The 5th GREENHOUSE GAS INVENTORY SYSTEM TRAINING WORKSHOP

Main Contents of 2006 IPCC Guideline Vol.5 (Waste)

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PRESENTATION OBJECTIVE

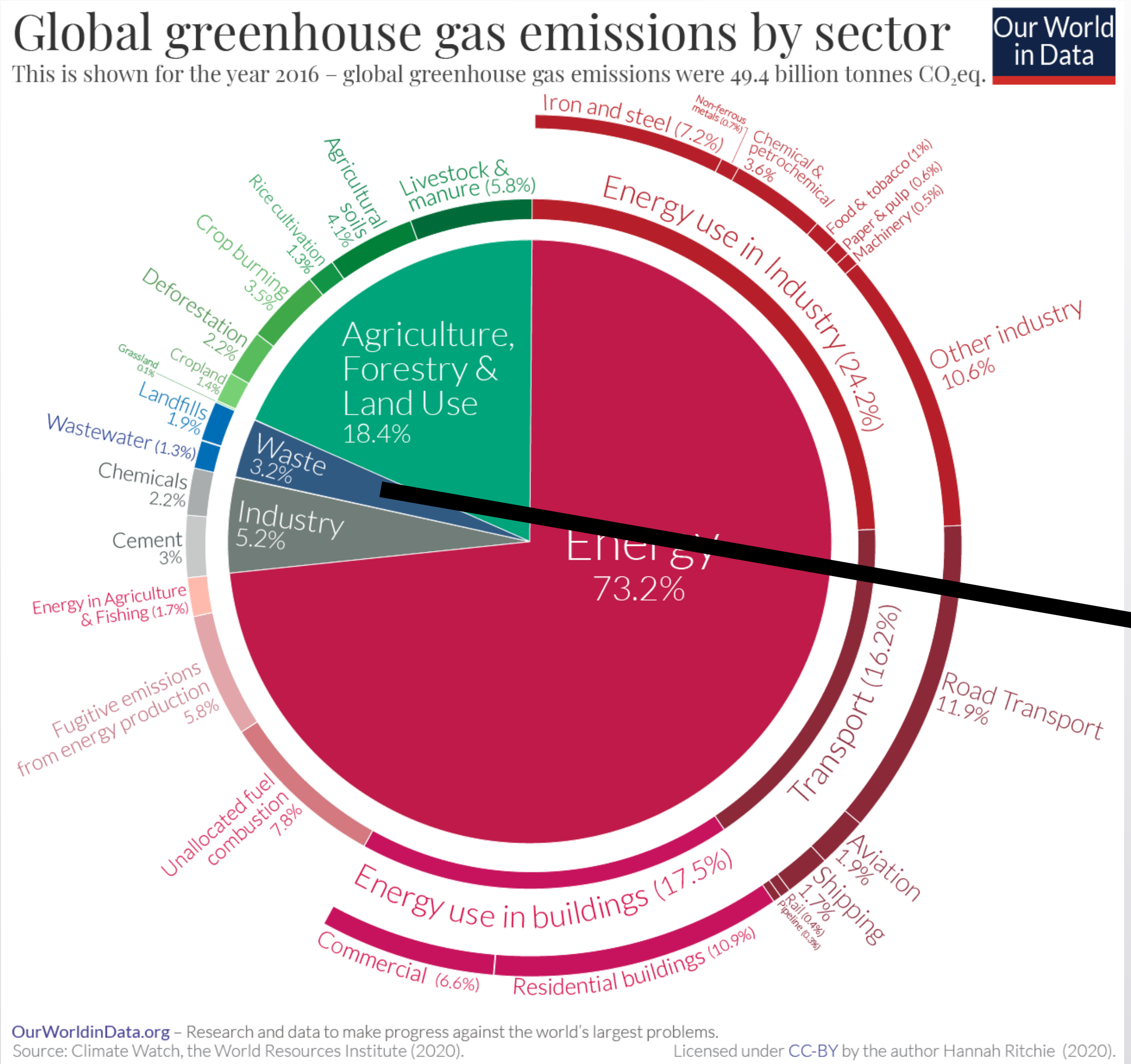
"To reduce GHG emissions by establishing a transparent and reliable GHG inventory system to monitor and verify the current state of emissions. The GHG inventory system provides a basic approach in organizing monitoring, reporting, and verifying (MRV) procedures in each country."

1) Provide overview of the rationale behind Vol 5

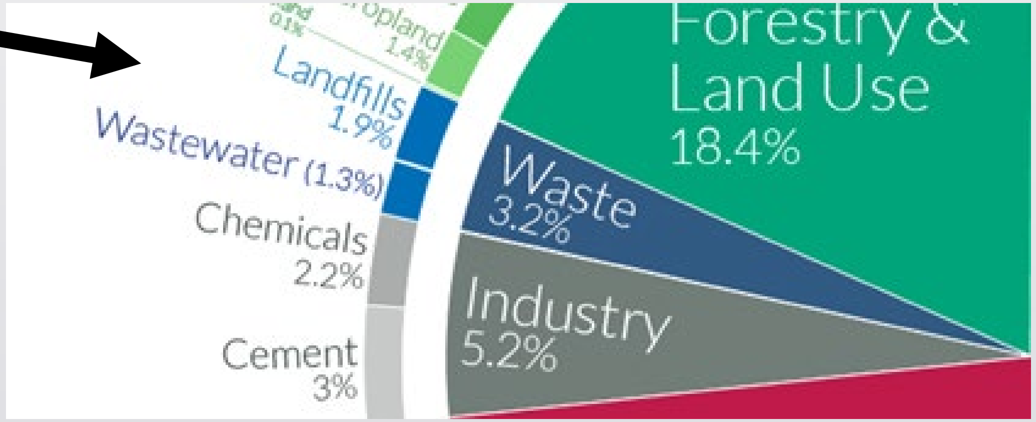
2) offer insights into how methodology translates into practical waste management on the ground

3) support understanding of concept through case study work

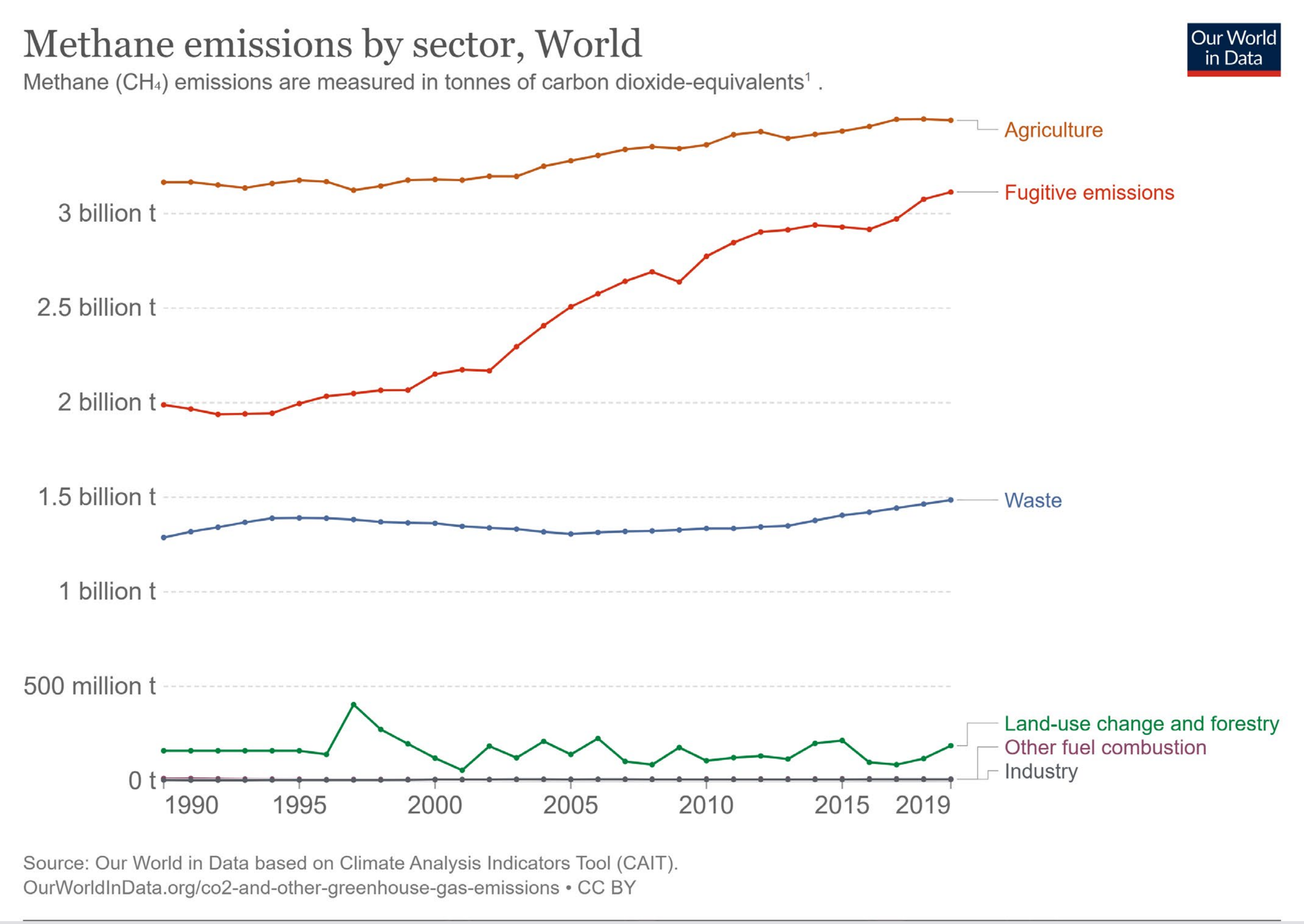
INTRODUCTION - Waste sector emissions



CO_2 = 84%
N_2O = 5%
Fluorinated Gases= 2%
Methane = 9%



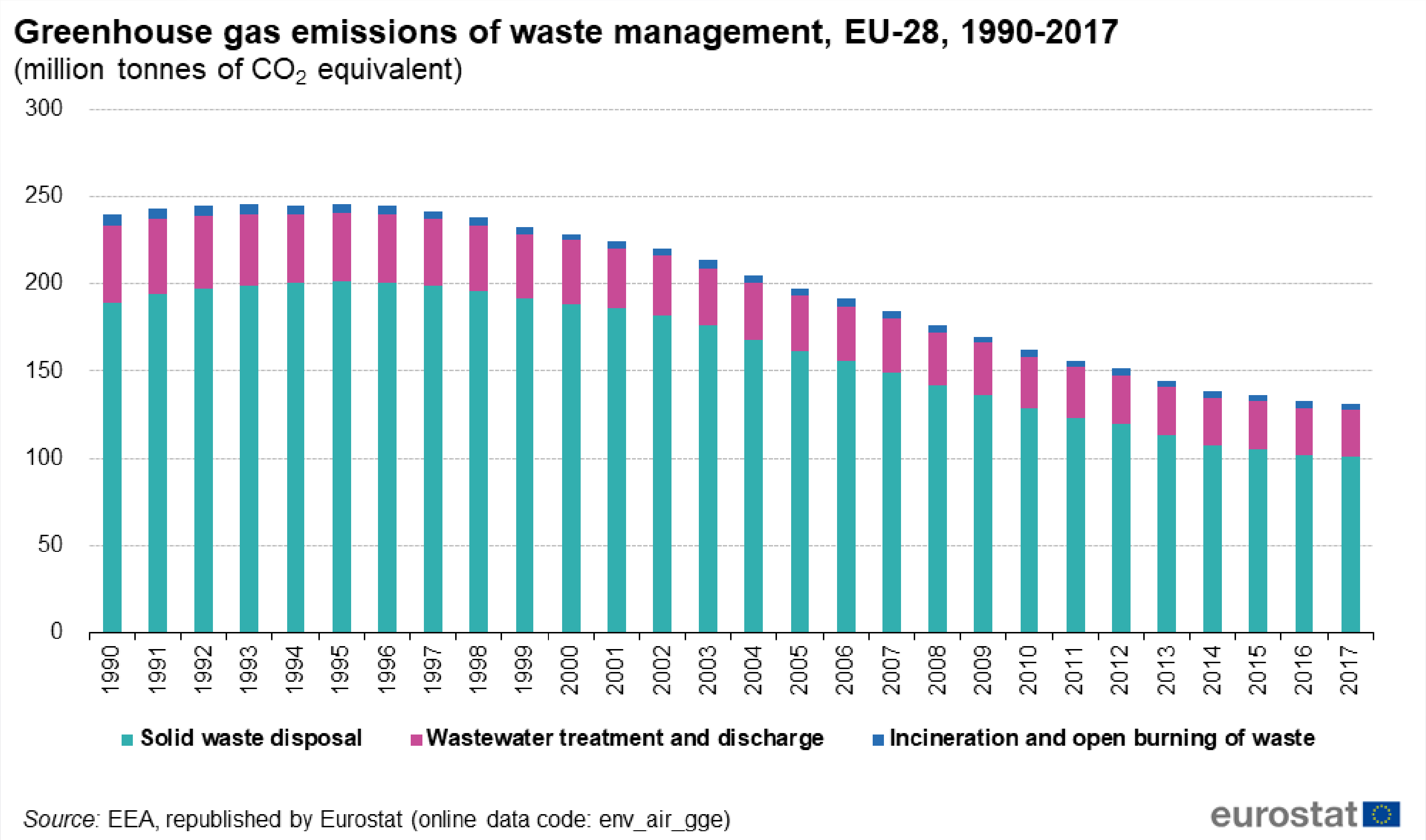
INTRODUCTION - Waste sector emissions



Waste is **third largest** contributor to **methane (CH_4) emissions**, after agriculture and 'Fugitive emissions'.

Methane is **produced in landfills** when organic materials decompose.

INTRODUCTION - Waste sector emissions



Landfills around the world contribute to an estimated eleven percent **(11%) of all global methane emissions**, with methane being a climate amplifier and up to 25 times stronger than CO_2 (carbon dioxide) as a greenhouse gas on a longer term.

2006 IPCC Guidelines for National Greenhouse Gas Inventories (Waste)

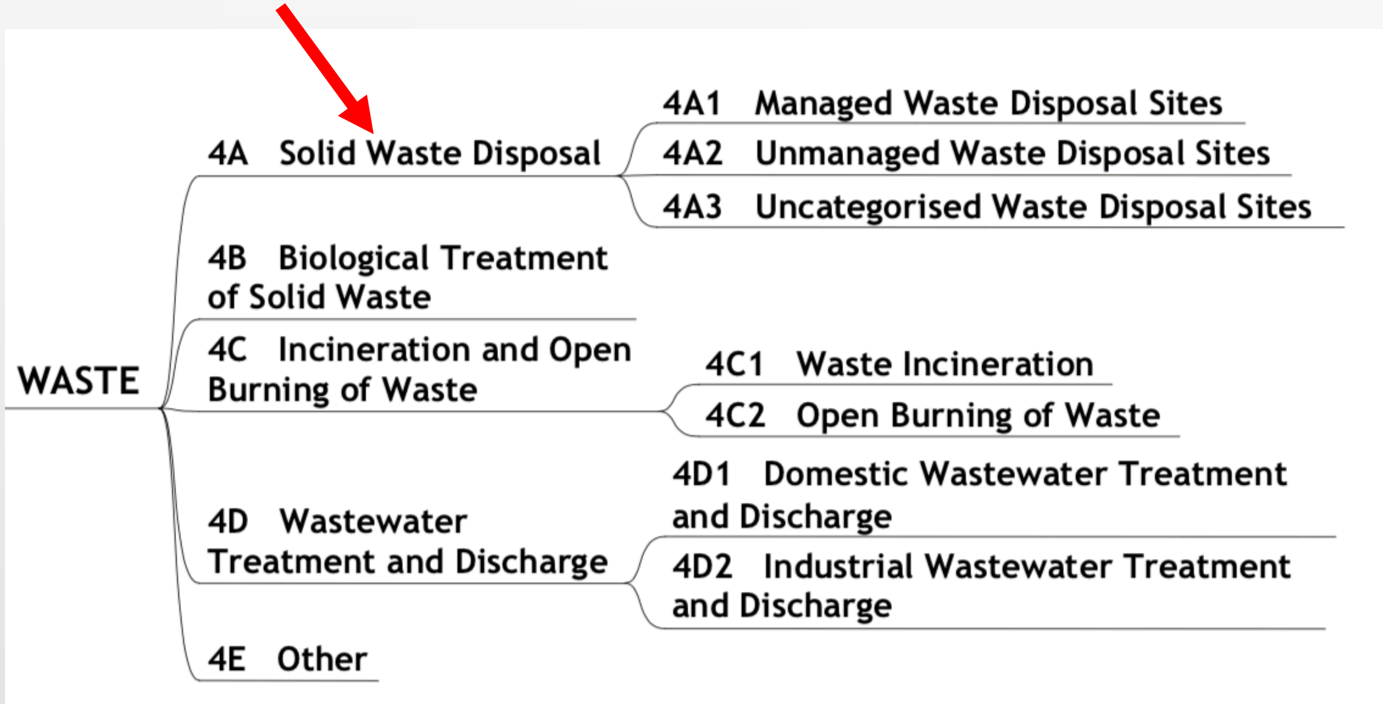
Contents

- Waste Generation, Composition and Management Data
- Solid Waste Disposal
- Biological Treatment of Solid Waste
- Incineration and Open Burning of Waste
- Wastewater Treatment and Discharge

** IPPC Waste Model*

Waste Sector Overview

Volume 5 (Waste) provides methodological guidance for estimation of CO_2, CH_4 and N_2O emissions from following categories:



Estimates emissions of:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous Oxide (N_2O)

Global warming potential:

- CO_2 = 1 (reference)
- CH_4 = 25
- N_2O = 298

CH_4 emissions from solid waste disposal sites (SWDS) are typically the largest source in the Waste sector.

Incineration and open burning of waste containing fossil carbon, e.g., plastics, are the most important sources of CO_4 emissions in the Waste Sector.

Waste generation, composition and management data

The **starting point** for the estimation of GHG emissions from solid waste management is relevant **data on waste generation & composition**.

Solid waste generation rates and composition **vary from country to country** (due to different influencing factors)

Also, **availability and quality** of data can **vary significantly**

Data are separately required for:

- Municipal solid waste (MSW)
- Sludge
- Industrial waste
- Other waste

Municipal Solid Waste - Analysis

It is good practice that countries use data on country-specific MSW generation & composition:

- Statistics, surveys, research projects…
- **Direct measurements/analysis**

*Determining **the total amount** of municipal waste in the municipality*

by measuring the amount of collected/generated MSW on weighbridges

*Defining **morphological composition** of municipal waste*

by sorting and measuring 23 fractions of waste according to the waste sorting catalog

Municipal Solid Waste - Generation

- Household waste
- Garden (yard) and park waste
- Commercial/ institutional waste

Estimated based on country-specific data from a limited number of countries (**Annex 2A.1**).

Assumed to be applicable **for the year 2000**.

TABLE 2.1
MSW GENERATION AND TREATMENT DATA - REGIONAL DEFAULTS

Region	MSW Generation Rate[1, 2, 3] (tonnes/cap/yr)	Fraction of MSW disposed to SWDS	Fraction of MSW incinerated	Fraction of MSW composted	Fraction of other MSW management, unspecified[4]
Asia					
Eastern Asia	0.37	0.55	0.26	0.01	0.18
South-Central Asia	0.21	0.74	-	0.05	0.21
South-East Asia	0.27	0.59	0.09	0.05	0.27

Municipal Solid Waste - Composition

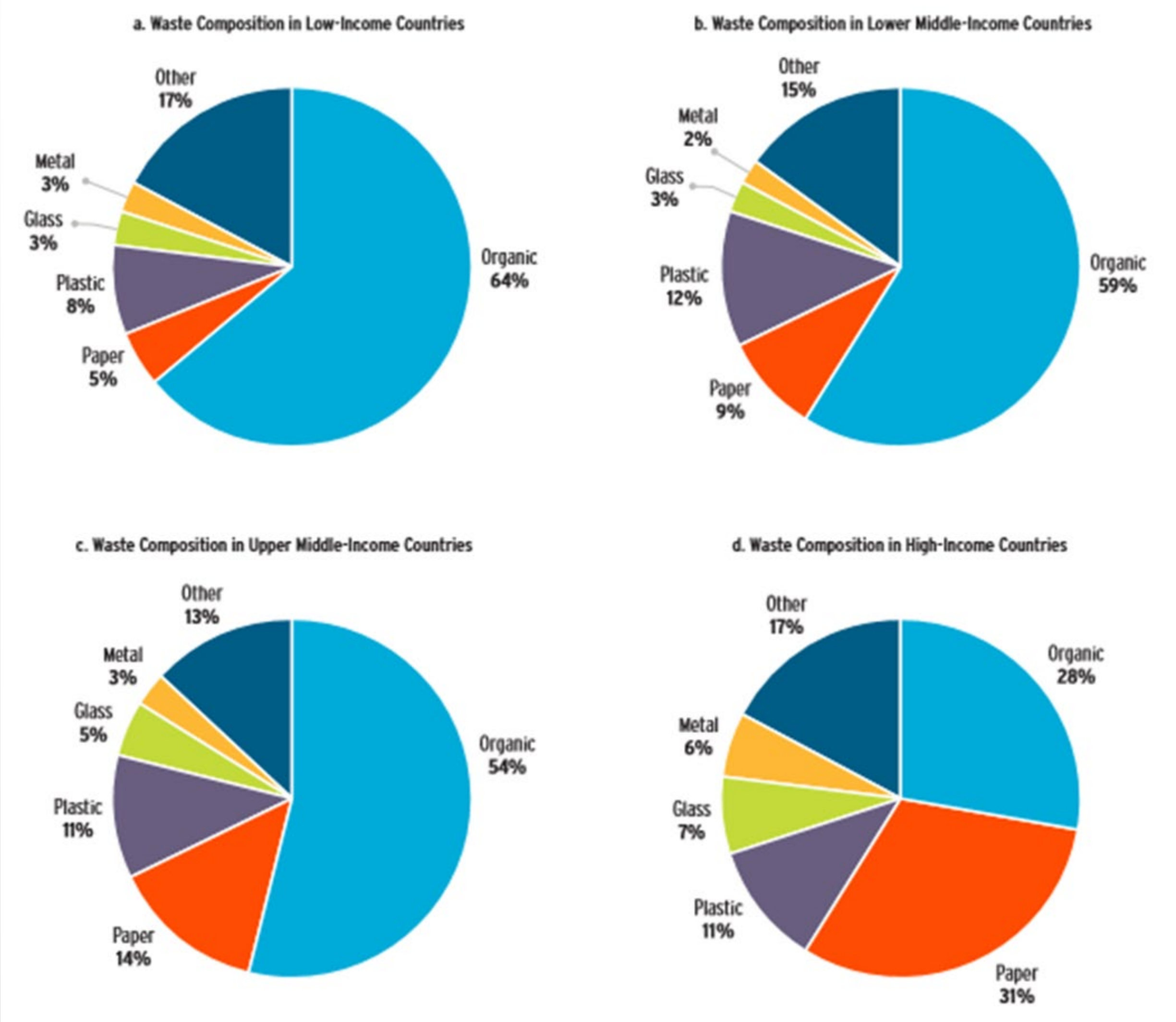
Waste composition **is one of the main factors influencing emissions from solid waste treatment**, as different waste types contain **different amount of degradable organic carbon (DOC)** and **fossil carbon.**

Default data provided for :

1. food waste
2. garden (yard) and park waste
3. paper and cardboard
4. wood
5. textiles
6. nappies (disposable diapers)
7. rubber and leather
8. plastics
9. metal
10. glass (and pottery and china)
11. other (e.g., ash, dirt, dust, soil, electronic waste)

contain most of the DOC in MSW

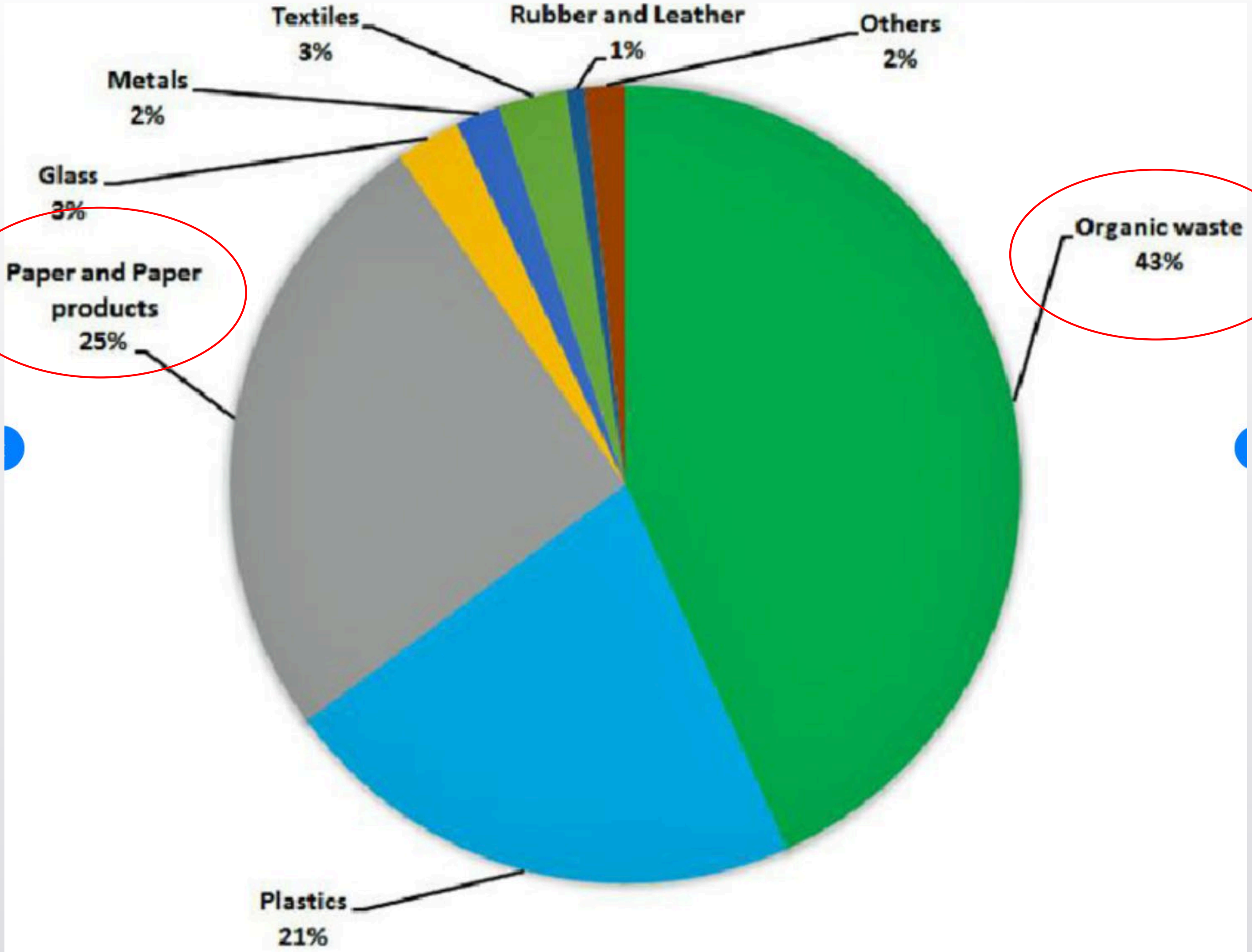
Municipal Solid Waste - Composition



Municipal Solid Waste - Composition

MSW characteristics of waste generated in 2012

Kathmandu, Nepal



Municipal Solid Waste - Composition

TABLE 2.3
MSW COMPOSITION DATA BY PERCENT - REGIONAL DEFAULTS

Region	Food waste	Paper/cardboard	Wood	Textiles	Rubber/leather	Plastic	Metal	Glass	Other
Asia									
Eastern Asia	26.2	18.8	3.5	3.5	1.0	14.3	2.7	3.1	7.4
South-Central Asia	40.3	11.3	7.9	2.5	0.8	6.4	3.8	3.5	21.9
South-Eastern Asia	43.5	12.9	9.9	2.7	0.9	7.2	3.3	4.0	16.3
Western Asia & Middle East	41.1	18.0	9.8	2.9	0.6	6.3	1.3	2.2	5.4
Africa									
Eastern Africa	53.9	7.7	7.0	1.7	1.1	5.5	1.8	2.3	11.6
Middle Africa	43.4	16.8	6.5	2.5		4.5	3.5	2.0	1.5
Northern Africa	51.1	16.5	2	2.5		4.5	3.5	2	1.5
Southern Africa	23	25	15						
Western Africa	40.4	9.8	4.4	1.0		3.0	1.0		
Europe									
Eastern Europe	30.1	21.8	7.5	4.7	1.4	6.2	3.6	10.0	14.6
Northern Europe	23.8	30.6	10.0	2.0		13.0	7.0	8.0	
Southern Europe	36.9	17.0	10.6						
Western Europe	24.2	27.5	11.0						
Oceania									
Australia and New Zealand	36.0	30.0	24.0						
Rest of Oceania	67.5	6.0	2.5						
America									
North America	33.9	23.2	6.2	3.9	1.4	8.5	4.6	6.5	9.8
Central America	43.8	13.7	13.5	2.6	1.8	6.7	2.6	3.7	12.3
South America	44.9	17.1	4.7	2.6	0.7	10.8	2.9	3.3	13.0
Caribbean	46.9	17.0	2.4	5.1	1.9	9.9	5.0	5.7	3.5

Sludge

Sludge from domestic and industrial **wastewater treatment plants** is addressed as a **separate waste category** in this Volume.

In some countries, sludge from domestic wastewater treatment is included in MSW and sludge from industrial wastewater treatment in industrial waste. Countries may also include all sludge in industrial waste.

Industrial waste

Industrial waste generation and composition **vary depending on the type of industry and processes/technologies** in the concerned country. In many countries industrial solid waste is managed as a specific stream and the waste amounts are not covered by general waste statistics. However, in some developing countries industrial wastes are included in the municipal solid waste stream, therefore, it is difficult to obtain data of the industrial waste separately.

Industrial solid waste disposal data may be obtained by **surveys or from national statistics**. Only those industrial wastes which are **expected to contain DOC and fossil carbon should** be considered for the purpose of **emission estimation** from waste.

Other waste

Clinical/medical waste: These wastes include materials like plastic syringes, animal tissues, bandages, cloths, etc. In most countries, the amount of greenhouse gas emissions due to clinical waste appears to be insignificant.

Hazardous waste: Waste oil, waste solvents, ash, cinder and other wastes with hazardous nature, such as flammability, explosiveness, causticity, and toxicity, are included in hazardous waste. Hazardous wastes are generally collected, treated and disposed separately from non-hazardous MSW and industrial waste streams. Some hazardous wastes are incinerated and can contribute to the emissions from incineration

Agricultural waste: Manure management and burning of agricultural residues are considered in the AFOLU Volume. Agricultural waste which will be treated and/or disposed with other solid waste may however be included in MSW or industrial waste.

Degradable organic carbon (DOC) - MSW

TABLE 2.4
DEFAULT DRY MATTER CONTENT, DOC CONTENT, TOTAL CARBON CONTENT AND FOSSIL CARBON FRACTION OF DIFFERENT MSW COMPONENTS

MSW component	Dry matter content in % of wet weight [1]	DOC content in % of wet waste		DOC content in % of dry waste		Total carbon content in % of dry weight		Fossil carbon fraction in % of total carbon	
	Default	Default	Range	Default	Range [2]	Default	Range	Default	Range
Paper/cardboard	90	40	36 - 45	44	40 - 50	46	42 - 50	1	0 - 5
Textiles [3]	80	24	20 - 40	30	25 - 50	50	25 - 50	20	0 - 50
Food waste	40	15	8 - 20	38	20 - 50	38	20 - 50	-	-
Wood	85 [4]	43	39 - 46	50	46 - 54	50	46 - 54	-	-
Garden and Park waste	40	20	18 - 22	49	45 - 55	49	45 - 55	0	0
Nappies	40	24	18 - 32	60	44 - 80	70	54 - 90	10	10
Rubber and Leather	84	(39) [5]	(39) [5]	(47) [5]	(47) [5]	67	67	20	20
Plastics	100	-	-	-	-	75	67 - 85	100	95 - 100
Metal [6]	100	-	-	-	-	NA	NA	NA	NA
Glass [6]	100	-	-	-	-	NA	NA	NA	NA
Other, inert waste	90	-	-	-	-	3	0 - 5	100	50 - 100

DOC - Sludge

The DOC content in sludge vary depending on the **wastewater treatment method** producing the sludge, and also be **different for domestic and industrial sludge**.

If country and/or industry-specific DOC values are not available:

- For **domestic sludge** – used default DOC value is **5 %** (of wet waste) or **40-50 %** of dry matter

- **Industrial sludge** – **9 %** (wet waste) or **35 %** of dry matter

DOC – Industrial waste

DOC and fossil carbon in industrial waste is mainly found in the same waste types as in MSW. DOC is found in paper and cardboard, textiles, food and wood. Synthetic leather, rubber, and plastics are major sources of fossil carbon.

Table 2.5 provides default values of DOC and fossil carbon contents in industrial waste by industry type per amount waste produced. The default values are only for process waste generated at the facilities.

TABLE 2.5
DEFAULT DOC AND FOSSIL CARBON CONTENT IN INDUSTRIAL WASTE (PERCENTAGE IN WET WASTE PRODUCED)[1]

Industry type	DOC	Fossil carbon	Total carbon	Water content [2]
Food, beverages and tobacco (other than sludge)	15	-	15	60
Textile	24	16	40	20
Wood and wood products	43	-	43	15
Pulp and paper (other than sludge)	40	1	41	10
Petroleum products, Solvents, Plastics	-	80	80	0
Rubber	(39) [3]	17	56	16
Construction and demolition	4	20	24	0
Other [4]	1	3	4	10

DOC – Other waste

Default values for DOC and fossil carbon for hazardous waste and clinical waste are given in Table 2.6. The values should be applied only for total amounts of hazardous and clinical waste generated in the country.

TABLE 2.6
DEFAULT DOC AND FOSSIL CARBON CONTENTS IN OTHER WASTE (PERCENTAGE IN WET WASTE PRODUCED)

Waste type	DOC	Fossil carbon	Total carbon	Water Content
Hazardous waste	NA	5 - 50 [1]	NA	10 - 90 [1]
Clinical waste	15	25	40	35

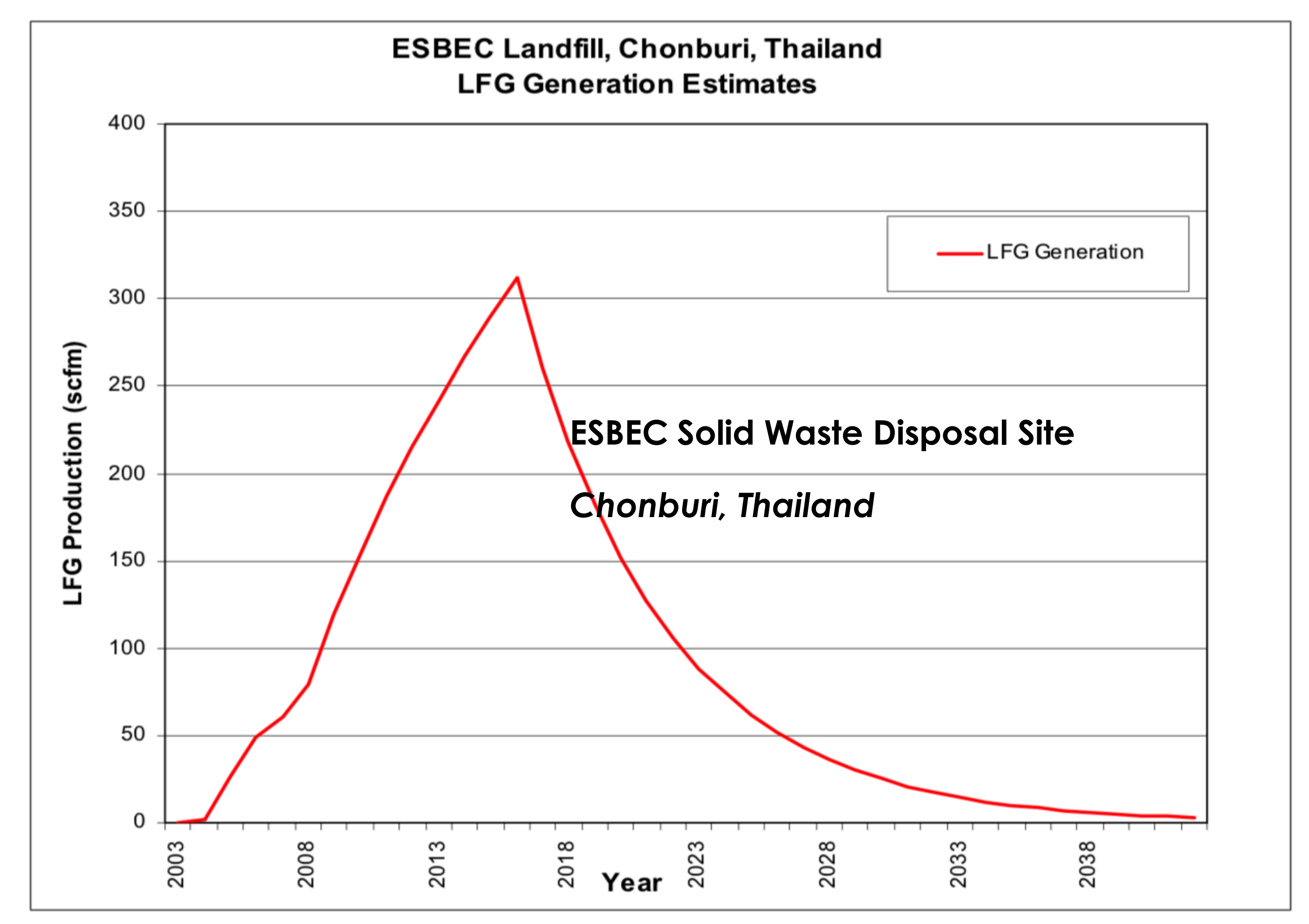
Solid waste disposal site

Disposal of municipal, industrial and other solid waste produces significant amounts of methane (CH_4). In addition, SWDS also produce biogenic carbon dioxide (CO_2), non-methane volatile organic compounds (NMVOCs), smaller amounts of nitrous oxide (N_2O), nitrogen oxides (NO) and carbon monoxide (CO).

- Time in place
- Treatment
- Temperature / precipitation
- Oxidation
- Recovery / utilization

Solid waste disposal site – CH_4 emissions estimating

The IPCC methodology for estimating CH_4 emissions from SWDS is based on the First Order Decay (FOD) method. This method assumes that the degradable organic component (degradable organic carbon, DOC) in waste decays slowly throughout a few decades, during which CH_4 and CO_2 are formed. If conditions are constant.



Solid waste disposal site – CH_4 emissions estimating

Three tiers to estimate the CH_4 emissions from SWDS:

Tier 1: The estimations are based on the IPCC FOD method using mainly **default activity data and default parameters**.

Tier 2: use the IPCC FOD method and some **default parameters**, but require good quality country-specific activity **data on current and historical waste disposal at SWDS**.

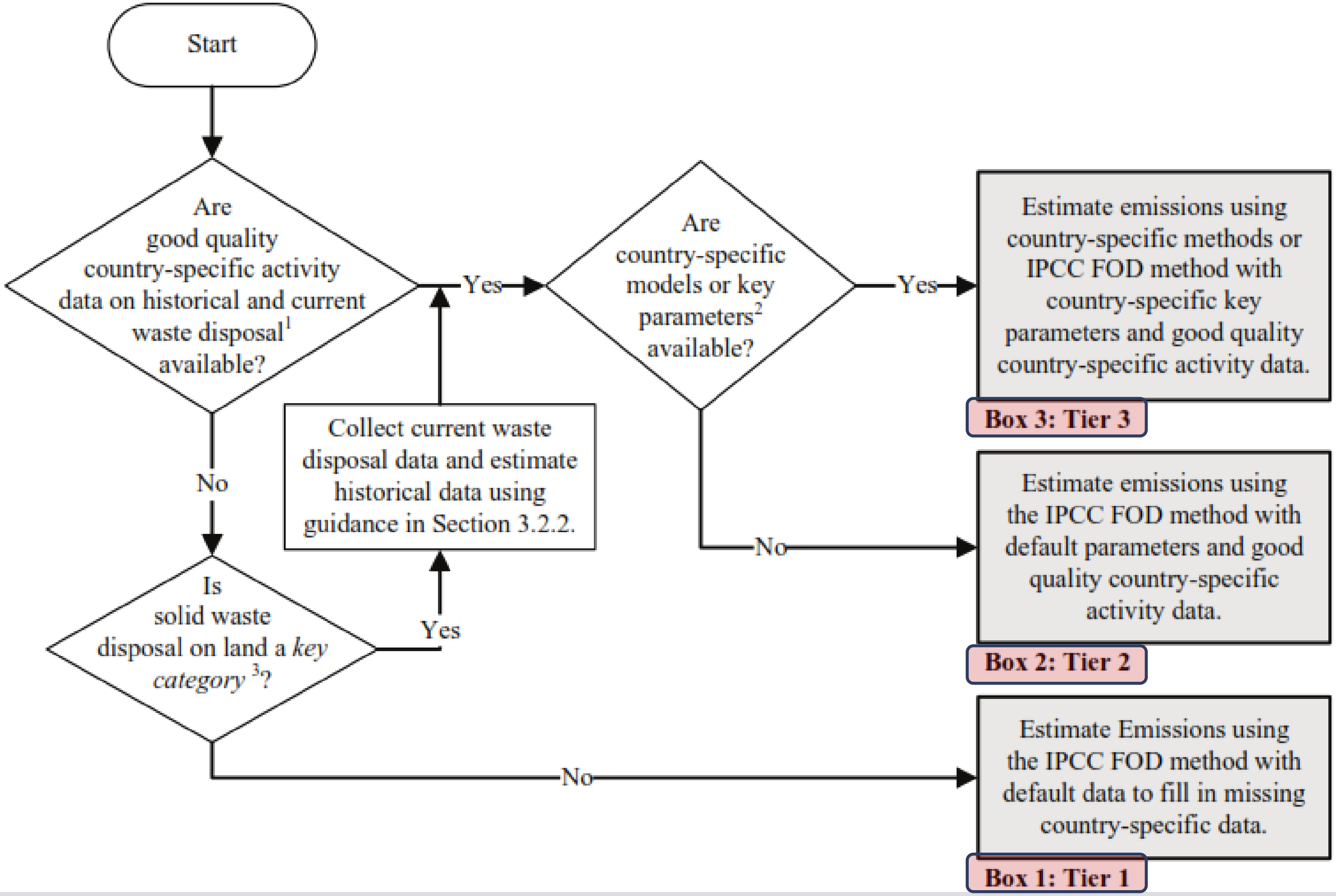
Tier 3: based on the use **of good quality country-specific activity data** (Tier 2) and the use of either the FOD method with (1) nationally developed key parameters, or (2) **measurement derived country-specific parameters**.

Key parameters should include the **half-life, and either methane generation potential (Lo) or DOC content in waste and the fraction of DOC which decomposes (DOCf)**. These parameters can be based on measurements.

Source: Global Methane Initiative, EPA LandGem

Solid waste disposal site – CH_4 emissions estimating

Figure 3.1 Decision Tree for CH_4 emissions from Solid Waste Disposal Sites



First Order Decay (FOD)

EQUATION 3.1
CH_4 EMISSION FROM SWDS

$$CH_4\ Emissions = \left[\sum_x CH_4\ generated_{x,T} - R_T \right] \bullet (1 - OX_T)$$

Where:

CH_4 Emissions = CH_4 emitted in year *T*, Gg

T = inventory year

x = waste category or type/material

R_T = recovered CH_4 in year *T*, Gg

OX_T = oxidation factor in year *T*, (fraction)

CH_4 generated is estimated on the basis of the amount of **Decomposable Degradable Organic Carbon (DDOCm)** which is the part of the organic carbon that will degrade under the anaerobic conditions in SWDS.

Equations for estimating the CH_4

EQUATION 3.2
DECOMPOSABLE DOC FROM WASTE DISPOSAL DATA

$$DDOCm = W \bullet DOC \bullet DOC_f \bullet MCF$$

Where:

DDOCm	=	mass of decomposable DOC deposited, Gg
W	=	mass of waste deposited, Gg
DOC	=	degradable organic carbon in the year of deposition, fraction, Gg C/Gg waste
DOC_f	=	fraction of DOC that can decompose (fraction)
MCF	=	CH_4 correction factor for aerobic decomposition in the year of deposition (fraction)

EQUATION 3.3
TRANSFORMATION FROM DDOCm TO L_o

$$L_o = DDOCm \bullet F \bullet 16/12$$

Where:

L_o	=	CH_4 generation potential, Gg CH_4
DDOCm	=	mass of decomposable DOC, Gg
F	=	fraction of CH_4 in generated landfill gas (volume fraction)
16/12	=	molecular weight ratio CH_4/C (ratio)

EQUATION 3.4
DDOCm ACCUMULATED IN THE SWDS AT THE END OF YEAR T

$$DDOCma_T = DDOCmd_T + \left(DDOCma_{T-1} \bullet e^{-k}\right)$$

EQUATION 3.5
DDOCm DECOMPOSED AT THE END OF YEAR T

$$DDOCm\ decomp_T = DDOCma_{T-1} \bullet \left(1 - e^{-k}\right)$$

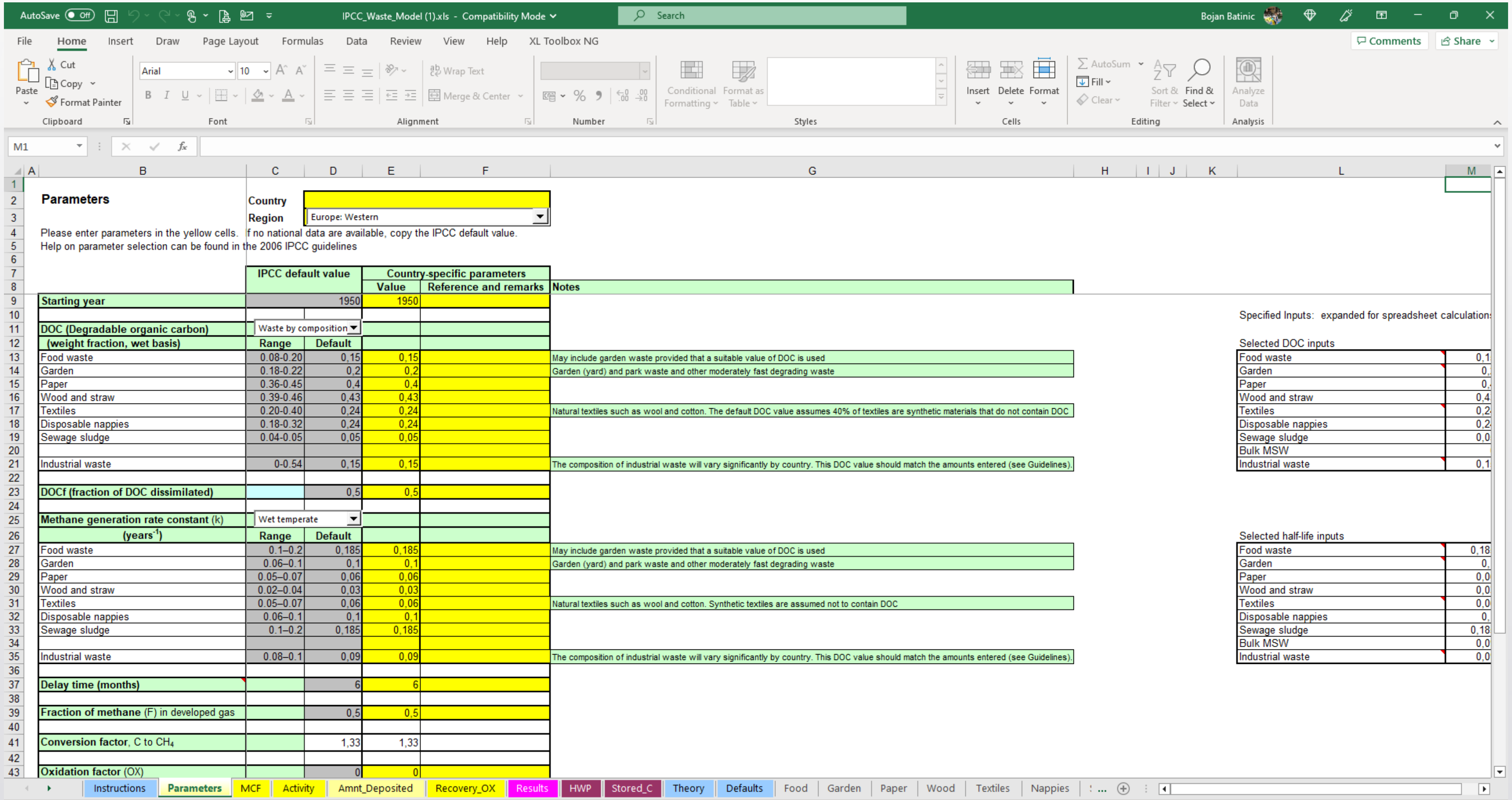
EQUATION 3.6
CH_4 GENERATED FROM DECAYED DDOCm

$$CH_4\ generated_T = DDOCm\ decomp_T \bullet F \bullet 16/12$$

Where:

CH_4 generated$_T$	=	amount of CH_4 generated from decomposable material
DDOCm decomp$_T$	=	DDOCm decomposed in year T, Gg
F	=	fraction of CH_4, by volume, in generated landfill gas (fraction)
16/12	=	molecular weight ratio CH_4/C (ratio)

Equations for estimating the CH_4 – *IPCC Waste Model*



IPCC_Waste_Model (1).xls - Compatibility Mode

Parameters

Country:

Region: Europe: Western

Please enter parameters in the yellow cells. f no national data are available, copy the IPCC default value.
Help on parameter selection can be found in the 2006 IPCC guidelines

	IPCC default value		Country-specific parameters		
			Value	Reference and remarks	Notes
Starting year		1950	1950		
DOC (Degradable organic carbon)	Waste by composition				
(weight fraction, wet basis)	Range	Default			
Food waste	0.08-0.20	0,15	0,15		May include garden waste provided that a suitable value of DOC is used
Garden	0.18-0.22	0,2	0,2		Garden (yard) and park waste and other moderately fast degrading waste
Paper	0.36-0.45	0,4	0,4		
Wood and straw	0.39-0.46	0,43	0,43		
Textiles	0.20-0.40	0,24	0,24		Natural textiles such as wool and cotton. The default DOC value assumes 40% of textiles are synthetic materials that do not contain DOC
Disposable nappies	0.18-0.32	0,24	0,24		
Sewage sludge	0.04-0.05	0,05	0,05		
Industrial waste	0-0.54	0,15	0,15		The composition of industrial waste will vary significantly by country. This DOC value should match the amounts entered (see Guidelines).
DOCf (fraction of DOC dissimilated)		0,5	0,5		
Methane generation rate constant (k)	Wet temperate				
(years^{-1})	Range	Default			
Food waste	0.1–0.2	0,185	0,185		May include garden waste provided that a suitable value of DOC is used
Garden	0.06–0.1	0,1	0,1		Garden (yard) and park waste and other moderately fast degrading waste
Paper	0.05–0.07	0,06	0,06		
Wood and straw	0.02–0.04	0,03	0,03		
Textiles	0.05–0.07	0,06	0,06		Natural textiles such as wool and cotton. Synthetic textiles are assumed not to contain DOC
Disposable nappies	0.06–0.1	0,1	0,1		
Sewage sludge	0.1–0.2	0,185	0,185		
Industrial waste	0.08–0.1	0,09	0,09		The composition of industrial waste will vary significantly by country. This DOC value should match the amounts entered (see Guidelines).
Delay time (months)		6	6		
Fraction of methane (F) in developed gas		0,5	0,5		
Conversion factor, C to CH_4		1,33	1,33		
Oxidation factor (OX)		0	0		

Specified Inputs: expanded for spreadsheet calculation

Selected DOC inputs	
Food waste	0,1
Garden	0,
Paper	0,
Wood and straw	0,4
Textiles	0,2
Disposable nappies	0,2
Sewage sludge	0,0
Bulk MSW	
Industrial waste	0,1

Selected half-life inputs	
Food waste	0,18
Garden	0,
Paper	0,0
Wood and straw	0,0
Textiles	0,0
Disposable nappies	0,
Sewage sludge	0,18
Bulk MSW	0,0
Industrial waste	0,0

Instructions | Parameters | MCF | Activity | Amnt_Deposited | Recovery_OX | Results | HWP | Stored_C | Theory | Defaults | Food | Garden | Paper | Wood | Textiles | Nappies

Other important default values

- **Degradable Organic Carbon (DOC)** – carbon that is accessible to decomposition (Gg C / Gg waste) **- Table 2.4**
- **Fraction of DOC that Decomposes (DOC_f)** – estimate of fraction of carbon degraded and released from site – recommended default value **is 0.5**
- **CH_4 content in Landfill Gas** – typically **50% CH_4 / 50% CO_2**
- **Oxidation Factor (OX)** - reflects amount of CH_4 from site that oxidized in the soil or other material covering the waste. The default value for oxidation factor is zero. Use of the oxidation value of **0.1** is justified only for **covered, well-managed SWDS.**

Other important default values

- **Methane Correction Factor (MCF)** - assigned based on the estimated fraction of waste which decays aerobically and does not produce methane (**unmanaged** SWDS produce **less CH_4** from a given amount of waste **than anaerobic managed** SWDS)

TABLE 3.1
SWDS CLASSIFICATION AND METHANE CORRECTION FACTORS (MCF)

Type of Site	Methane Correction Factor (MCF) Default Values
Managed – anaerobic [1]	1.0
Managed – semi-aerobic [2]	0.5
Unmanaged [3] – deep (>5 m waste) and /or high water table	0.8
Unmanaged [4] – shallow (<5 m waste)	0.4
Uncategorised SWDS [5]	0.6

Other important default values

- **Half-life ($t_{1/2}$)** – time taken for DOC in waste to decay to half its initial mass

TABLE 3.4
RECOMMENDED DEFAULT HALF-LIFE ($t_{1/2}$) VALUES (YR) UNDER TIER 1

(Derived from *k* values obtained in experimental measurements, calculated by models, or used in greenhouse gas inventories and other studies)

Type of Waste		Climate Zone*							
		Boreal and Temperate (MAT ≤ 20°C)				Tropical[1] (MAT > 20°C)			
		Dry (MAP/PET < 1)		Wet (MAP/PET > 1)		Dry (MAP < 1000 mm)		Moist and Wet (MAP ≥ 1000 mm)	
		Default	Range[2]	Default	Range[2]	Default	Range[2]	Default	Range[2]
Slowly degrading waste	Paper/textiles waste	17	14[3,5] – 23[3,4]	12	10 – 14[3,5]	15	12 – 17	10	8 – 12
	Wood/ straw waste	35	23[3,4] – 69[6,7]	23	17 – 35	28	17 – 35	20	14 – 23
Moderately degrading waste	Other (non – food) organic putrescible/ Garden and park waste	14	12 – 17	7	6 – 9[8]	11	9 – 14	4	3 – 5
Rapidly degrading waste	Food waste/Sewage sludge	12	9 – 14	4[4]	3[3,4] – 6[9]	8	6 – 10	2	1[10] – 4
Bulk Waste		14	12 – 17	7	6 – 9[8]	11	9 – 14	4	3 – 5[11]

Other important default values

- **Methane Recovery (R)** – CH_4 generated at SWDS can be recovered and combusted in a flare or energy device. If the recovered gas is used for energy, then the resulting greenhouse gas emissions should be reported under the Energy Sector. Emissions from flaring are however not significant – default value for recovery **is zero**.

- **Delay time** – Period between deposition of the waste and full production of CH_4. It is good practice to choose a delay time of **between zero and six months**. Values outside this range should be supported by evidence.

Biological treatment of solid waste

Composting and anaerobic digestion of organic waste

- Reduced volume in the waste material – stabilization of the waste
- Production of biogas for energy use
- End product can be recycled as a fertilizer or soil amendment

Composting

- large fraction of DOC in waste is converted to CO_2
- CH_4 and N_2O can both be formed during composting

Anaerobic digestion

- Biogas (CH_4 and CO_2)
- N_2O is assumed to be negligible

Biological treatment

- **Composting** - **aerobic** process where large fraction of the DOC in the waste material is converted into carbon dioxide (CO_2). Estimated CH_4 released into atmosphere is < 1%. Composting can also produce emissions of N_2O - range varies up to 5%)

- **Anaerobic digestion -** decomposition of organic material **without oxygen** by maintaining the temperature, moisture content and pH. The CO_2 emissions are of biogenic origin, thus should be reported only as an information (in the Energy Sector). Emissions of CH_4 due to unintentional leakages during process can generally be between 0 and 10 % of the amount of CH_4 generated (5 % is usually used as a default value)

- **Mechanical Biological Treatment (MBT) –** waste material undergoes a series of mechanical and biological operations with aim to reduce the volume of the waste and stabilize it prior final disposal. MB-treated waste produce up to 95 % less CH_4 than untreated waste disposed in SWDS.

Biological treatment

The CH_4 and N_2O emissions of biological treatment can be estimated using following equations

EQUATION 4.1
CH_4 EMISSIONS FROM BIOLOGICAL TREATMENT

$$CH_4\ Emissions = \sum_i (M_i \bullet EF_i) \bullet 10^{-3} - R$$

Where:

CH_4 Emissions = total CH_4 emissions in inventory year, Gg CH_4

M_i = mass of organic waste treated by biological treatment type *i*, Gg

EF = emission factor for treatment *i*, g CH_4/kg waste treated

i = composting or anaerobic digestion

R = total amount of CH_4 recovered in inventory year, Gg CH_4

EQUATION 4.2
N_2O EMISSIONS FROM BIOLOGICAL TREATMENT

$$N_2O\ Emissions = \sum_i (M_i \bullet EF_i) \bullet 10^{-3}$$

Where:

N_2O Emissions = total N_2O emissions in inventory year, Gg N_2O

M_i = mass of organic waste treated by biological treatment type *i*, Gg

EF = emission factor for treatment *i*, g N_2O/kg waste treated

i = composting or anaerobic digestion

When CH_4 emissions from anaerobic digestion are reported, the amount of recovered gas should be subtracted. The recovered gas can be combusted in a flare or energy device.

If the recovered gas is used for energy, then also the resulting GHG emissions from the combustion should be reported under Energy Sector.

The emissions from flare combustion are not significant, as the CO_2 emissions are of biogenic origin, and the CH_4 and N_2O emissions are very small, so good practice in the Waste Sector does not require their estimation.

Biological treatment

Type of biological treatment	CH_4 Emission Factors (g CH_4/kg waste treated)		N_2O Emission Factors (g N_2O/kg waste treated)		Remarks
	on a dry weight basis	on a wet weight basis	on a dry weight basis	on a wet weight basis	
Composting	10 (0.08 - 20)	4 (0.03 - 8)	0.6 (0.2 - 1.6)	0.24 (0.06 - 0.6)	Assumptions on the waste treated: 25-50% DOC in dry matter, 2% N in dry matter, moisture content 60%. The emission factors for dry waste are estimated from those for wet waste assuming a moisture content of 60% in wet waste.
Anaerobic digestion at biogas facilities	2 (0 - 20)	0.8 (0 - 8)	Assumed negligible	Assumed negligible	

Table 4.1: Default emission factors for CH_4 and N_2O emissions from biological treatment of waste

Emission from MBT can be estimated using the default values in Table for the biological treatment. Emissions during mechanical operations can be assumed negligible.

Incineration / open burning

Waste incineration is defined as the combustion of solid and liquid waste in controlled incineration facilities. Emissions from waste incineration without energy recovery are reported in the Waste Sector, while emissions from incineration with energy recovery are reported in the Energy Sector.

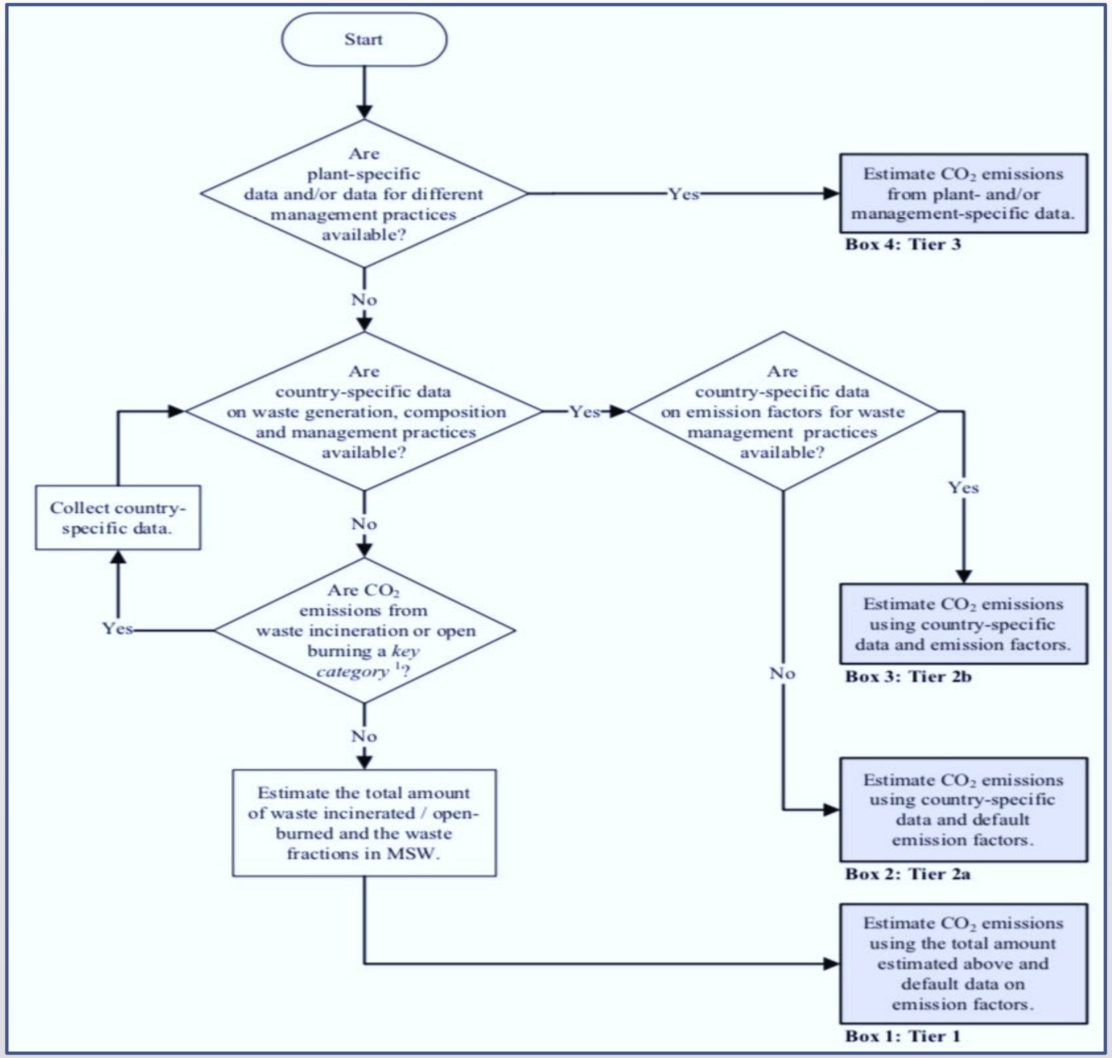
Open burning of waste can be defined as the combustion of waste materials in nature (open-air) or in open dumps, where smoke and other emissions are released directly into the air without passing through a chimney or stack.

Incineration and open burning of waste are sources of greenhouse gas emissions, like other types of combustion. **Relevant gases emitted include CO_2, methane (CH_4) and nitrous oxide (N_2O)**. Normally, emissions of CO_2 from waste incineration are more significant than CH_4 and N_2O emissions.

Incineration / open burning

The methods for estimating emissions from incineration and open burning of waste vary because of the different factors that influence emission levels.

Estimation of the amount of fossil carbon is the most important factor determining the CO_2 emissions as **only CO_2 emissions of fossil origin** (e.g., plastics, certain textiles, rubber, liquid solvents, and waste oil) **should be included.**



Incineration / open burning

CO_2

Method based on total amount of waste combusted

$$CO_2 Emissions = \sum_i (SW_i \bullet dm_i \bullet CF_i \bullet FCF_i \bullet OF_i) \bullet 44/12$$

CO_2 Emissions: CO_2 emissions in inventory year, Gg/yr
SW_i : total amount of solid waste of type *i (wet weight) incinerated or open-burned, Gg/yr*
dm_i : dry matter content in the waste (wet weight) incinerated or open-burned, (fraction)
CF_i : fraction of carbon in the dry matter (total carbon content), (fraction)
FCF_i : fraction of fossil carbon in the total carbon, (fraction)
OF_i : oxidation factor, (fraction)
44/12 : conversion factor from C to CO_2
i : type of waste incinerated/open-burned such as MSW, industrial solid waste (ISW), sewage sludge, hazardous waste, clinical waste, etc.

Incineration / open burning

CO_2

Method based on MSW composition

$$CO_2Emissions = MSW \bullet \sum_j (WF_j \bullet dm_j \bullet CF_j \bullet FCF_j \bullet OF_j) \bullet 44/12$$

CO_2 Emissions: CO_2 emissions in inventory year, Gg/yr
MSW : total amount of municipal solid waste as wet weight incinerated or open-burned, Gg/yr
WF_j : fraction of waste type/material of component ***j*** in the MSW (as wet weight incinerated or open-burned)
dm_j : dry matter content in the component j of the MSW incinerated or open-burned, (fraction)
CF_j : fraction of carbon in the dry matter (i.e., carbon content) of component ***j***
FCF_j : fraction of fossil carbon in the total carbon of component ***j***
OF_j : oxidation factor, (fraction)
44/12 : conversion factor from C to CO_2
j : component of the MSW incinerated/open-burned such as paper/cardboard, textiles, food waste, wood, garden (yard) and park waste, disposable nappies, rubber and leather, plastics, metal, glass, other inert waste

Incineration / open burning

CO_2

TABLE 5.2 DEFAULT DATA FOR CO_2 EMISSION FACTORS FOR INCINERATION AND OPEN BURNING OF WASTE							
Parameters	**Management practice**	**MSW**	**Industrial Waste (%)**	**Clinical Waste (%)**	**Sewage Sludge (%)** Note 4	**Fossil liquid waste (%)** Note 5
Dry matter content in % of wet weight		see Note 1	NA	NA	NA	NA
Total carbon content in % of dry weight		see Note 1	50	60	40 – 50	80
Fossil carbon fraction in % of total carbon content		see Note 2	90	40	0	100
Oxidation factor in % of carbon input	incineration	100	100	100	100	100
	Open- burning (see Note 3)	58	NO	NO	NO	NO

Incineration / open burning

CH_4

EQUATION 5.4

CH_4 EMISSION ESTIMATE BASED ON THE TOTAL AMOUNT OF WASTE COMBUSTED

$$CH_4\ Emissions = \sum_i (IW_i \bullet EF_i) \bullet 10^{-6}$$

Where:

CH_4 Emissions = CH_4 emissions in inventory year, Gg/yr

IW_i = amount of solid waste of type *i* incinerated or open-burned, Gg/yr

EF_i = aggregate CH_4 emission factor, kg CH_4/Gg of waste

10^{-6} = conversion factor from kilogram to gigagram

i = category or type of waste incinerated/open-burned, specified as follows:

MSW: municipal solid waste, ISW: industrial solid waste, HW: hazardous waste, CW: clinical waste, SS: sewage sludge, others (that must be specified)

Incineration / open burning

CH_4

Table 5.3 CH_4 emission factors for incineration of MSW		
Type of incineration/technology		**CH_4 Emission Factors (kg/Gg waste incinerated on a wet weight basis)**
Continuous incineration	stoker	0.2
	fluidised bed [Note1]	~0
Semi-continuous incineration	stoker	6
	fluidised bed	188
Batch type incineration	stoker	60
	fluidised bed	237

Incineration / open burning

N_2O

EQUATION 5.5

N_2O EMISSION ESTIMATE BASED ON THE WASTE INPUT TO THE INCINERATORS

$$N_2O\ Emissions = \sum_i (IW_i \bullet EF_i) \bullet 10^{-6}$$

Where:

N_2O Emissions = N_2O emissions in inventory year, Gg/yr

IW_i = amount of incinerated/open-burned waste of type *i* , Gg/yr

EF_i = N_2O emission factor (kg N_2O/Gg of waste) for waste of type *i*

10^{-6} = conversion from kilogram to gigagram

i = category or type of waste incinerated/open-burned, specified as follows:

MSW: municipal solid waste, ISW: industrial solid waste, HW: hazardous waste, CW: clinical waste, SS: sewage sludge, others (that must be specified)

Incineration / open burning

N_2O

TABLE 5.6 DEFAULT N_2O EMISSION FACTORS FOR DIFFERENT TYPES OF WASTE AND MANAGEMENT PRACTICES			
Type of waste	**Technology / Management practice**	**Emission factor (g N_2O / t waste)**	**weight basis**
MSW	continuous and semi-continuous incinerators	50	wet weight
MSW	batch-type incinerators	60	wet weight
MSW	open burning	150	dry weight
Industrial waste	all types of incineration	100	wet weight
Sludge (except sewage sludge)	all types of incineration	450	wet weight
Sewage sludge	incineration	990	dry weight
		900	wet weight

Incineration / open burning

Amount of open-burned waste

EQUATION 5.7

TOTAL AMOUNT OF MUNICIPAL SOLID WASTE OPEN-BURNED

$$MSW_B = P \bullet P_{frac} \bullet MSW_P \bullet B_{frac} \bullet 365 \bullet 10^{-6}$$

Where:

MSW_B	=	Total amount of municipal solid waste open-burned, Gg/yr
P	=	population (capita)
P_{frac}	=	fraction of population burning waste, (fraction)
MSW_P	=	per capita waste generation, kg waste/capita/day
B_{frac}	=	fraction of the waste amount that is burned relative to the total amount of waste treated, (fraction)
365	=	number of days by year
10^{-6}	=	conversion factor from kilogram to gigagram

Wastewater

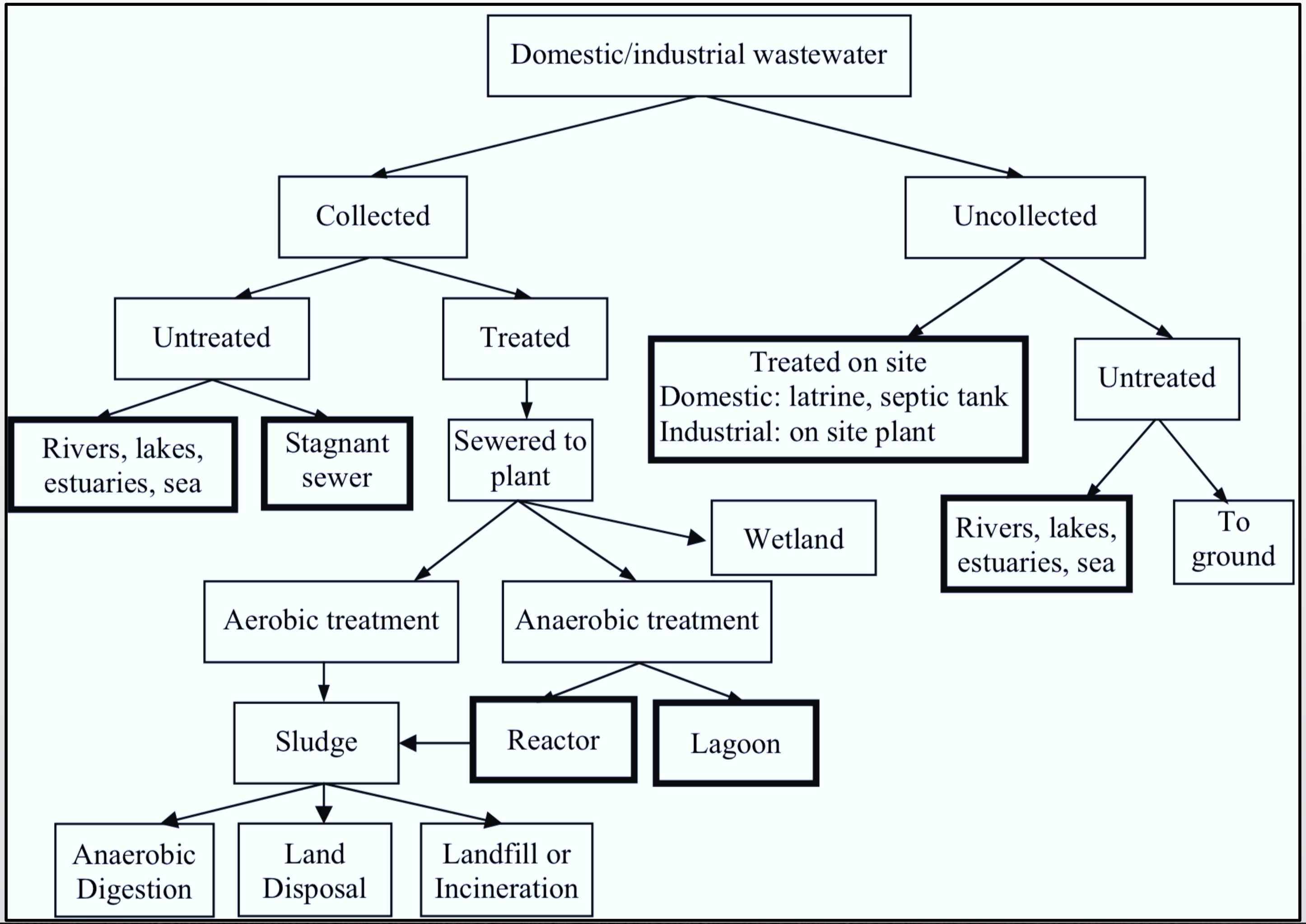
Wastewater can be a source of methane (CH_4) when treated or disposed anaerobically. It can also be a source of nitrous oxide (N_2O) emissions. Carbon dioxide (CO_2) emissions from wastewater are not considered in the IPCC Guidelines because these are of biogenic origin.

Wastewater originates from a variety of domestic, commercial and industrial sources and may be treated on site (uncollected), sewered to a centralized plant (collected) or disposed untreated nearby or via an outfall.

Treatment and disposal of wastewater produce GHGs such as CO_2, CH_4 and N_2O. CO_2 is of biogenic origin and not included. N_2O emissions from sludge and wastewater spread on agricultural land are considered in AFOLU sector

Wastewater

Different pathways for wastewater treatment and discharge



Wastewater

TABLE 6.1
CH_4 AND N_2O EMISSION POTENTIALS FOR WASTEWATER AND SLUDGE TREATMENT AND DISCHARGE SYSTEMS

Types of treatment and disposal				CH_4 and N_2O emission potentials
Collected	Untreated	River discharge		Stagnant, oxygen-deficient rivers and lakes may allow for anaerobic decomposition to produce CH_4. Rivers, lakes and estuaries are likely sources of N_2O.
		Sewers (closed and under ground)		Not a source of CH_4/N_2O.
		Sewers (open)		Stagnant, overloaded open collection sewers or ditches/canals are likely significant sources of CH_4.
	Treated	Aerobic treatment	Centralized aerobic wastewater treatment plants	May produce limited CH_4 from anaerobic pockets. Poorly designed or managed aerobic treatment systems produce CH_4. Advanced plants with nutrient removal (nitrification and denitrification) are small but distinct sources of N_2O.
			Sludge anaerobic treatment in centralized aerobic wastewater treatment plant	Sludge may be a significant source of CH_4 if emitted CH_4 is not recovered and flared.
			Aerobic shallow ponds	Unlikely source of CH_4/N_2O. Poorly designed or managed aerobic systems produce CH_4.
		Anaerobic treatment	Anaerobic lagoons	Likely source of CH_4. Not a source of N_2O.
			Anaerobic reactors	May be a significant source of CH_4 if emitted CH_4 is not recovered and flared.
Uncollected	Septic tanks			Frequent solids removal reduces CH_4 production.
	Open pits/Latrines			Pits/latrines are likely to produce CH_4 when temperature and retention time are favourable.
	River discharge			See above.

Wastewater

Domestic wastewater – CH_4

EQUATION 6.1
TOTAL CH_4 EMISSIONS FROM DOMESTIC WASTEWATER

$$CH_4\ Emissions = \left[\sum_{i,j} \left(U_i \bullet T_{i,j} \bullet EF_j \right) \right] (TOW - S) - R$$

Where:

CH_4 Emissions = CH_4 emissions in inventory year, kg CH_4/yr

TOW = total organics in wastewater in inventory year, kg BOD/yr

S = organic component removed as sludge in inventory year, kg BOD/yr

U_i = fraction of population in income group *i* in inventory year, See Table 6.5.

$T_{i,j}$ = degree of utilisation of treatment/discharge pathway or system, *j*, for each income group fraction *i* in inventory year, See Table 6.5.

i = income group: rural, urban high income and urban low income

j = each treatment/discharge pathway or system

EF_j = emission factor, kg CH_4 / kg BOD

R = amount of CH_4 recovered in inventory year, kg CH_4/yr

Wastewater

Domestic wastewater – CH_4

EQUATION 6.2
CH_4 EMISSION FACTOR FOR
EACH DOMESTIC WASTEWATER TREATMENT/DISCHARGE PATHWAY OR SYSTEM

$$EF_j = B_o \bullet MCF_j$$

Where:

EF_j = emission factor, kg CH_4/kg BOD

j = each treatment/discharge pathway or system

B_o = maximum CH_4 producing capacity, kg CH_4/kg BOD

MCF_j = methane correction factor (fraction), See Table 6.3.

Wastewater

Domestic wastewater – CH_4

TABLE 6.2 DEFAULT MAXIMUM CH_4 PRODUCING CAPACITY (B_0) FOR DOMESTIC WASTEWATER
0.6 kg CH_4/kg BOD
0.25 kg CH_4/kg COD
Based on expert judgment by lead authors and on Doorn *et al.*, (1997)

TABLE 6.3
DEFAULT MCF VALUES FOR DOMESTIC WASTEWATER

Type of treatment and discharge pathway or system	Comments	MCF [1]	Range
Untreated system			
Sea, river and lake discharge	Rivers with high organics loadings can turn anaerobic.	0.1	0 – 0.2
Stagnant sewer	Open and warm	0.5	0.4 – 0.8
Flowing sewer (open or closed)	Fast moving, clean. (Insignificant amounts of CH_4 from pump stations, etc)	0	0
Treated system			
Centralized, aerobic treatment plant	Must be well managed. Some CH_4 can be emitted from settling basins and other pockets.	0	0 – 0.1
Centralized, aerobic treatment plant	Not well managed. Overloaded.	0.3	0.2 – 0.4
Anaerobic digester for sludge	CH_4 recovery is not considered here.	0.8	0.8 – 1.0
Anaerobic reactor	CH_4 recovery is not considered here.	0.8	0.8 – 1.0
Anaerobic shallow lagoon	Depth less than 2 metres, use expert judgment.	0.2	0 – 0.3
Anaerobic deep lagoon	Depth more than 2 metres	0.8	0.8 – 1.0
Septic system	Half of BOD settles in anaerobic tank.	0.5	0.5
Latrine	Dry climate, ground water table lower than latrine, small family (3-5 persons)	0.1	0.05 – 0.15
Latrine	Dry climate, ground water table lower than latrine, communal (many users)	0.5	0.4 – 0.6
Latrine	Wet climate/flush water use, ground water table higher than latrine	0.7	0.7 – 1.0
Latrine	Regular sediment removal for fertilizer	0.1	0.1

[1] Based on expert judgment by lead authors of this section.

Wastewater

Industrial wastewater – CH_4

The general equation to estimate CH_4 emissions from industrial wastewater is as follows:

EQUATION 6.4

TOTAL CH_4 EMISSIONS FROM INDUSTRIAL WASTEWATER

$$CH_4 \ Emissions = \sum_i \left[\left(TOW_i - S_i \right) EF_i - R_i \right]$$

Where:

CH_4 Emissions = CH_4 emissions in inventory year, kg CH_4/yr

TOW_i = total organically degradable material in wastewater from industry *i* in inventory year, kg COD/yr

i = industrial sector

S_i = organic component removed as sludge in inventory year, kg COD/yr

EF_i = emission factor for industry *i*, kg CH_4/kg COD for treatment/discharge pathway or system(s) used in inventory year

If more than one treatment practice is used in an industry this factor would need to be a weighted average.

R_i = amount of CH_4 recovered in inventory year, kg CH_4/yr

Wastewater

Industrial wastewater – CH_4

EQUATION 6.5
CH_4 EMISSION FACTOR FOR INDUSTRIAL WASTEWATER

$$EF_j = B_o \bullet MCF_j$$

Where:

EF_j = emission factor for each treatment/discharge pathway or system, kg CH_4/kg COD, (See Table 6.8.)

j = each treatment/discharge pathway or system

B_o = maximum CH_4 producing capacity, kg CH_4/kg COD

MCF_j = methane correction factor (fraction) (See Table 6.8.)

If no country-specific data are available, it is good practice to use the IPCC COD-default factor for Bo (0.25 kg CH_4/kg COD).

TABLE 6.8
DEFAULT MCF VALUES FOR INDUSTRIAL WASTEWATER

Type of treatment and discharge pathway or system	Comments	MCF [1]	Range
Untreated			
Sea, river and lake discharge	Rivers with high organics loadings may turn anaerobic, however this is not considered here.	0.1	0 – 0.2
Treated			
Aerobic treatment plant	Must be well managed. Some CH_4 can be emitted from settling basins and other pockets.	0	0 – 0.1
Aerobic treatment plant	Not well managed. Overloaded	0.3	0.2 – 0.4
Anaerobic digester for sludge	CH_4 recovery not considered here	0.8	0.8 – 1.0
Anaerobic reactor (e.g., UASB, Fixed Film Reactor)	CH_4 recovery not considered here	0.8	0.8 – 1.0
Anaerobic shallow lagoon	Depth less than 2 metres, use expert judgment	0.2	0 – 0.3
Anaerobic deep lagoon	Depth more than 2 metres	0.8	0.8 – 1.0

[1] Based on expert judgment by lead authors of this section

Wastewater

N_2O

EQUATION 6.7
N_2O EMISSIONS FROM WASTEWATER EFFLUENT

$$N_2O\ Emissions = N_{EFFLUENT} \bullet EF_{EFFLUENT} \bullet 44/28$$

Where:

N_2O emissions = N_2O emissions in inventory year, kg N_2O/yr

$N_{EFFLUENT}$ = nitrogen in the effluent discharged to aquatic environments, kg N/yr

$EF_{EFFLUENT}$ = emission factor for N_2O emissions from discharged to wastewater, kg N_2O-N/kg N

The factor 44/28 is the conversion of kg N_2O-N into kg N_2O.

EQUATION 6.8
TOTAL NITROGEN IN THE EFFLUENT

$$N_{EFFLUENT} = (P \bullet Protein \bullet F_{NPR} \bullet F_{NON-CON} \bullet F_{IND-COM}) - N_{SLUDGE}$$

Where:

$N_{EFFLUENT}$ = total annual amount of nitrogen in the wastewater effluent, kg N/yr

P = human population

Protein = annual per capita protein consumption, kg/person/yr

F_{NPR} = fraction of nitrogen in protein, default = 0.16, kg N/kg protein

$F_{NON-CON}$ = factor for non-consumed protein added to the wastewater

$F_{IND-COM}$ = factor for industrial and commercial co-discharged protein into the sewer system

N_{SLUDGE} = nitrogen removed with sludge (default = zero), kg N/yr

TABLE 6.11
N_2O METHODOLOGY DEFAULT DATA

	Definition	Default Value	Range
Emission Factor			
$EF_{EFFLUENT}$	Emission factor, (kg N_2O-N/kg –N)	0.005	0.0005 – 0.25
EF_{PLANTS}	Emission factor, (g N_2O/person/year)	3.2	2 – 8
Activity Data			
P	Number of people in country	Country-specific	± 10 %
Protein	Annual per capita protein consumption	Country-specific	± 10 %
F_{NPR}	Fraction of nitrogen in protein (kg N/kg protein)	0.16	0.15 – 0.17
T_{plant}	Degree of utilization of large WWT plants	Country-specific	± 20 %
$F_{NON-CON}$	Factor to adjust for non-consumed protein	1.1 for countries with no garbage disposals, 1.4 for countries with garbage disposals	1.0 – 1.5
$F_{IND-COM}$	Factor to allow for co-discharge of industrial nitrogen into sewers. For countries with significant fish processing plants, this factor may be higher. Expert judgment is recommended.	1.25	1.0 – 1.5

IPCC Refinement highlights

WASTE GENERATION, COMPOSITION AND MANAGEMENT DATA

Updated regional default values of waste generation rate and their treatment and updated waste composition default values of carbon content, nitrogen content and DOC of sludge from specific industry and domestic sludge

SOLID WASTE DISPOSAL

Section 3.2.1.1 provides information on aerobic management of SWDS including information on calculation of MCF for new categories of aerobic management. Section 3.2.3 provides additional information on DOCf including updated default values and their uncertainties by different type waste (less, moderately and highly decomposable). Information on MCF including default MCF values and definition for new categories of aerobic management

INCINERATION AND OPEN BURNING OF WASTE

Section 5.1 provides definition of and information on pyrolysis, gasification and plasma technology. Section 5.4.1.3 presents an updated oxidation factor of MSW open burning

WASTEWATER TREATMENT AND DISCHARGE

Sections that discuss CH_4 emissions from domestic and industrial wastewater, as well as N_2O emissions from domestic wastewater have been updated to reflect the refinements presented throughout the chapter.

The 5th GREENHOUSE GAS INVENTORY SYSTEM TRAINING WORKSHOP

II PART

Case Study and GHG Estimation Practice in the Waste Sector

IPCC 2006 Waste Model

- ✓ Directed to countries with limited data on waste disposal
- ✓ Estimates GHG emissions over a time-series, using the first-order decay model
- ✓ Facilitates comparison of estimates between countries
- ✓ Permits assessment of impacts of different waste management and emission mitigation practices

IPPC Waste Model: Parameters - waste input

Parameters

Country	**Thailand**
Region	Asia- Southeast

Please enter parameters in the yellow cells. If no national data are available, copy the IPCC default value.
Help on parameter selection can be found in the 2006 IPCC guidelines

	IPCC default value		Country-specific parameters	
			Value	Reference and remarks
Starting year		1950	1950	
DOC (Degradable organic carbon)	Waste by compo			
(weight fraction, wet basis)	Waste by composi			
Food waste	Bulk waste data o		0.15	
Garden	0.18-0.22	0.2	0.2	
Paper	0.36-0.45	0.4	0.4	
Wood and straw	0.39-0.46	0.43	0.43	
Textiles	0.20-0.40	0.24	0.24	
Disposable nappies	0.18-0.32	0.24	0.24	
Sewage sludge	0.04-0.05	0.05	0.05	
Industrial waste	0-0.54	0.15	0.15	
DOCf (fraction of DOC dissimilated)		0.5	0.5	

Asia- Southeast
- Asia: Eastern
- Asia: South-central
- Asia- Southeast
- Asia- Western & Middle East

IPPC Waste Model: Parameters – climate selection

Methane generation rate constant (k) (years^{-1})	Wet temperate			
Food waste			0.185	
Garden			0.1	
Paper			0.06	
Wood and straw			0.03	
Textiles	0.05–0.07	0.06	0.06	
Disposable nappies	0.06–0.1	0.1	0.1	
Sewage sludge	0.1–0.2	0.185	0.185	
Industrial waste	0.08–0.1	0.09	0.09	

Dry temperate
Wet temperate
Dry tropical
Moist and wet tro

IPPC Waste Model: Parameters – MSW activity data

MSW activity data

Enter population, waste per capita and MSW waste composition into the yellow cells.
Help and default regional values are given in the 2006 IPCC Guidelines.
Industrial waste activity data must be entered separately starting in Column Q.

IPCC Regional defaults

Year	Population	Waste per capita	Total MSW	% to SWDS	Food	Garden	Paper	Wood	Textile	Nappies	Plastics, other inert	Total
		270		59%	44%	0%	13%	10%	3%	0%	31%	100%
					Composition of waste going to solid waste disposal sites							
	millions	kg/cap/yr	Gg	%	%	%	%	%	%	%	%	(=100%)
1950	10	270	2700	59%	44%	0%	13%	10%	3%	0%	31%	100%
1951	10	270	2700	59%	44%	0%	13%	10%	3%	0%	31%	100%
1952	10	270	2700	59%	44%	0%	13%	10%	3%	0%	31%	100%
1953	10	270	2700	59%	44%	0%	13%	10%	3%	0%	31%	100%
1954	10	270	2700	59%	44%	0%	13%	10%	3%	0%	31%	100%
1955	10	270	2700	59%	44%	0%	13%	10%	3%	0%	31%	100%
1956	10	270	2700	59%	44%	0%	13%	10%	3%	0%	31%	100%
1957	10	270	2700	59%	44%	0%	13%	10%	3%	0%	31%	100%
1958	10	270	2700	59%	44%	0%	13%	10%	3%	0%	31%	100%
1959	10	270	2700	59%	44%	0%	13%	10%	3%	0%	31%	100%
1960	10	270	2700	59%	44%	0%	13%	10%	3%	0%	31%	100%
1961	10	270	2700	59%	44%	0%	13%	10%	3%	0%	31%	100%
1962	10	270	2700	59%	44%	0%	13%	10%	3%	0%	31%	100%
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1964	10	270	2700	59%	44%	0%	13%	10%	3%	0%	31%	100%
1965	10	270	2700	59%	44%	0%	13%	10%	3%	0%	31%	100%
1966	10	270	2700	59%	44%	0%	13%	10%	3%	0%	31%	100%
1967	10	270	2700	59%	44%	0%	13%	10%	3%	0%	31%	100%
1968	10	270	2700	59%	44%	0%	13%	10%	3%	0%	31%	100%
1969	10	270	2700	59%	44%	0%	13%	10%	3%	0%	31%	100%
1970	10	270	2700	59%	44%	0%	13%	10%	3%	0%	31%	100%
1971	10	270	2700	59%	44%	0%	13%	10%	3%	0%	31%	100%
1972	10	270	2700	59%	44%	0%	13%	10%	3%	0%	31%	100%
1973	10	270	2700	59%	44%	0%	13%	10%	3%	0%	31%	100%
1974	10	270	2700	59%	44%	0%	13%	10%	3%	0%	31%	100%
1975	10	270	2700	59%	44%	0%	13%	10%	3%	0%	31%	100%
1976	10	270	2700	59%	44%	0%	13%	10%	3%	0%	31%	100%

IPPC Waste Model: Parameters - Results

Results

Country

Thailand

Enter starting year, industrial waste disposal data and methane recovery into the yellow cells.
MSW activity data is entered on MSW sheet

Year	Methane generated											
Year	Food	Garden	Paper	Wood	Textile	Nappies	Sludge	MSW	Industrial	Total	Methane recovery	Methane emission
	A	B	C	D	E	F	G	H	J	K	L	M = (K-L)*(1-OX)
	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1950	0	0	0	0	0	0	0		0	0	0	0
1951	4	0	1	0	0	0	0		2	7	0	7
1952	8	0	2	1	0	0	0		3	14	0	14
1953	10	0	3	1	0	0	0		4	20	0	20
1954	13	0	4	2	1	0	0		5	25	0	25
1955	15	0	5	2	1	0	0		6	29	0	29
1956	16	0	6	3	1	0	0		7	33	0	33
1957	18	0	7	3	1	0	0		8	37	0	37
1958	19	0	7	3	1	0	0		9	40	0	40
1959	20	0	8	4	1	0	0		10	43	0	43
1960	21	0	9	4	1	0	0		11	45	0	45
1961	21	0	9	4	1	0	0		11	47	0	47
1962	22	0	10	5	1	0	0		12	50	0	50
1963	22	0	10	5	1	0	0		12	51	0	51
1964	23	0	11	5	1	0	0		13	53	0	53
1965	23	0	11	6	1	0	0		13	55	0	55
1966	23	0	12	6	1	0	0		14	56	0	56
1967	23	0	12	6	2	0	0		14	58	0	58
1968	24	0	13	7	2	0	0		14	59	0	59
1969	24	0	13	7	2	0	0		15	60	0	60
1970	24	0	13	7	2	0	0		15	61	0	61
1971	24	0	14	7	2	0	0		15	62	0	62
1972	24	0	14	8	2	0	0		15	63	0	63
1973	24	0	14	8	2	0	0		16	64	0	64
1974	24	0	15	8	2	0	0		16	65	0	65
1975	24	0	15	8	2	0	0		16	65	0	65

Summary: Default values

- ✓Climate
- ✓MSW composition
- ✓MSW generation
- ✓MSW management

Sample model - Indonesia

INPUTS

1

Parameters

Country	Indonesia
Region	Asia- Southeast

Please enter parameters in the yellow cells. If no national data are available, copy the IPCC default value.
Help on parameter selection can be found in the 2006 IPCC guidelines

	IPCC default value		Country-specific parameters	
			Value	Reference and remarks
Starting year		1950	1950	
DOC (Degradable organic carbon)	Waste by compo			
(weight fraction, wet basis)	Range	Default		
Food waste	0.08-0.20	0.15	0.15	
Garden	0.18-0.22	0.2	0.2	
Paper	0.36-0.45	0.4	0.4	
Wood and straw	0.39-0.46	0.43		
Textiles	0.20-0.40	0.24		
Disposable nappies	0.18-0.32	0.24		
Sewage sludge	0.04-0.05	0.05		
Industrial waste	0-0.54	0.15		
DOCf (fraction of DOC dissimilated)		0.5		
Methane generation rate constant (k)	Moist and wet t			
(years^{-1})	Range	Default		
Food waste	0.17–0.7	0.4		
Garden	0.15–0.2	0.17		
Paper	0.06–0.085	0.07		
Wood and straw	0.03–0.05	0.035		
Textiles	0.06–0.085	0.07		
Disposable nappies	0.15–0.2	0.17		
Sewage sludge	0.17–0.7	0.4		

2

MSW activity data

Enter population, waste per capita and MSW waste composition into the yellow cells.
Help and default regional values are given in the 2006 IPCC Guidelines.
Industrial waste activity data must be entered separately starting in Column Q.

IPCC Regional defaults

		270		59%	44%	0%	13%	10%	3%	0%	31%	100%
					Composition of waste going to solid waste disposal sites							
Year	Population	Waste per capita	Total MSW	% to SWDS	Food	Garden	Paper	Wood	Textile	Nappies	Plastics, other inert	Total
	millions	kg/cap/yr	Gg	%	%	%	%	%	%	%	%	(=100%)
2013	237	270	63990	59%	44%	0%	13%	10%	3%	0%	31%	100%
2014	237	270	63990	59%	44%	0%	13%	10%	3%	0%	31%	100%
2015	255	270	68850	59%	44%	0%	13%	10%	3%	0%	31%	100%
2016	255	270	68850	59%	44%	0%	13%	10%	3%	0%	31%	100%
2017	255	270	68850	59%	44%	0%	13%	10%	3%	0%	31%	100%
2018	255	270	68850	59%	44%	0%	13%	10%	3%	0%	31%	100%
2019	260	270	70200	59%	44%	0%	13%	10%	3%	0%	31%	100%
2020	260	270	70200	59%	44%	0%	13%	10%	3%	0%	31%	100%
2021	260	270	70200	59%	44%	0%	13%	10%	3%	0%	31%	100%
2022	260	270	70200	59%	44%	0%	13%	10%	3%	0%	31%	100%
2023	268	270	72360	59%	44%	0%	13%	10%	3%	0%	31%	100%
2024	268	270	72360	59%	44%	0%	13%	10%	3%	0%	31%	100%
2025	268	270	72360	59%	44%	0%	13%	10%	3%	0%	31%	100%
2026	268	270	72360	59%	44%	0%	13%	10%	3%	0%	31%	100%
2027	270	270	72900	59%	44%	0%	13%	10%	3%	0%	31%	100%
2028	270	270	72900	59%	44%	0%	13%	10%	3%	0%	31%	100%
2029	270	270	72900	59%	44%	0%	13%	10%	3%	0%	31%	100%
2030	270	270	72900	59%	44%	0%	13%	10%	3%	0%	31%	100%

3

Methane Correction Factor (MCF)

This worksheet calculates a weighted average MCF from the estimated distri
Enter either IPCC default values or national values into the yellow MCF cells
Then enter the approximate distribution of waste disposals (by mass) betwee
Totals on each row must add up to 100% (see "distribution check" values)

	MSW					
	Un-managed, shallow	Un-managed, deep	Managed	Managed, semi-aerobic	Uncate-gorised	Distri-bution Check
	MCF	MCF	MCF	MCF	MCF	
IPCC default	0.4	0.8	1	0.5	0.6	
Country-specific value	0.4	0.8	1	0.5	0.6	
	Distribution of Waste by Waste Management Type					
"Fixed" Country-specifc value	25%	30%	25%	5%	15%	Total
Year	%	%	%	%	%	(100%)
	25%	30%	25%	5%	15%	100%
	25%	30%	25%	5%	15%	100%
	25%	30%	25%	5%	15%	100%
	25%	30%	25%	5%	15%	100%
	25%	30%	25%	5%	15%	100%
	25%	30%	25%	5%	15%	100%
	25%	25%	30%	5%	15%	100%
	25%	25%	30%	5%	15%	100%
	25%	25%	30%	5%	15%	100%
	25%	25%	30%	5%	15%	100%
	25%	25%	30%	5%	15%	100%
	25%	25%	30%	5%	15%	100%
	25%	25%	30%	5%	15%	100%
	25%	25%	30%	5%	15%	100%
	25%	25%	30%	5%	15%	100%
	25%	25%	30%	5%	15%	100%
	25%	25%	30%	5%	15%	100%

Sample model - Indonesia

Results

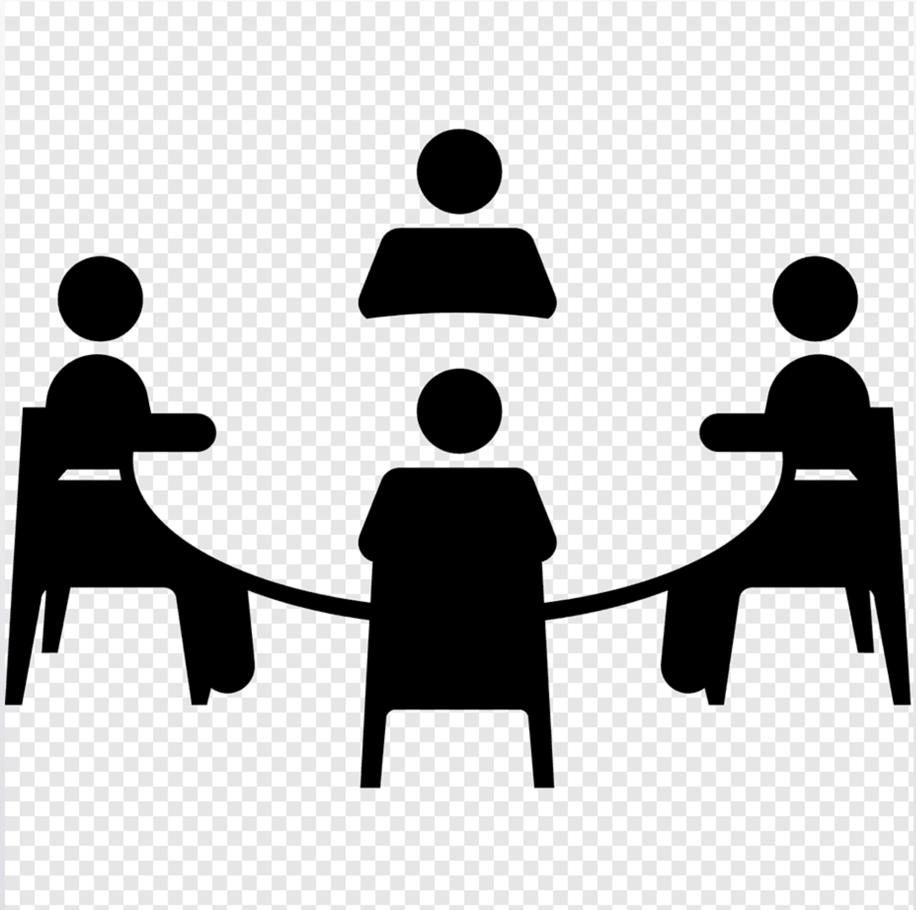
Country

Indonesia

Enter starting year, industrial waste disposal data and methane recovery into the yellow cells.
MSW activity data is entered on MSW sheet

	Methane generated											
Year	Food	Garden	Paper	Wood	Textile	Nappies	Sludge	MSW	Industrial	Total	Methane recovery	Methane emission
	A	B	C	D	E	F	G	H	J	K	L	M = (K-L)*(1-OX)
	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1950	0	0	0	0	0	0	0		0	0	0	0
1951	68	0	11	5	1	0	0		3	88	0	88
1952	114	0	21	9	3	0	0		5	153	0	153
1953	145	0	31	14	4	0	0		7	201	0	201
1954	167	0	40	18	5	0	0		9	239	0	239
1955	182	0	49	22	6	0	0		10	270	0	270
1956	192	0	57	26	7	0	0		11	294	0	294
1957	201	0	65	30	8	0	0		12	316	0	316
1958	206	0	72	34	9	0	0		13	334	0	334
2013	572	0	388	258	49	0	0		18	1,285	10	1,275
2014	575	0	393	262	49	0	0		18	1,296	10	1,286
2015	576	0	397	266	50	0	0		18	1,307	10	1,297
2016	591	0	403	271	51	0	0		18	1,334	10	1,324
2017	602	0	410	276	51	0	0		18	1,356	10	1,346
2018	612	0	416	280	52	0	0		18	1,378	10	1,368
2019	618	0	421	285	53	0	0		18	1,395	10	1,385
2020	627	0	427	289	54	0	0		18	1,415	10	1,405
2021	632	0	433	294	54	0	0		18	1,431	10	1,421
2022	636	0	438	298	55	0	0		18	1,445	10	1,435
2023	639	0	443	303	56	0	0		18	1,458	10	1,448

IPPC Waste Model - CASE STUDY EXERCISES….



THANK YOU

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CECC