands |
| **Food - Oils** | | | |
| Generic - Vegetable oil | 1.6 | 0.3 | |
| Middle East | NAV | 42 | Turkey |
| Asia | NAV | 25 | Malaysia |
| **Food - Sugar** | | | |
| Central America (cane) | NAV | 98 | Mexico |
| **Iron And Steel** | | | |
| South America | 0.1 | NAV | Brazil |
| **Organic Chemicals** | | | |
| Western Europe | NAV | 20- 40 | Netherlands |
| **Pharmaceuticals** | | | |
| Middle East | NAV | 1.3 | Egypt |

| TABLE 6-6 (CONTINUED)<br>INDUSTRIAL WASTEWATER DATA BY REGION | | | |
|---|---|---|---|
| Industry Type and Region | Wastewater Produced($M^3$/Tonnes of Product) | COD Value (Kg COD/$M^3$ Wastewater) | Country |
| **Starch** | | | |
| Generic, potato starch | NAV | 4.0 - 16 | |
| Generic, wheat starch | NAV | 2.0 - 42 | |
| Generic, corn starch | NAV | 10 | |
| **Petroleum Production** | | | |
| North America | NAV | 0.3 -0.4 | USA |
| North America | NAV | 1.8 | Canada |
| **Pulp & Paper** | | | |
| Generic (pulp) | 58 | 2.0 - 15 | |
| North America pulp mill | 140 | NAV | USA |
| Generic (paper) | NAV | 2.0 - 8.0 | |
| North America (virgin paper) | 97 | 1.6 | USA |
| North America (recycled paper) | 44 | 3.0 | USA |
| Western Europe (paper) | NAV | 1.0 - 3.0 | Netherlands |
| **Textiles** | | | |
| Rayon | 501 | NAV | |
| Greece | NAV | 0.09 | |
| North America, textile mills | NAV | 1.0 | USA |
| **Leather Tanning** | | | |
| North America, generic | NAV | 5.8 | USA |
| Source: Doorn and Eklund (1995). For a detailed list of references for each wastewater category, see Doorn and Eklund (1995). Wastewater production of COD values are not available (NAV) for every country and region. Research is ongoing to develop wastewater production and COD values for these countries and regions. Note that these data are currently undergoing revision and updating. | | | |

| TABLE 6-7 DOMESTIC WASTEWATER TREATMENT EMISSIONS FACTOR DERIVATION DATA | | | |
|---|---|---|---|
| Region | Type of Treatment | Fraction of Wastewater Treated (%) | MCF (%) |
| **Africa** | | | |
| Kenya | Lagoons | 50 | NAV |
| Tunisia | Lagoons | 20 | NAV |
| Zimbabwe | Activated Sludge | 50 | NAV |
| Other Africa | Lagoons | 5 | 80 |
| **Asia** | | | |
| Indonesia | not specified | 1 | NAV |
| Singapore | not specified | 1 | NAV |
| South Korea | not specified | 1 | NAV |
| Taiwan | not specified | 1 | NAV |
| Other Asia | not specified | 5 | 75 |
| **Latin America And Caribbean** | not specified | 10 | 80 |
| **Australia And New Zealand** | not specified | 80 | 70 |
| Source: Doorn and Eklund (1995). For a detailed list of references for each region, see Doorn and Eklund (1995). Methane correction factor (MCF) data are not available (NAV) for some countries and regions. Research is ongoing to provide MCF estimates for these countries and regions. Note that these data are currently undergoing revision and updating. | | | |

| TABLE 6-8 INDUSTRIAL WASTEWATER TREATMENT EMISSIONS FACTOR DERIVATION | | | | |
|---|---|---|---|---|
| Region | Type of Industry | Type of Treatment | Fraction of Wastewater Treated (%) | MCF (%) |
| **Africa** | | | | |
| Kenya | textiles | Lagoons | 60 | NAV |
| Kenya | coffee production | Lagoons | 5 | NAV |
| Other Africa | All | Lagoons | 10 | 90 |
| **Asia** | | | | |
| Indonesia | All | not specified | 10 | NAV |
| Malaysia | palm oil | not specified | 90 | NAV |
| Singapore | All | not specified | 10 | NAV |
| South Korea | All | not specified | 10 | NAV |
| Taiwan | All | not specified | 10 | NAV |
| Thailand | breweries | activated sludge | 50 | NAV |
| Other Asia | All | not specified | 20 | 90 |
| **North America** | | | | |
| Canada | All | not specified | 90 | 70 |
| USA | All | not specified | 90 | 70 |
| **Latin America & Caribbean** | All | not specified | 20 | 90 |
| **Australia & New Zealand** | All | not specified | 95 | 70 |
| Source: Doorn and Eklund (1995). For a detailed list of references for each region, see Doorn and Eklund (1995). Methane correction factor (MCF) data are not available (NAV) for some countries and regions. Research is ongoing to provide MCF estimates for these countries and regions. Note that these data are currently undergoing revision and updating. | | | | |

| TABLE 6-9<br>UNSPECIFIED WASTEWATER TYPE EMISSIONS FACTOR DERIVATION DATA | | | |
|---|---|---|---|
| Region | Type of Treatment | Fraction of Wastewater Treated (%) | MCF (%) |
| **Africa** | | | |
| South Africa | not specified | 10 | NAV |
| **Asia** | | | |
| Afghanistan | not specified | 1 | NAV |
| **Latin America And Caribbean** | | | |
| Colombia | Lagoons | 3 | NAV |
| Argentina | Lagoons | 3 | NAV |
| **Europe** | | | |
| Albania | not specified | 1-92 | NAV |
| Austria | not specified | 65 | NAV |
| Belgium | not specified | 85 | NAV |
| Bulgaria | not specified | 10-100 | NAV |
| Belarus | not specified | 10-80 | NAV |
| Croatia | not specified | 57 | NAV |
| Czech Rep | not specified | 10-5 | NAV |
| Denmark | not specified | 90 | NAV |
| Estonia | not specified | 10-80 | NAV |
| Finland | not specified | 68 | NAV |
| France | not specified | 50-85 | NAV |
| Germany | not specified | 90 | NAV |
| Hungary | not specified | 44 | NAV |
| Ireland | not specified | 66 | NAV |
| Italy | not specified | 92 | NAV |
| Latvia | not specified | 10-80 | NAV |
| Lithuania | not specified | 10-80 | NAV |
| Moldavia | not specified | 10-80 | NAV |
| Netherlands | not specified | 90 | NAV |
| Norway | not specified | 94 | NAV |
| Poland | not specified | 10-50 | NAV |
| Portugal | not specified | 42 | NAV |
| Romania | not specified | 10-46 | NAV |
| Russia | not specified | 10-80 | NAV |
| Serbia | not specified | 57 | NAV |
| Slovenia | not specified | 87 | NAV |
| Spain | not specified | 67 | NAV |
| Sweden | not specified | 98 | NAV |
| Switzerland | not specified | 88 | NAV |
| Turkey | not specified | 38 | NAV |
| Ukraine | not specified | 10-80 | NAV |
| United Kingdom | not specified | 90 | NAV |
| Slovakia | not specified | 10-65 | NAV |
| Source: Doorn and Eklund (1995). Methane correction factor (MCF) data are not available (NAV). Research is ongoing to provide MCF estimates for these and other wastewater treatment systems. Note that these data are currently undergoing revision and updating. | | | |

## 6.4    Methane from Industrial Wastewater and Sludge Streams

Use WORKSHEET 6-3 METHANE EMISSIONS FROM INDUSTRIAL WASTEWATER AND SLUDGE HANDLING to enter data for this submodule.

### STEP 1    ESTIMATING TOTAL ORGANIC WASTEWATER AND SLUDGE

1   Enter Total Industrial Output for each industry in column A, in tonnes per year.

2   Enter the Degradable Organic Component in kg COD/m$^3$ wastewater in column B.  Default values are provided in Table 6-6.

3   Enter the Wastewater Produced per unit product by industry in m$^3$/tonnes of product in column C.

4   Enter the Fraction of Degradable Organic Component Removed as Sludge in column D.  The default fraction is zero.

5   Multiply the values in columns A, B, C, and one minus the value in column D.  Enter the product in column E.  This is the Total Organic Wastewater from Industrial Source.

6   Multiply the values in columns A, B, C, and D.  Enter the product in column F.  This is the Total Organic Sludge from Industrial Source.

### STEP 2    ESTIMATE EMISSION FACTORS FOR INDUSTRIAL WASTEWATER HANDLING SYSTEMS

Determine the Aggregate MCF for the industrial wastewater stream.

1   Enter the name of the industrial wastewater source on the 'Source' line.

2   In column A, enter the types of Wastewater Handling Systems used for the selected wastewater source.

3   In column B, enter the Fraction of Wastewater Treated by the Handling System in column A.

4   In column C, enter the Methane Conversion Factor for the Handling System in column A.

5   Multiply the values in columns B and C.  Enter the Product in column D.

6   Enter the sum of the products in the bottom of column D.

7   Enter the Maximum Methane Producing Capacity for the wastewater in the bottom of column E.  The default (theoretical) value for $B_o$ is 0.25 kg CH$_4$/kg BOD.

8   Calculate the average Emission Factor for the Industrial Wastewater Source by multiplying the value in the bottom of column D by the value in the bottom of column E.  Enter the product in the bottom of column F.

### STEP 3 ESTIMATE EMISSION FACTORS FOR INDUSTRIAL SLUDGE HANDLING SYSTEMS

Determine the Aggregate MCF for the industrial sludge stream.

1   Enter the name of the industrial sludge source on the 'Source' line.

2   In column A, enter the types of Sludge Handling System used for the selected sludge source.

3   In column B, enter the Fraction of Sludge Treated by the handling system in column A.

4   In column C, enter the Methane Conversion Factor for the handling system in column A.

5   Multiply the values in columns B and C. Enter the Product in column D.

6   Enter the sum of the products in the bottom of column D.

7   Enter the Maximum Methane Producing Capacity for the sludge in the bottom of column E. The default (theoretical) value for $B_o$ is 0.25 kg $CH_4$/kg BOD.

8   Calculate the average Emission Factor for the Industrial Sludge Source by multiplying the value in the bottom of column D by the value in the bottom of column E. Enter the product in the bottom of column F.

### STEP 4 ESTIMATE METHANE EMISSIONS FROM INDUSTRIAL WASTEWATER AND SLUDGE

1   In column A, rows 1 and 2, copy the Total Organic Wastewater from Industrial Source value from column E of Worksheet 6-3, Sheet 1, and the Total Organic Sludge from Industrial Source value from column F of Worksheet 6-3, Sheet 1.

2   In column B, copy the average Emission Factor for Industrial Wastewater value from column F of Worksheet 6-3, Sheet 2 and the average Emission Factor for Industrial Sludge Source from column F of Worksheet 6-3, Sheet 3.

3   Multiply the values of columns A and B. Enter the product in column C.

4   Enter the total amount of Methane Recovered and/or Flared from the industrial wastewater and sludge source in column D in kg $CH_4$. If no data are available, the default is zero.

5   Subtract the value in column D from the product in column C. Multiply by $10^{-6}$ to convert emissions to gigagrams. Enter the difference in column E. Sum the values in both rows of column E at the bottom of the column. This is the Net $CH_4$ Emissions from the selected industrial wastewater and sludge source.

## 6.5 Nitrous Oxide from Human Sewage

**ESTIMATE INDIRECT NITROUS OXIDE EMISSIONS FROM HUMAN SEWAGE**

Use WORKSHEET 6-4 INDIRECT NITROUS OXIDE EMISSIONS FROM HUMAN SEWAGE to enter date for this submodule.

1  In column A, enter, average annual Per Capita Protein Consumption in the country (Protein in kg/person/yr).

2  In column B, enter the Population in country (number)(where number equals $NR_{PEOPLE}$).

3  In column C, enter the Fraction of Nitrogen in Protein ($Frac_{NPR}$). The default value is 0.16 kg N/kg protein.  (Table 4-19 in Agriculture Chapter.)

4  In column D, enter the Emission Factor, $EF_6$.  The default factor is 0.01 kg $N_2$O-N/kg sewage-N produced.  (Table 4-18 in Agriculture Chapter.)

5  Multiply the values in columns A, B, C and D, and then multiply by the conversion ratio 44/28 and by $10^{-6}$ to convert to gigagrams.  Enter the product in column E. This value is the Total Annual $N_2$O Emissions from human sewage.

For a detailed description of this methodology see Section 4.5.4 of the *Reference Manual.*

| MODULE | WASTE |
|---|---|
| SUBMODULE | METHANE EMISSIONS FROM SOLID WASTE DISPOSAL SITES |
| WORKSHEET | 6-1 |
| SHEET | 1 OF 1 |

| | STEP 1 | STEP 2 | | | | | STEP 3 | | | STEP 4 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | G | H | J | K | L | M | N |
| | Total Annual MSW Disposed to SWDSs (Gg MSW) | Methane Correction Factor (MCF) | Fraction of DOC in MSW | Fraction of DOC which Actually Degrades | Fraction of Carbon Released as Methane | Conversion Ratio | Potential Methane Generation Rate per Unit of Waste (Gg CH$_4$/Gg MSW) | Realised (Country-specific) Methane Generation Rate per Unit of Waste (Gg CH$_4$/ Gg MSW) | Gross Annual Methane Generation (Gg CH$_4$) | Recovered Methane per Year (Gg CH$_4$) | Net Annual Methane Generation (Gg CH$_4$) | One Minus Methane Oxidation Correction Factor | Net Annual Methane Emissions (Gg CH$_4$) |
| | | | | | | 16/12 | $G=(C \times D \times E \times F)$ | $H=(B \times G)$ | $J=(H \times A)$ | | $L=(J-K)$ | | $N=(L \times M)$ |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

| MODULE | WASTE |
|---|---|
| SUBMODULE | QUANTITY OF **MSW** DISPOSED OF IN SOLID WASTE DISPOSAL SITES USING COUNTRY DATA |
| WORKSHEET | 6-1A (SUPPLEMENTAL) |
| SHEET | 1 OF 1 |

| A | B | C | D | E |
|---|---|---|---|---|
| Population whose Waste goes to SWDSs (Urban or Total) (persons) | MSW Generation Rate (kg/capita/day) | Annual Amount of MSW Generated (Gg MSW) | Fraction of MSW Disposed to SWDSs (Urban or Total) | Total Annual MSW Disposed to SWDSs (Gg MSW) |
| | | $C = (A \times B \times 365)/10^6$ | | $E = (C \times D)$ |
| | | | | |

| | |
|---|---|
| **MODULE** | **W**ASTE |
| **SUBMODULE** | **QUANTITY OF MSW DISPOSED OF IN SOLID WASTE DISPOSAL SITES USING DISPOSAL RATE DEFAULT DATA** |
| **WORKSHEET** | **6-1B (SUPPLEMENTAL)** |
| **SHEET** | **1 OF 1** |

| A | B | C |
|---|---|---|
| Population whose Waste goes to SWDSs (Urban or Total) (persons) | MSW Disposal Rate to SWDSs (kg/capita/day) | Total Annual MSW Disposed to SWDSs (Gg MSW) |
| | | $C = (A \times B \times 365)/10^6$ |
| | | |

| | | | |
|---|---|---|---|
| **MODULE** | **WASTE** | | |
| **SUBMODULE** | **METHANE CORRECTION FACTOR** | | |
| **WORKSHEET** | **6-1C (SUPPLEMENTAL)** | | |
| **SHEET** | **1 OF 1** | | |
| | W | X | Y |
| Type of Site | Proportion of Waste (by weight) for Each Type of SWDSs | Methane Correction Factor (MCF) | Weighted Average MCF for Each Type of SWDS |
| | | | Y = W x X |
| Managed | | 1.0 | |
| Unmanaged - deep (≥ 5m waste) | | 0.8 | |
| Unmanaged-shallow (< 5m waste) | | 0.4 | |
| Total | | 0.6 | |

| MODULE | WASTE | | | | |
|---|---|---|---|---|---|
| SUBMODULE | METHANE EMISSIONS FROM DOMESTIC AND COMMERCIAL WASTEWATER AND SLUDGE TREATMENT | | | | |
| WORKSHEET | 6- 2 | | | | |
| SHEET | 1 OF 4    ESTIMATION OF ORGANIC WASTEWATER AND SLUDGE | | | | |
| STEP 1 | | | | | |
| A | B | C | D | E | F |
| Region or City | Population (1,000 persons) | Degradable Organic Component (kg BOD/1000 persons/yr) | Fraction of Degradable Organic Component Removed as Sludge | Total Domestic/Commercial Organic Wastewater (kg BOD/yr) | Total Domestic/Commercial Organic Sludge (kg BOD/yr) |
| | | | | E = [B x C x (1-D)] | F = (B x C x D) |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | Total: | | |

# WASTE

| MODULE | WASTE |
|---|---|
| SUBMODULE | METHANE EMISSIONS FROM DOMESTIC AND COMMERCIAL WASTEWATER TREATMENT |
| WORKSHEET | 6- 2 |
| SHEET | 2 OF 4   ESTIMATION OF EMISSION FACTOR FOR WASTEWATER HANDLING SYSTEMS |

| | | | STEP 2 | | |
|---|---|---|---|---|---|
| A | B | C | D | E | F |
| Wastewater Handling System | Fraction of Wastewater Treated by the Handling System | Methane Conversion Factor for the Handling System | Product | Maximum Methane Producing Capacity (kg CH$_4$/kg BOD | Emission Factor for Domestic/Commercial Wastewater (kg CH$_4$/kg BOD) |
| | | | D = (B x C) | | F = (D x E) |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | **Aggregate MCF:** | | | |

| MODULE | WASTE |
|---|---|
| SUBMODULE | METHANE EMISSIONS FROM DOMESTIC AND COMMERCIAL WASTEWATER TREATMENT |
| WORKSHEET | 6- 2 |
| SHEET | 3 OF 4 ESTIMATION OF EMISSION FACTOR FOR SLUDGE HANDLING SYSTEMS |

| | | | STEP 3 | | |
|---|---|---|---|---|---|
| A | B | C | D | E | F |
| Sludge Handling System | Fraction of Sludge Treated by the Handling System | Methane Conversion Factor for the Handling System | Product | Maximum Methane Producing Capacity (kg CH$_4$/kg BOD) | Emission Factor for Domestic/ Commercial Sludge (kg CH$_4$/kg BOD) |
| | | | D = (B x C) | | F = (D x E) |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | **Aggregate MCF:** | | | |

| MODULE | WASTE |
|---|---|
| SUBMODULE | METHANE EMISSIONS FROM DOMESTIC AND COMMERCIAL WASTEWATER AND SLUDGE TREATMENT |
| WORKSHEET | 6- 2 |
| SHEET | 4 OF 4   ESTIMATION OF METHANE EMISSIONS FROM DOMESTIC/COMMERCIAL WASTEWATER AND SLUDGE |

| | STEP 4 | | | | |
|---|---|---|---|---|---|
| | A | B | C | D | E |
| | Total Organic Product (kg BOD/yr) | Emission Factor (kg $CH_4$/kg BOD) | Methane Emissions Without Recovery/Flaring | Methane Recovered and/or Flared (kg $CH_4$) | Net Methane Emissions (Gg $CH_4$) |
| | from Worksheet 6-2, Sheet 1 | from Worksheet 6-2, Sheets 2 and 3 | C = (A x B) | | E = (C - D) x $10^{-6}$ |
| Wastewater | | | | | |
| Sludge | | | | | |
| | | | | Total: | |

| MODULE | WASTE | | | | |
|---|---|---|---|---|---|
| SUBMODULE | METHANE EMISSIONS FROM INDUSTRIAL WASTEWATER AND SLUDGE HANDLING | | | | |
| WORKSHEET | 6-3 | | | | |
| SHEET | 1 OF 4  TOTAL ORGANIC WASTEWATER AND SLUDGE | | | | |

| | | STEP 1 | | | | |
|---|---|---|---|---|---|---|
| | | A | B | C | D | E | F |
| | | Total Industrial Output (t/yr) | Degradable Organic Component (kg COD/m$^3$ wastewater) | Wastewater Produced (m$^3$/tonne product) | Fraction of Degradable Organic Component Removed as Sludge | Total Organic Wastewater from Industrial Source (kg COD/yr) | Total Organic Sludge from Industrial Source (kg COD/yr) |
| | | | | | | E = [A x B x C x(1-D)] | F = (A x B x C x D) |
| **Iron and Steel** | | | | | | | |
| **Non-ferrous metals** | | | | | | | |
| **Fertiliser** | | | | | | | |
| **Food & Beverage** | Canneries | | | | | | |
| | Beer | | | | | | |
| | Wine | | | | | | |
| | Meatpacking | | | | | | |
| | Dairy products | | | | | | |
| | Sugar | | | | | | |
| | Fish processing | | | | | | |
| | Oil & grease | | | | | | |
| | Coffee | | | | | | |
| | Soft drinks | | | | | | |
| | Other | | | | | | |
| **Paper & Pulp** | Paper | | | | | | |
| | Pulp | | | | | | |
| | Other | | | | | | |
| **Petroleum refining/Petrochemicals** | | | | | | | |
| | Bleaching | | | | | | |
| | Dying | | | | | | |
| | Other | | | | | | |
| **Rubber** | | | | | | | |
| **Other** | | | | | | | |
| **Total** | | | | | | | |

| MODULE | WASTE |
|---|---|
| SUBMODULE | METHANE EMISSIONS FROM INDUSTRIAL WASTEWATER TREATMENT |
| SOURCE | |
| WORKSHEET | 6- 3 |
| SHEET | 2 OF 4   ESTIMATION OF EMISSION FACTOR FOR WASTEWATER HANDLING SYSTEMS |

| STEP 2 | | | | | |
|---|---|---|---|---|---|
| A | B | C | D | E | F |
| Wastewater Handling System | Fraction of Wastewater Treated by the Handling System | Methane Conversion Factor (MCF) | Product | Maximum Methane Producing Capacity (kg CH$_4$/kg BOD) | Emission Factor for Industrial Wastewater Source (kg CH$_4$/kg BOD) |
| | | | D = (B x C) | | F = (D x E) |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | **Aggregate MCF:** | | | |

| MODULE | WASTE |
|---|---|
| SUBMODULE | METHANE EMISSIONS FROM INDUSTRIAL WASTEWATER TREATMENT |
| SOURCE | |
| WORKSHEET | 6- 3 |
| SHEET | 3 OF 4   ESTIMATION OF EMISSION FACTOR FOR SLUDGE HANDLING SYSTEMS |

| STEP 3 | | | | | |
|---|---|---|---|---|---|
| A | B | C | D | E | F |
| Sludge Handling System | Fraction of Sludge Treated by the Handling System | Methane Conversion Factor (MCF) | Product | Maximum Methane Producing Capacity (kg CH$_4$/kg COD) | Emission Factor for Industrial Sludge Source (kg CH$_4$/kg COD) |
| | | | D = (B x C) | | F = (D x E) |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | **Aggregate MCF:** | | | |

# WASTE

| MODULE | WASTE |
|---|---|
| SUBMODULE | METHANE EMISSIONS FROM INDUSTRIAL WASTEWATER AND SLUDGE TREATMENT |
| WORKSHEET | 6- 3 |
| SHEET | 4 OF 4   ESTIMATION OF METHANE EMISSIONS FROM INDUSTRIAL WASTEWATER AND SLUDGE |

| | STEP 4 | | | | |
|---|---|---|---|---|---|
| | A | B | C | D | E |
| | Total Organic Product (kg BOD/yr) | Emission Factor (kg $CH_4$/kg BOD) | Methane Emissions without Recovery/Flaring | Methane Recovered and/or Flared (kg $CH_4$) | Net Methane Emissions (Gg $CH_4$) |
| | Worksheet 6-3, Sheet 1 | Worksheets 6-3, Sheets 2 and 3 | C = ( A x B) | | E = (C - D) x $10^{-6}$ |
| Wastewater | | | | | |
| Sludge | | | | | |
| | | | | Total: | |

| MODULE | WASTE |
|---|---|
| SUBMODULE | INDIRECT NITROUS OXIDE EMISSIONS FROM HUMAN SEWAGE |
| WORKSHEET | 6-4 |
| SHEET | 1 OF 1 |

| | A | B | C | D | E |
|---|---|---|---|---|---|
| | Per Capita Protein Consumption (Protein in kg/person/yr) | Population (number) | Fraction of Nitrogen in Protein $Frac_{NPR}$ (kg N/kg protein) | Emission factor $EF_6$ (kg $N_2O$-N/kg sewage-N produced) | Total Annual $N_2O$ Emissions (Gg $N_2O$/yr) |
| | | | | | $E = (A \times B \times C \times D) \times 44/28 \times 10^{-6}$ |
| **Total** | | | | | |