2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Waste Sector Overview

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2019 Refinement : Volume 5 Waste sector

LAM1

Bibao - Spain

LAM2

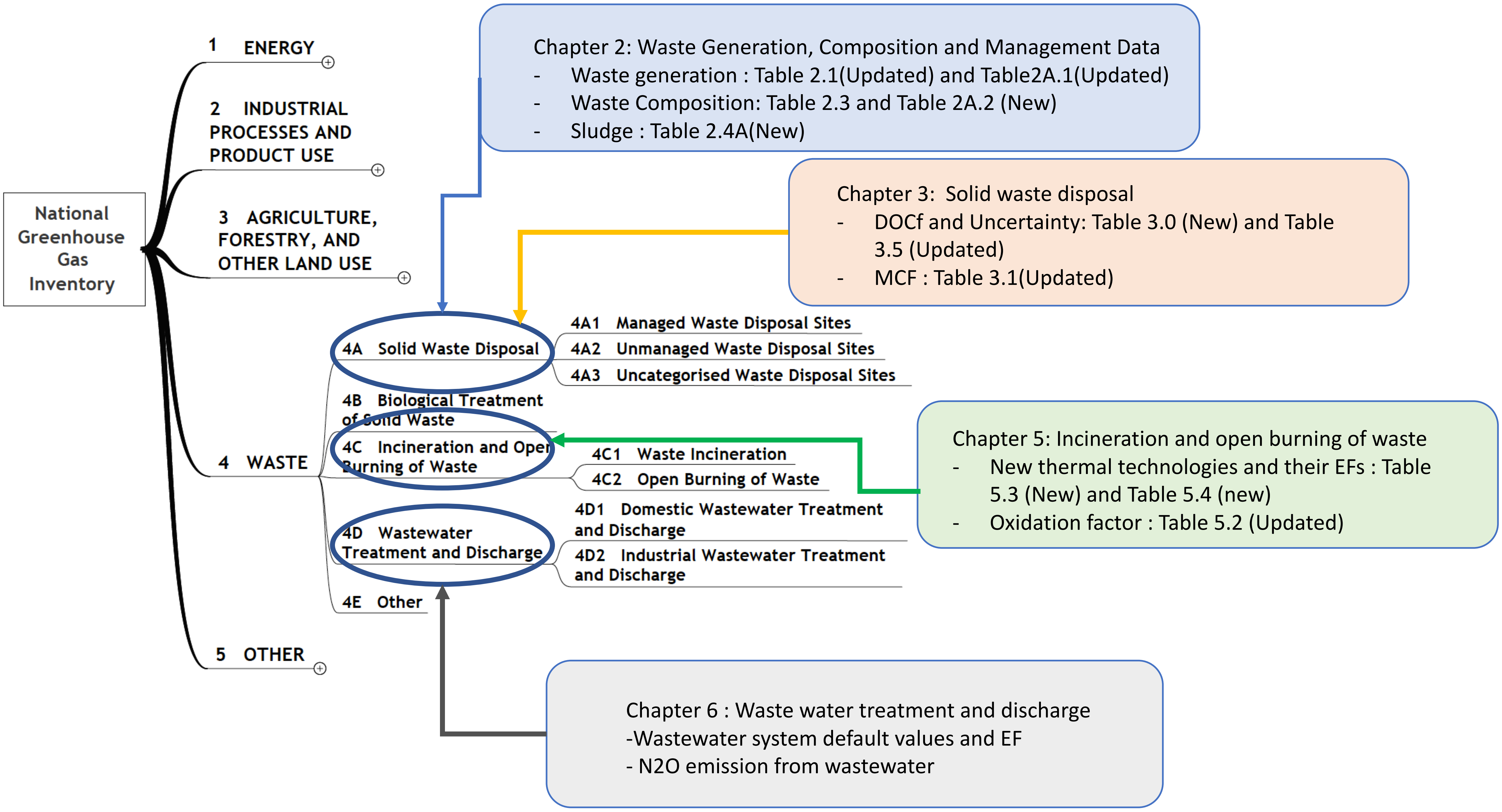
Victoria-Zimbabwe

LAM3

Cairns -Australia

LAM4

Rome-Italy


National Greenhouse Gas Inventory
1 ENERGY
2 INDUSTRIAL PROCESSES AND PRODUCT USE
3 AGRICULTURE, FORESTRY, AND OTHER LAND USE
4 WASTE
5 OTHER
4A Solid Waste Disposal
4A1 Managed Waste Disposal Sites
4A2 Unmanaged Waste Disposal Sites
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4B Biological Treatment of Solid Waste
4C Incineration and Open Burning of Waste
4C1 Waste Incineration
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4D Wastewater Treatment and Discharge
4D1 Domestic Wastewater Treatment and Discharge
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4E Other
Chapter 2: Waste Generation, Composition and Management Data
- Waste generation : Table 2.1(Updated) and Table2A.1(Updated)
- Waste Composition: Table 2.3 and Table 2A.2 (New)
- Sludge : Table 2.4A(New)
Chapter 3: Solid waste disposal
- DOCf and Uncertainty: Table 3.0 (New) and Table 3.5 (Updated)
- MCF : Table 3.1(Updated)
Chapter 5: Incineration and open burning of waste
- New thermal technologies and their EFs : Table 5.3 (New) and Table 5.4 (new)
- Oxidation factor : Table 5.2 (Updated)
Chapter 6 : Waste water treatment and discharge
-Wastewater system default values and EF
- N2O emission from wastewater

Chapter 2: Waste Generation, Composition and Management Data -Waste generation

- Waste generation and waste composition are key parameter used in FOD model and can change over time.
- Waste generation in the year 2010 presents by country and regional level according to UN classification.
- Parties can construct proper 10 years' historical time series by using Table 2A.1 (updated) with the information in the year 2000 from 2006 IPCC guideline and year 2010 from 2019 Refinement.

TABLE 2.1 (UPDATED)
MSW GENERATION AND TREATMENT DATA – REGIONAL DEFAULTS

Region	MSW Generation Rate[1,2,3] (tonnes/cap/yr)	Fraction of MSW open dumped	Fraction of MSW disposed to landfills	Fraction of MSW incinerated	Fraction of MSW composted	Fraction of other MSW management, unspecified[4]

Annex 2A.1 (Updated) Waste Generation and Management Data – by country and regional averages

TABLE 2A.1 (UPDATED)
MSW GENERATION AND MANAGEMENT DATA – BY COUNTRY AND REGIONAL AVERAGE

Region/country	MSW [1,2] Generation Rate IPCC-1996 Values [4] (tonnes/cap/yr)	MSW [1,2,3] Generation Rate IPCC-2006 Values [5] (tonnes/cap/yr)	MSW Generation Rate Values [1,2,3] (tonnes/cap/yr)	Fraction of MSW disposed to SWDS IPCC-1996 Values [4]	Fraction of MSW disposed to SWDS IPCC-2006 Values [5]	Fraction of MSW disposed to SWDS: Open dumped	Fraction of MSW disposed to SWDS: Disposed to landfills	Fraction of MSW incinerated	Fraction of MSW composted	Fraction of other MSW management, unspecified [6]	Source
Year	1990	2000	2010	1990	2000	2010	2010	2010	2010	2010	
Asia											

Chapter 2: Waste Generation, Composition and Management Data -Waste Composition

- Waste composition is updated by country and regional level
- In order to be in line with waste model additional components, additional components of of garden waste and nappies are presented.
- New appendix table –Table 2A.2 is added to the refinement as the reference of the waste composition value.

Annex 2A.2 (New) Waste composition–by country and regional averages

TABLE 2A.2 (NEW) WASTE COMPOSITION – BY COUNTRY AND REGIONAL AVERAGES												
Countries	Food waste	Garden (yard) and park waste	Paper and cardboard	Wood	Textiles	Nappies (disposable diapers)	Rubber and leather	Plastics	Metal	Glass (and pottery and china)	Other	Sources
Asia												

Chapter 2: Waste Generation, Composition and Management Data - Sludge

- Clarification of definition of sludge as a mixture of liquid and solid components and can be produced as sewage sludge from wastewater treatment processes or as a settled suspension obtained from conventional drinking water treatment or from numerous other industrial processes
- Estimation of degradable organic carbon (DOC) values include default values of carbon nitrogen content and DOC of domestic and industrial sludge are provided
- Categorize domestic sewage sludge as treated and untreated

Derived from IPCC 2006 GL

TABLE 2.4A (NEW)
DEFAULT VALUE AND UNCERTAINTY OF CARBON CONTENT, NITROGEN CONTENT AND DOC OF DOMESTIC AND INDUSTRIAL SLUDGE (PERCENT OR FRACTION OF DRY MATTER)

Sludge	Carbon content		Nitrogen content		DOC	
	Default value (percent)	Uncertainty (percent)	Default value (percent)	Uncertainty (percent)	Default value fraction	Uncertainty (percent)
Domestic Sewage Treated Sludge [2-6]	31	+/- 27	4.2	+/- 56	0.30	+/- 61
Domestic Sewage Untreated Sludge [1]					0.50	+/- 30
Food Industry (fruits & vegetables)[2]	44	+/- 33	1.1	+/- 45	0.36	+/- 69
Paper Industry (process sludge)[2]	28	+/-49	0.5	+/-100	0.12	+/-25
Paper Industry (Wastewater sludge)[2]	31	+/- 15	0.9	+/- 60		
Chemical Industry[1]	52	+/-100				
Default for Industrial Sludge[1]					0.26	

Chapter 3: Solid Waste Disposal

- New categories of SWDS
  - semi-aerobic (managed poorly)
  - active aeration (well managed)
  - active aeration (poorly managed)

TABLE 3.1 (UPDATED)
SWDS CLASSIFICATION AND METHANE CORRECTION FACTORS (MCF)

Type of Site	Methane Correction Factor (MCF) Default Values	Remarks
Managed – anaerobic	1.0[a]	These 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: (i) cover material; (ii) mechanical compacting; or (iii) levelling of the waste.
Managed well – semi-aerobic	0.5[b]	When semi-aerobic managed SWDS type is managed under one of the following condition, it is regarded as well magement ; (i) permeable cover material; (ii) leachate drainage system without sunk; (iii) regulating pondage; and (iv) gas ventilation system without cap, (v) connection of leachate drainage system and gas ventilation system.
Managed poorly – semi-aerobic	0.7[c]	When semi-aerobic managed SWDS type is managed under one of the following condition, it is regarded as poor management; (i) condition of sunk of leachate drainage system; (ii) closing of valve of drainage or atmosphere-unopening of drainage exit; (iii) capping of gas ventilation exit.
Managed well – active-aeration	0.4[d,e,f]	Active aeration of managed landfills includes the technology of in-situ low pressure aeration, air sparging, bioventing, passive ventilation with extraction (suction). These must have controlled placement of waste and will include leachate drainage system to avoid the blockage of air penetration, and (i) cover material; (ii) air injection or gas extraction system without drying of waste.
Managed poorly – active-aeration	0.7[f,g,h]	When SWDS, that is equipped as well as active aeration of managed SWDS, is managed under one of the following condition, it is judged as poor management; (i) blockage of aeration system due to failure of drainage; (ii) lack of available moisture for microorganisms due to high- pressure aeration.
Unmanaged – deep (>5 m waste) and /or high water table	0.8[a]	All SWDS not meeting the criteria of managed SWDS and which have depths of greater than or equal to 5 metres and/or high water table at near ground level. Latter situation corresponds to filling inland water, such as pond, river or wetland, by waste.
Unmanaged – shallow (<5 m waste)	0.4[a]	All SWDS not meeting the criteria of managed SWDS and which have depths of less than 5 metres.
Uncategorised SWDS	0.6[a]	Only if countries cannot categorise their SWDS into above four categories of managed and unmanaged SWDS, the MCF for this category can be used.

Sources: [a]IPCC (2000); [b]Matsufuji *et al.* (1996); [c]Yamada *et al.* (2013); [d]Hrad *et al.* (2013); [e]Ishigaki *et al.* (2003); [f]Ritzkowski & Stegmann (2013); [g]Raga & Cossu (2014); [h]Ritzkowski *et al.* (2016)

Chapter 3: Solid Waste Disposal

- DOC_f
  - Default data on fraction of DOC_f by types of waste are updated.
    - Less decomposable waste
    - Moderately decomposable waste
    - Highly decomposable waste
  - This allow parties to choose DOC_f that fit with country waste types.
  - Improve waste model to accommodate updated DOC_f

TABLE 3.0 (NEW)
FRACTION OF DEGRADABLE ORGANIC CARBON WHICH DECOMPOSES (DOC_F) FOR DIFFERENT WASTE TYPES

Type of Waste	Recommended Default DOC_f Values	Remark
Less decomposable wastes e.g. wood, engineered wood products, tree branches (wood)	0.1	An average value of 0.088 was derived from DOC_f values for engineered wood products, sawn woods, tree branches reported in 3 references[1-3]
Moderately decomposable wastes e.g. paper, textile, nappies	0.5	An average value of 0.523 was derived from DOC_f values for paper products, textile and nappies reported in 4 references[4-7].
Highly decomposable wastes, e.g. food wastes, grasses (garden and park waste excluding tree branches)	0.7	An average value of 0.706 was derived from DOC_f values for food wastes and grasses reported in 3 references[4-6]
Bulk waste*	0.5	

[1] Wang *et al*. (2011); [2] Wang and Barlaz (2016); [3] Ximenes *et al*. (2018); [4] Eleazer *et al*. (1997); [5] Bayard *et al*. (2017); [6] Jeong (2016); [7] Wang *et al*. (2015)

* It is used when the fractions of less, moderately and highly decomposable wastes in MSW are not known.

Chapter 3: Solid Waste Disposal

- Guidance on estimation of DOC lost with leachate from SWDS.
- Whenever DOC lost with the leachate from SWDS is considered, the emission from leachate handling should be estimated and accounted for in wastewater treatment and discharge category.

BOX 3.0B (NEW)
INFORMATION ON EFFECT OF DOC LEACHING FROM SWDS

Recent literature reported that the operation of anaerobic landfills under wet conditions yielded higher organic carbon release with leachate forms while reducing landfill gas production potential due to carbon washout by leachate (Jiang *et al*. 2007). Average rainfall of 2-12 mm/d influenced total amount of CH_4 generated from food waste because carbon washout increase with rainfall (Karanjekar *et al*. 2015). Drainage of accumulated leachate from municipal solid waste landfills containing waste with high percentage of food waste (~60% wet wt. basis) led to a loss of landfill gas of more than 10% (Zhan *et al*. 2017).

Chapter 3: Solid Waste Disposal

Waste Model

DOCf

Parameters

Country

Region Asia– Southern

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	Note
Industrial waste	0-0.54	0.15	0.15		The c
DOCf (fraction of DOC dissimilated)		0.5	0.5		
Less decomposable waste, e.g. wood, engineered wood products, branches		0.1	0.1		
Moderately decomposable waste, e.g. paper, textile, nappies		0.5	0.5		
Highly decomposable waste, e.g. food waste, grass (garden and park waste excluding tree branches)		0.7	0.7		
Methane generation rate constant (k)	Wet temperate				
(years^{-1})	**Range**	**Default**			

MCF

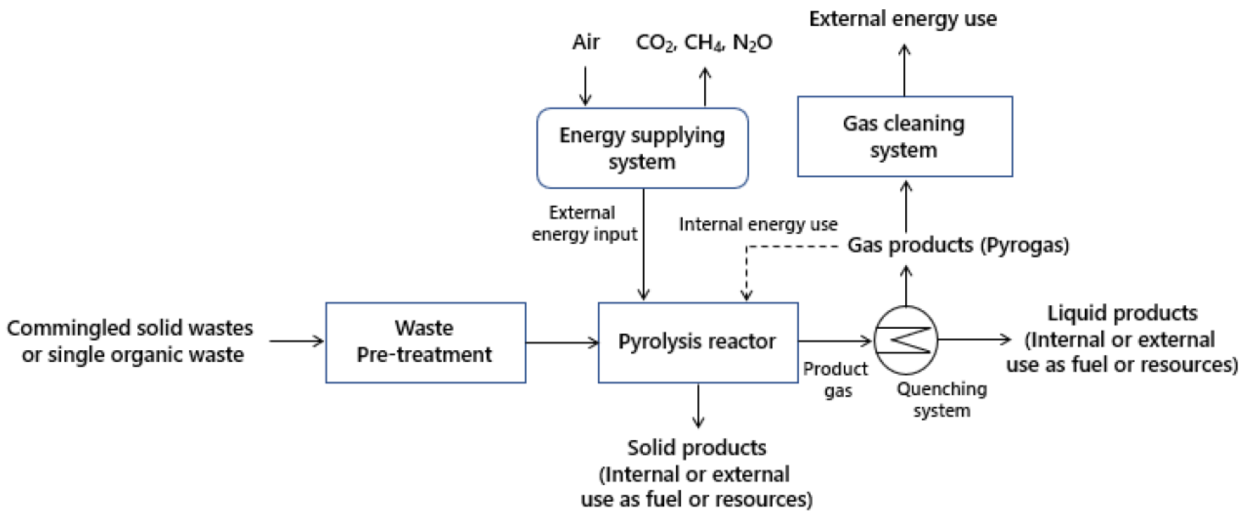
Methane Correction Factor (MCF)

This worksheet calculates a weighted average MCF from the estimated distribution of site types
Enter either IPCC default values or national values into the yellow MCF cells in row 12
Then enter the approximate distribution of waste disposals (by mass) between site types in the columns below.
Totals on each row must add up to 100% (see "distribution check" values)

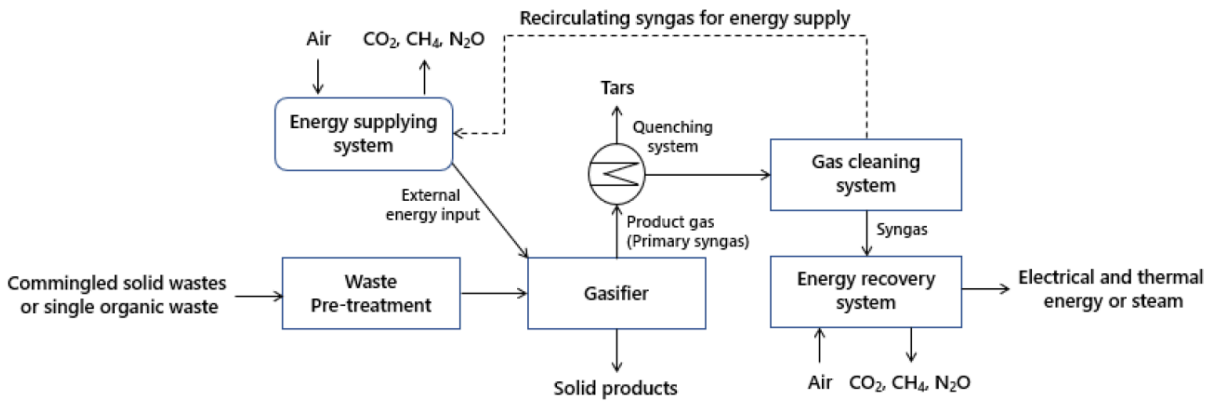
	MSW								
	Un-managed, shallow	Un-managed, deep	Managed	Managed well – semi aerobic	Managed poorly – semi-aerobic	Managed well – active-aeration	Managed poorly – active-aeration	Uncate-gorised	Distri-bution Check
	MCF	MCF	MCF	MCF	MCF	MCF	MCF	MCF	
IPCC default	0.4	0.8	1	0.5	0.7	0.4	0.7	0.6	
Country-specific value	0.4	0.8	1	0.5	0.7	0.4	0.7	0.6	
	Distribution of Waste by Waste Management Type								
"Fixed" Country-specifc value	25%	30%	25%	5%				15%	**Total**
Year	%	%	%	%				%	**(100%)**
1950	25%	30%	25%	5%				15%	100%
1951	25%	30%	25%	5%				15%	100%
1952	25%	30%	25%	5%				15%	100%
1953	25%	30%	25%	5%				15%	100%
1954	25%	30%	25%	5%				15%	100%
1955	25%	30%	25%	5%				15%	100%

Chapter 5: Incineration and Open Burning of Waste

- New technology on thermal treatment are defined to increase understanding of thermal treatment.



Pyrolysis



Gasification

Chapter 5: Incineration and Open Burning of Waste

- Default emission factor of CH4 and N2O of updated thermal technology are presented.

TABLE 5.3A (NEW)
CH_4 EMISSION FACTORS FOR PYROLYSIS-MELTING AND GASIFICATION-MELTING PLANT OF MSW

Process	Operating temperature (°C)	CH_4 Emission Factors (g/t waste on a wet basis)	Reactor Type
Pyrolysis-melting and gasification-melting	Pyrolysis: 300 ~ 600°C Gasification: 700~900°C Melting: 1300~1700°C	5.81[1,2] (n=11)	Shaft type
		9.70[1] (n=10)	Fluidized bed type
		5.40[1] (n=5)	Rotary kiln type

[1]Ministry of the Environment, Japan (2010)
[2]Lee *et al*. (2015)

TABLE 5.4A (NEW)
N_2O EMISSION FACTORS FOR PYROLYSIS-MELTING AND GASIFICATION-MELTING PLANT OF MSW

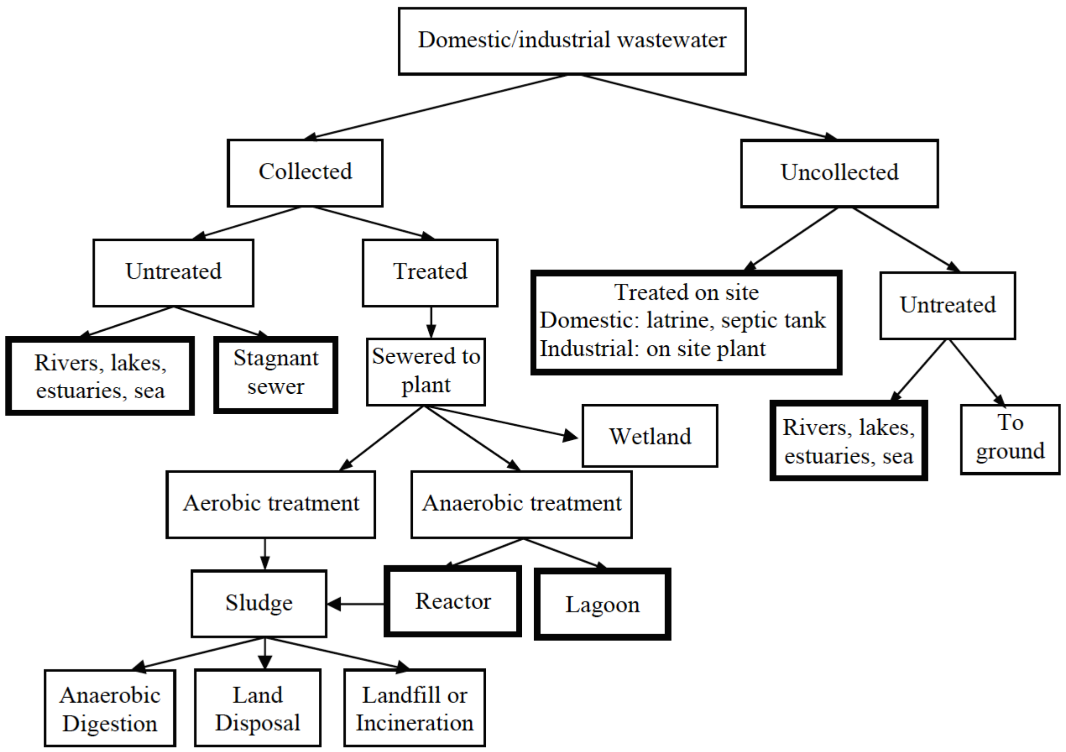
Process	Operating temperature (°C)	N_2O Emission Factors, (g/t waste on a wet basis)	Reactor Type
Pyrolysis-melting and gasification-melting	Pyrolysis: 300 ~ 600°C Gasification: 700~900°C Melting: 1300~1700°C	17.4[1,2] (n=11)	Shaft type
		5.80[1] (n=10)	Fluidized bed type
		8.38[1,3] (n=6)	Rotary kiln type

[1]Ministry of the Environment, Japan (2010)
[2]Lee *et al*. (2015)
[3]Yoon (2017)

Chapter 6: Waste Water Treatment and Discharge

2006 GL

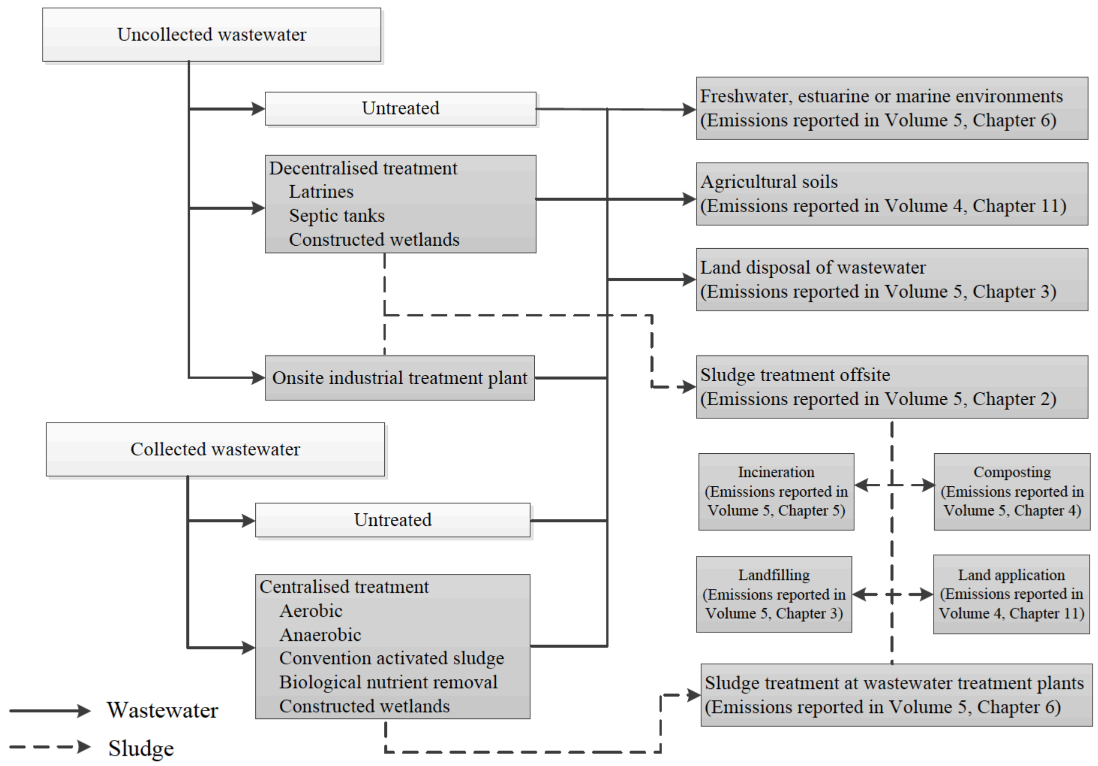
Figure 6.1 Wastewater treatment systems and discharge pathways



Note: Emissions from boxes with bold frames are accounted for in this chapter.

2019 Refinement

Figure 6.1 (Updated) Wastewater treatment systems and discharge pathways



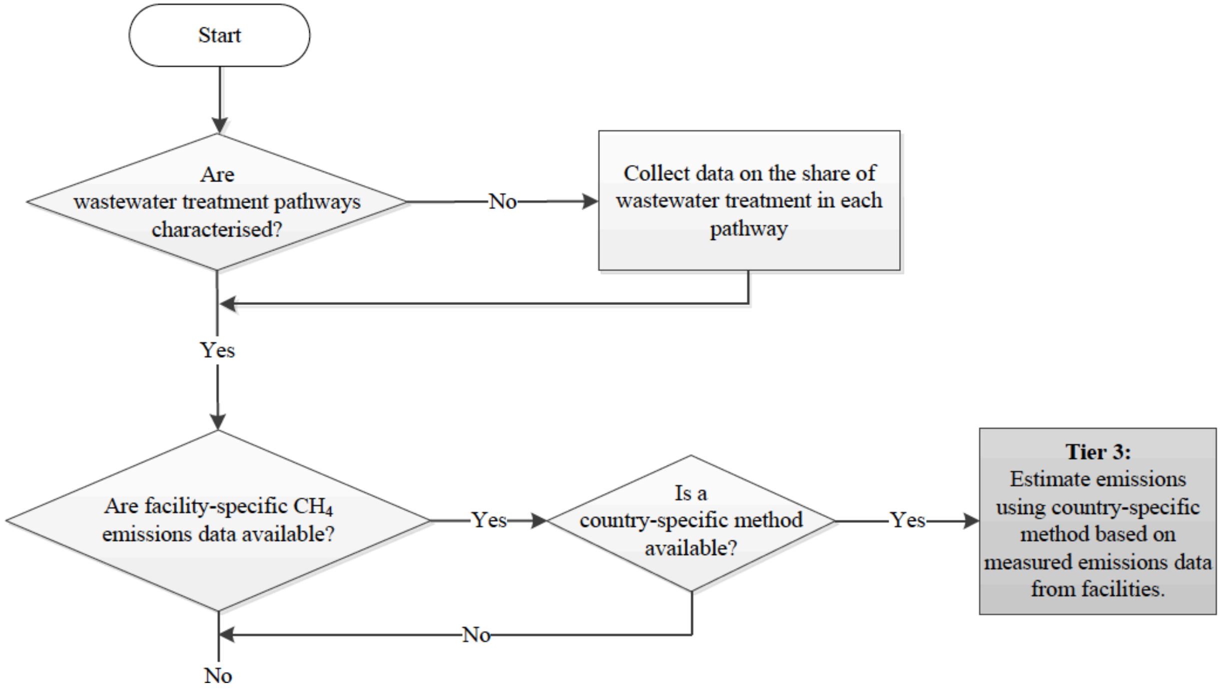
Chapter 6: Waste Water Treatment and Discharge

- Guidance and definition of wastewater treatment system including introduction of new and improved default values and emission factors with association of GHG emission mechanism from wastewater treatment

TABLE 6.3 (UPDATED)
DEFAULT MCF VALUES AND RESULTANT EFs FOR DOMESTIC WASTEWATER[1]

Type of treatment and discharge pathway or system	Comments	MCF [1] (Range)	EF[2] (kg CH_4/kg BOD)	EF[2] (kg CH_4/kg COD)
Discharge from treated or untreated system				
Discharge other than to reservoirs, lakes, and estuaries (Tier 1)	Most freshwater systems including rivers are supersaturated in CH_4. Nutrient oversupply will increase CH_4 emissions.	0.035[3] (0.004 – 0.06)	0.021	0.009
Discharge to reservoirs, lakes, and estuaries (Tier 1a)	Environments where carbon accumulates in sediments have higher potential for methane generation.	0.19[3] (0.08 – 0.27)	0.114	0.048
Discharge to soil	Dry climate; negligible emissions	0	0	0
Discharge to soil	Wet climate	0.7 (0.7 – 1.0)	0.42	0.175
Untreated system				
Stagnant sewer	Open and warm	0.5 (0.4 – 0.8)	0.3	0.125
Flowing sewer (open or closed)	Fast moving, clean. (Insignificant amounts of CH_4 from pump stations, etc.)	0	0	0

Figure 6.2 (Updated) Decision tree for CH_4 emissions from domestic wastewater



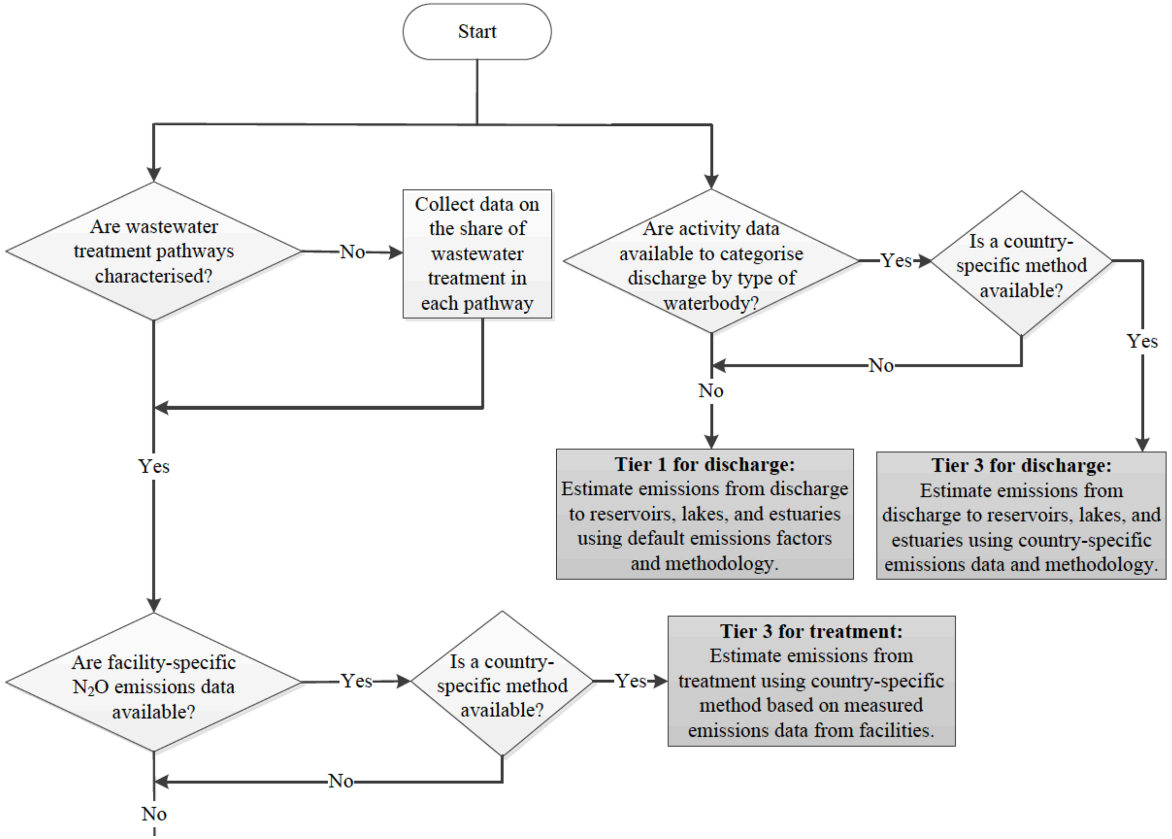
Chapter 6: Waste Water Treatment and Discharge

- Updates N2O emissions from domestic wastewater including centralized treatment plants and industrial wastewater.

Table 6.8A (New)
Default EF values for domestic and industrial wastewater

Type of treatment and discharge pathway or system	Comments	EF[1] (kg N_2O-N/kg N)	Range
Discharge from treated or untreated system, $EF_{EFFLUENT}$			
Freshwater, estuarine, and marine discharge (Tier 1)	Based on limited field data and on specific assumptions regarding the occurrence of nitrification and denitrification in rivers and in estuaries	0.005[2]	0.0005 – 0.075
Nutrient-impacted and/or hypoxic freshwater, estuarine, and marine environments (Tier 3, if needed)	Higher emissions are associated with nutrient-impacted/hypoxic water such as eutrophic lakes, estuaries and rivers, or locations where stagnant conditions occur	0.019[2]	0.0041 – 0.091
Discharge to soil	Dry climate	0.005	0.0005 – 0.075
Discharge to soil	Wet climate	0.005	0.0005 – 0.075
Wastewater treatment system, EF_{plants}			
Centralised, aerobic treatment plant	N_2O is variable and can be significant	0.016[1]	0.00016 – 0.045
Anaerobic reactor	N_2O is not significant	0	0 – 0.001
Anaerobic lagoons	N_2O is not significant	0	0 – 0.001
Constructed wetlands	See 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (IPCC 2014)		
Septic tank	N_2O is not significant	0	0 – 0.001
Septic tank + land dispersal field	N_2O is emitted by the soil dispersal system	0.0045	0 – 0.001
Latrine	N_2O is not significant	0	0 – 0.001
Sludge treatment system			

Figure 6.4 (New) Decision tree for N_2O emissions from domestic wastewater



How to start

- Familiar yourself with Annex 1 : Mapping tables
- Understanding type of Refinement: U – Update, NG – New Guidance, NR – No Refinement, R – Removed
- Follow the road map in related sections, equations, tables, figures and boxes in the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

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Thank you for your attention