How to estimate emissions from Wastewater Handling

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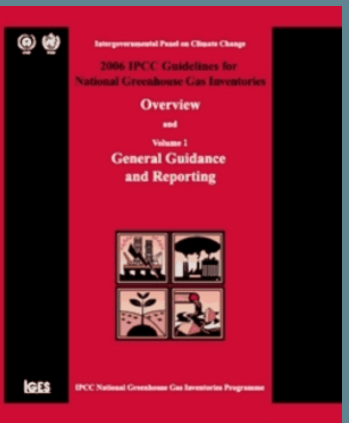
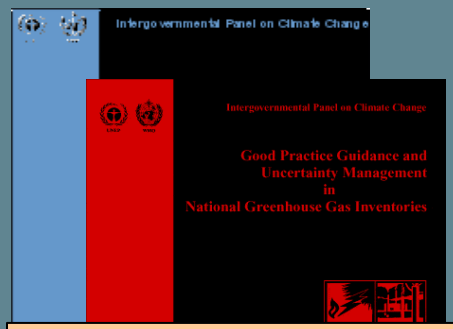
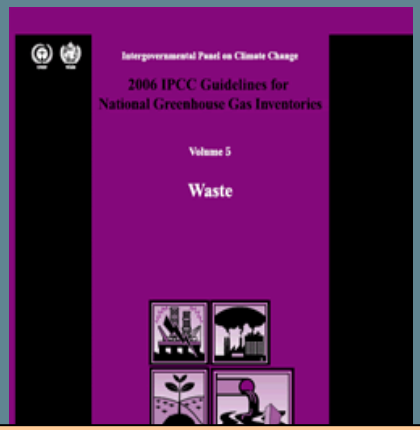


The 4th Workshop on GHG Inventories in Asia (WGIA)
14-15 February 2007, Jakarta, Indonesia

Reporting Categories



1996 Guidelines (Vol.3)
Chapter 6, Sections 6.3, 6.4
GPG2000
Chapter 5, Section 5.2



2006 Guidelines
Volume 5, Chapter 6

1996 Guidelines + GPG2000

6B: Wastewater Handling

- 6B1: Industrial Wastewater
- 6B2: Domestic and Commercial Wastewater
- 6B3: Other

Essentially the same!

2006 Guidelines

4D: Wastewater Treatment and Discharge

- 4D1: Domestic Wastewater Treatment and Discharge
- 4D2: Industrial Wastewater Treatment and Discharge

4E: Other

Methods for emission estimation

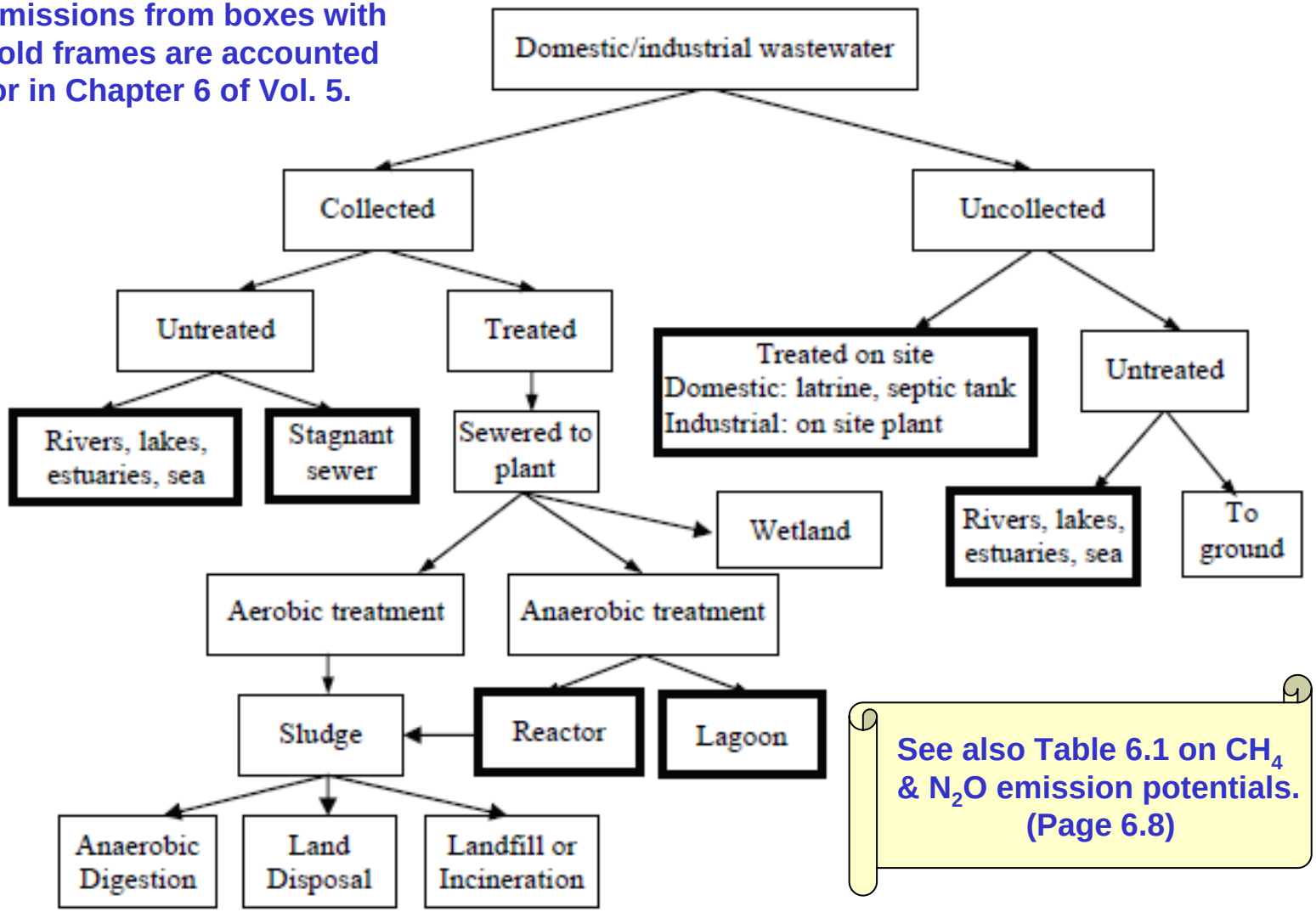
- Under the UNCCC, Non-Annex I Parties should use 1996GLs, and are encouraged to apply GPG2000.
- However, for this category, the 2006GLs can be used to estimate emissions, because the methods are essentially the same as, and better than, the 1996GLs.
  - ✓ Reasonably simplified (e.g., distinction between wastewater and sludge has been removed [following GPG2000])
  - ✓ Wider coverage (e.g., CH_4 from uncollected wastewater)
  - ✓ Up-to-date information and data available
- Therefore, let's see 2006GLs methods here.
- Attention!!
  - ✓ Spreadsheets in the UNFCCC Inventory Software are not entirely compatible with 2006GLs calc procedure.
  - ✓ Worksheets in Vol.5 can be used instead.

Overview of this category

- Gases to be estimated and reported
  - ✓ CH_4 and N_2O
  - ✓ CO_2 emissions are not considered because these are of biogenic origin
- Sources by type
  - ✓ Domestic (including commercial) wastewater / Industrial wastewater
  - ✓ Collected / Uncollected
  - ✓ Treated / Untreated

Wastewater treatment system and discharge pathways

Emissions from boxes with bold frames are accounted for in Chapter 6 of Vol. 5.



See also Table 6.1 on CH_4 & N_2O emission potentials. (Page 6.8)

Important factors for CH_4 production

- Wastewater and sludge can produce CH_4 if it degrades anaerobically.
- CH_4 production depends primarily on
  - ✓ Quantity of degradable organic material
    - BOD (BOD_5) for domestic wastewater
    - COD (by dichromate method) for industrial wastewater
  - ✓ Temperature
    - Below 15 ^oC, significant production is unlikely
  - ✓ Type of treatment system
    - Degree to which the system is anaerobic - MCF

Estimation of CH_4 emissions

- Three tiers according to data availability
  - ✓ Tier 1: Default values for EFs and activity parameters
  - ✓ Tier 2: Same method as Tier 1 with country-specific EFs and activity parameters
  - ✓ Tier 3: Advanced country-specific method (based on plant-specific data from large wastewater treatment facilities)
- Determine the tier to use following the decision trees
- If this is a key category, Tier 2 or 3 should be used.

CH_4 from domestic wastewater treatment and discharge (Tiers 1 & 2)

- Step 1: Estimate total organically degradable carbon in wastewater (TOW) [kg BOD/yr]

$$TOW = P \times BOD \times 0.001 \times I \times 365$$

P = country population [person]
BOD = per capita BOD [g/person/day]
I = correction factor for additional industrial BOD discharged into sewers [fraction]

- Step 2: Obtain emission factors (EF_j) [kg CH_4/kg BOD]
  - ✓ Select the pathways and systems
  - ✓ Obtain EFs for each pathway or system (j)

$$EF_j = B_o \times MCF_j$$

B_o = maximum CH_4 producing capacity [kg CH_4/kg BOD]
MCF_j = methane correction factor [fraction]

CH_4 from domestic wastewater treatment and discharge (Tiers 1 & 2)

- Step 3: Calculate emissions from TOW and EF_j, and adjust for possible sludge removal and/or CH_4 recovery

$$CH_4 \text{ emissions [kg } CH_4\text{/yr]} = [\sum_{i,j} (U_i \times T_{i,j} \times EF_j)] \times (TOW - S) - R$$

U_i = fraction of population in income group (i) [fraction]

$T_{i,j}$ = degree of utilisation of treatment/discharge pathway or system (j) for each income group (i) [fraction]

$\sum_i (U_i \times T_{i,j})$ = fraction of WW treated in the system (j)

(Ensure $\sum_{i,j} (U_i \times T_{i,j}) = 1$!!)

S = organic component removed as sludge [kg BOD/yr]

R = amount of CH_4 recovered [kg CH_4/yr]

- Default values for S and R = 0

CH_4 from domestic wastewater treatment and discharge (Tiers 1 & 2)

TABLE 6.6
EXAMPLE OF THE APPLICATION OF DEFAULT VALUES FOR DEGREES OF TREATMENT UTILIZATION (T) BY INCOME GROUPS

$U_i \times T_{i,j}$

Treatment or discharge system or pathway		T (%)	Notes
Urban high-income	To sea	10	No CH_4
	To aerobic plant	20	Add industrial component
	To septic systems	10	Uncollected
Urban low-income	To sea	10	Collected
	To pit latrines	15	Uncollected
Rural	To rivers, lakes, sea	15	
	To pit latrines	15	Uncollected
	To septic tanks	5	
Total		100%	Must add up to 100 %

Reference: [illegible]born and Liles (1999)

Income group (i)

Pathway or system (j)

CH_4 from industrial wastewater treatment and discharge (Tiers 1 & 2)

- Step 1: Estimate total organically degradable carbon in wastewater for industrial sector (i) (TOW_i) [kg COD/yr]
  - ✓ First, identify major industrial sectors with large potentials for CH_4 emissions. (e.g., pulp & paper, food & drink, etc.)

$$TOW_i = P_i \times W_i \times COD_i$$

P_i = total industrial product for industrial sector (i) [t/yr]

W_i = wastewater generated in industrial sector (i) [m^3/t-product]

COD_i = chemical oxygen demand (industrial organic component in wastewater generated in industrial sector (i) [kg COD/m^3]

- Step 2: Obtain emission factors (EF_i) [kg CH_4/kg COD]

$$EF_i = B_o \times MCF_i \text{ (similarly to dom. WW)}$$

CH_4 from industrial wastewater treatment and discharge (Tiers 1 & 2)

- Step 3: Calculate emissions from TOW_i and EF_i, and adjust for possible sludge removal and/or CH_4 recovery

$$CH_4 \text{ emissions [kg } CH_4\text{/yr]} = \sum_i [(TOW_i - S_i) \times EF_i - R_i]$$

S_i = organic component removed as sludge in industrial sector (i) [kg COD/yr]

R_i = amount of CH_4 recovered in industrial sector (i) [kg CH_4/yr]

- Default values for S_i and R_i = 0

Issues on sludge

- CH_4 emissions from sludge sent to landfills, incinerated or used in agriculture should not be included in this category.
- The amount of organic component removed as sludge ("S" in the equations) should be equal to the sum of:
  - ✓ amount of sludge disposed at SWDS
  - ✓ amount of sludge applied to agricultural land
  - ✓ amount of sludge incinerated or used elsewhere
- Wastewater and sludge that is applied on agricultural land should be considered in Agriculture (or AFOLU) Sector.

Estimation of N_2O emissions

- N_2O emissions can occur as:
  - ✓ direct emissions from treatment plants; or
  - ✓ indirect emissions from wastewater after disposal of effluent into waterways, lakes or the sea
- Typically, direct emissions are much smaller than indirect emissions.
  - ✓ Except for countries that predominantly have advanced centralized wastewater treatment plants with nitrification and denitrification steps
- Industrial sources are believed to be insignificant.
- Only one tier for indirect emissions from domestic wastewater:
  - ✓ No higher tiers, no decision tree
  - ✓ Industrial wastewater co-discharged with domestic wastewater into the sewer system is included

N_2O from domestic wastewater treatment effluent (indirect emissions)

- Step 1: Estimate total nitrogen in the effluent ($N_{EFFLUENT}$) [kg N/yr]

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

P = human population [person]

Protein = annual per capita protein consumption [kg/person/yr]

F_{NPR} = fraction of nitrogen in protein [kg N/kg protein] (default = 0.16)

$F_{NON\text{-}CON}$ = fraction for non-consumed protein added to the wastewater [fraction]

$F_{IND\text{-}COM}$ = fraction for industrial and commercial co-discharged protein into the sewer system [fraction]

N_{SLUDGE} = nitrogen removed with sludge [kg N/yr]

N_2O from domestic wastewater treatment effluent (indirect emissions)

- Step 2: Calculate emissions by multiplying an emission factor to $N_{EFFLUENT}$

$$N_2O \text{ emissions } [kg\ N_2O/yr] = N_{EFFLUENT} \times EF_{EFFLUENT} \times 44/28$$

$EF_{EFFLUENT}$ = emission factor for N2O emissions from wastewater effluent discharged into aquatic environments [kg N_2O-N/kg N]

(Default value is 0.005 (0.0005-0.25) [kg N_2O-N/kg N].
= Consistent with the EF for indirect N_2O in AFOLU.)

44/28 = factor for conversion of kg N_2O-N into kg N_2O

For more details…

- Default values for EFs and other various parameters can be found in Chapter 6 of Vol.5 of 2006GLs.
- Worksheets – See Annex 1 of Vol.5.
- Any questions?