Waste Management/Handling CDM Project

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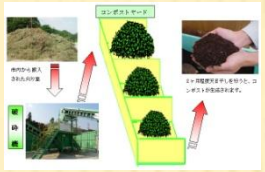
1. Waste Management and GHGs Emission

Waste Discharge at Sources

Collection and Transportation



Intermediate Treatment

Final Disposal at Landfills

CO_2

Fuel combustion by collection vehicles

CO_2

In the case of incinerating waste with the use of fossil fuels

CH_4

Anaerobic decomposition of organic wastes

2. Wastewater Management and GHGs Emission

CH_4

(Anaerobic Decomposition of organic matter)

Domestic Wastewater

Agricultural Wastewater

3. CDM Project Prototypes

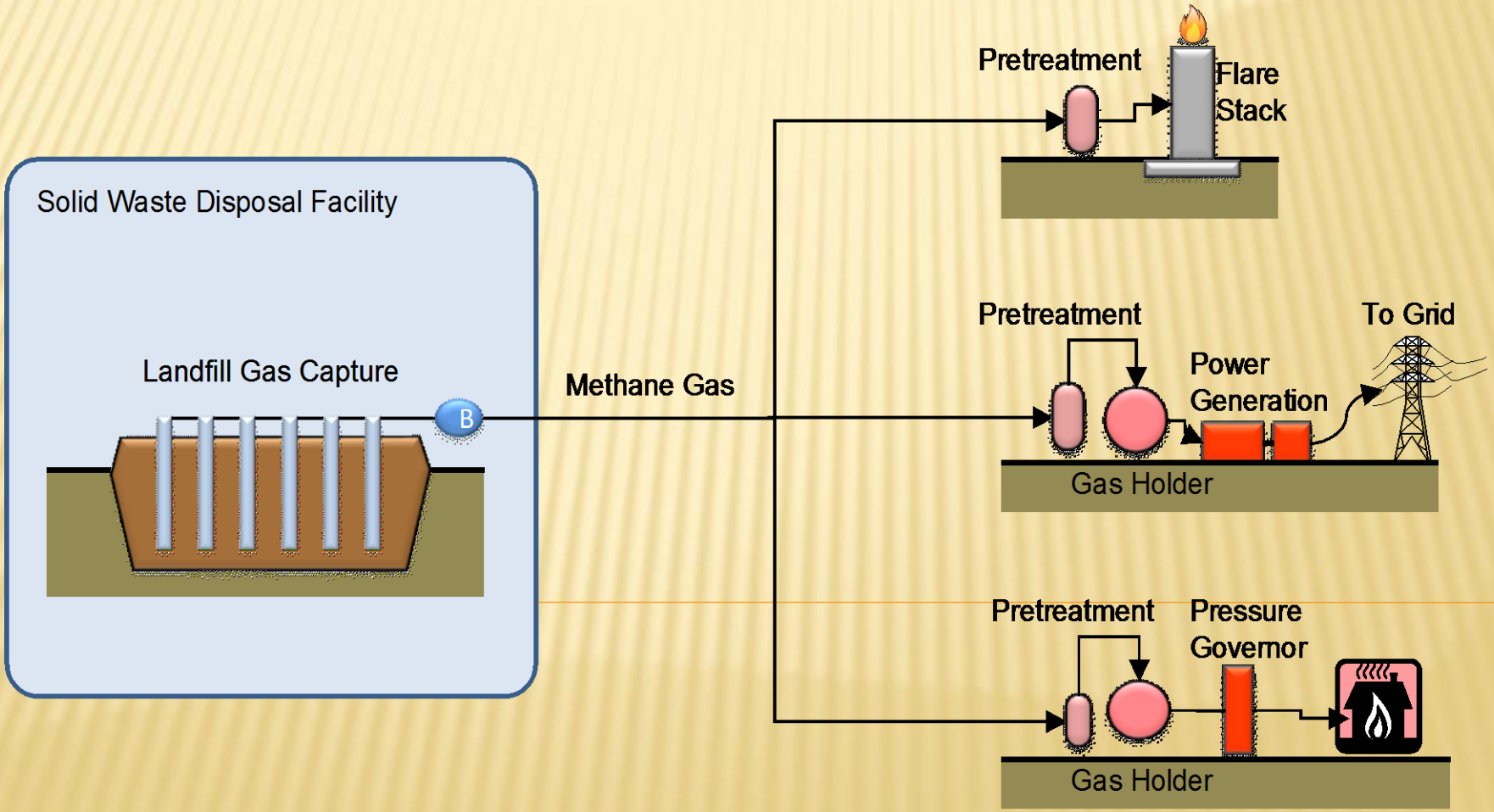
GHG emission source	Emission Reduction Methods	
Solid Waste/ Wastewater	CH_4 Capture	Flaring (Burning)
		Direct heat use
		Electricity generation
	CH_4 Emission Avoidance/Reduction by Aerobic Treatment of Organic Matter	

Including composting

Applicable GHGs emission reduction methods are basically same for solid waste and wastewater treatment.

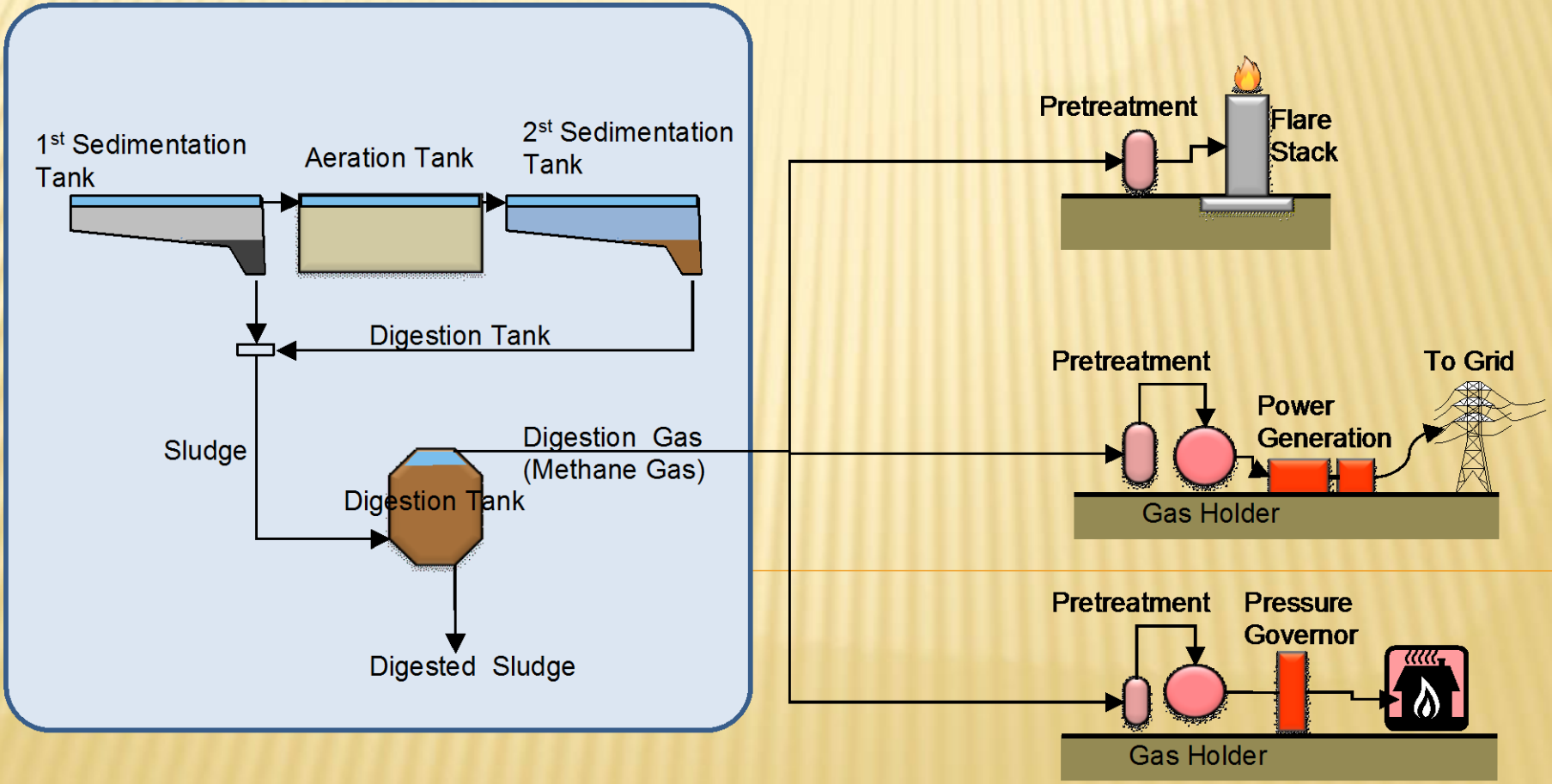
3. CDM Project Prototypes

(1) Methane capture from waste landfill



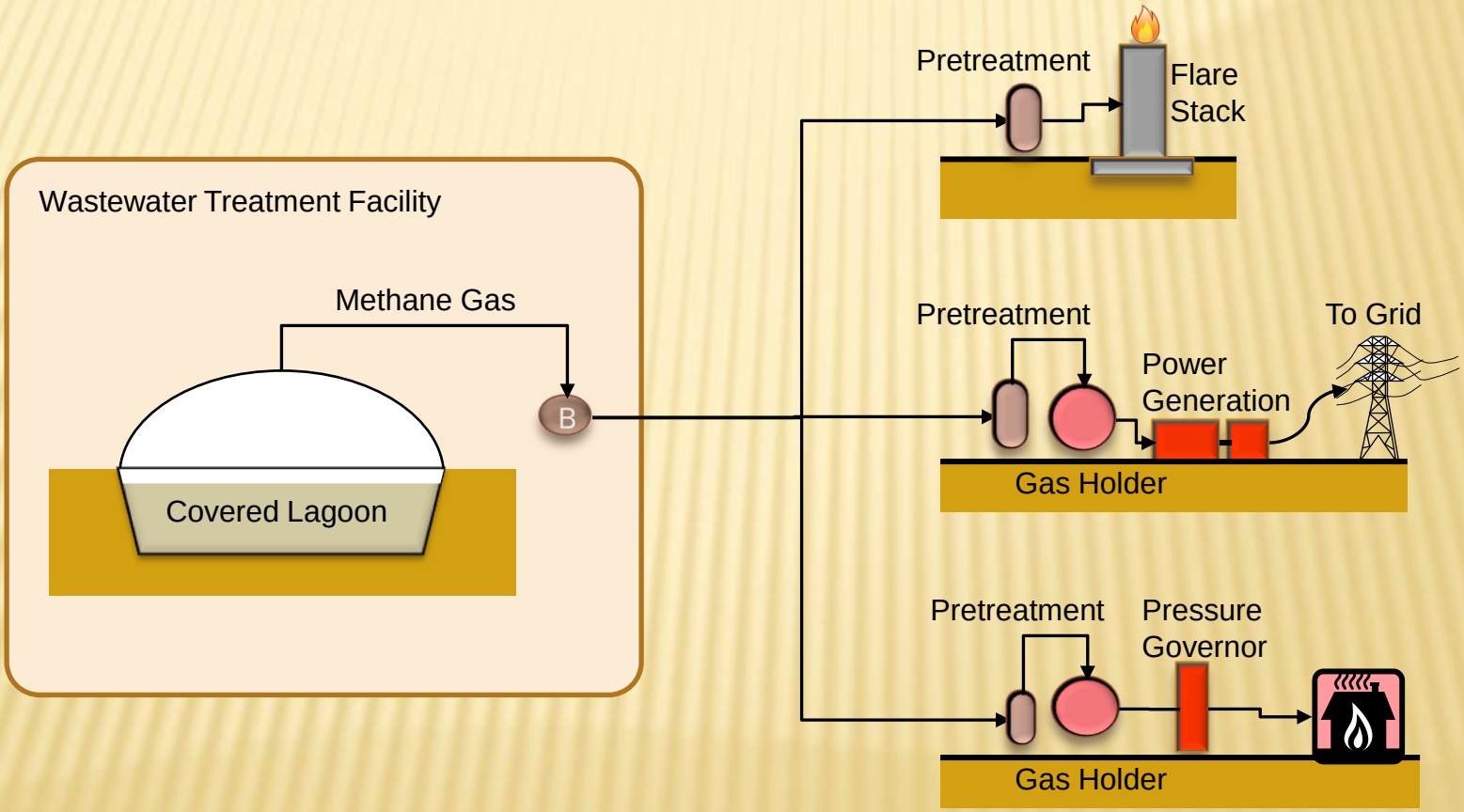
3. CDM Project Prototypes

(2) Methane capture from anaerobic wastewater treatment (Type A)



3. CDM Project Prototypes

(3) Methane capture from anaerobic wastewater treatment (Type B)

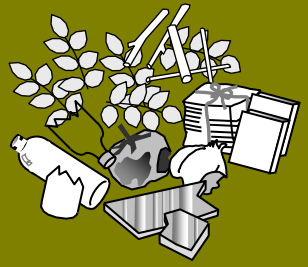


3. CDM Project Prototypes

(4) Methane avoidance by composting of organic matter in solid waste

Current Practice (before CDM Project)

Project Scenario



Organic

Inorganic

Composting

Recycling

Residue

Residue

4. Key parameters in CH_4 emission from waste

CH_4 emission from waste

- CH_4 is generated as a result of **degradation of organic materials** under **anaerobic conditions**.
- **The time required for the waste to decay (half-life) is different among the types of waste**.
- **Part of CH_4 generated is oxidized** in the cover of solid waste disposal (CH_4 oxidation by methanotrophic micro-organisms in cover soils).

Key Parameter in CH_4 emission

- Degradable organic materials (Degradable Organic Carbon: DOC) in waste.
- Degree of anaerobic condition in waste (Methane Correction Factor: MCF).
- The time required for the waste to decay (decay rate)

4. Key parameters in CH_4 emission from waste

(1) Content of DOC by types of waste

Type of Waste	DOC content (% on weight basis)	
	Wet waste	Dry waste
Paper/cardboard	40	44
Textiles	24	30
Food waste	15	38
Wood	43	50
Garden and park waste	20	49
Nappies	24	60
Rubber and leather	39	47
Inert waste (plastic, metal, glass)	-	-

Content of organic waste is the key to amount of CH_4 emission.

4. Key parameters in CH_4 emission from waste

(2) Degree of anaerobic condition (Methane Correction Factor)

Type of Waste disposal (Landfill)	Methane Correction Factor (MCF)
Managed – anaerobic	1.0
Managed – semi-aerobic	0.5
Unmanaged – deep (>5 m waste) and/or high water table	0.8
Unmanaged – Shallow (<5 m waste)	0.4
Uncategorised waste disposal	0.6

- The intensity of methane emission is considerably influenced by the anaerobic condition of waste varying with types of final disposal practices.
- The more anaerobic the condition of waste, the more CH_4 is generated.

4. Key parameters in CH_4 emission from

(2) Degree of anaerobic condition (Methane Correction Factor)

Type of Waste disposal (Landfill)	Definition
Managed – anaerobic	The landfills which 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 include at least one of the following: (i) cover material; (ii) mechanical compacting; or (iii) levelling of the waste.
Managed – semi-aerobic	The landfills which have controlled placement of waste and include all of the following structures for introducing air to waste layer: (i) permeable cover material; (ii) leachate drainage system; (iii) regulating pondage; and (iv) gas ventilation system.
Unmanaged – deep (>5 m waste) and/or high water table	All landfills not meeting the criteria of managed landfill s above and which have depths of greater than or equal to 5 meters and/or high water table at near ground level.
Unmanaged – Shallow (<5 m waste)	All landfills not meeting the criteria of managed landfills above and which have depths of less than 5 meters.

4. Key parameters in CH_4 emission from

(3) Time required for the waste to decay (Decay rate of waste)

Type of Waste		Tropical Climate (MAT >20℃)	
		Dry (MAP<1,000mm)	Moist and Wet (MAP>=1,000mm)
Slowly degrading waste	Paper/textiles waste	0.045	0.07
	Wood/straw waste	0.025	0.035
Moderately degrading waste	Other (non-food) organic putrescible/Garden and park waste	0.065	0.17
Rapidly degrading waste	Food waste/sewerage sludge	0.085	0.4

■ Decay rate of waste is given as a constant by types of waste based on the time required to decay.

5. Estimation of CH_4 from Waste Disposal Site

Equation

$$BE_{CH4,SWDS,y} = \varphi \cdot (1 - f) \cdot GWP_{CH4} \cdot (1 - OX) \cdot \frac{16}{12} \cdot F \cdot DOC_f \cdot MCF \cdot \sum_{x=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k_j \cdot (y-x)} \cdot (1 - e^{-k_j})$$

$BE_{CH4, SWDS,y}$	Methane emissions during the year y from waste disposal at the solid waste disposal site (SWDS) during the period from the start of waste disposal activity to the end of the year y (tCO_2e)
φ	Model correction factor to account for model uncertainties (0.9)
f	Fraction of methane captured at the SWDS and flared, combusted or used in another manner (in this case 0)
GWP_{CH4}	Global Warming Potential (GWP) of methane, valid for commitment (21)
OX	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste (default value: 0.1)
F	Fraction of methane in the SWDS gas (volume fraction) (default value:0.5)
DOC_f	Fraction of degradable organic carbon (DOC) that can decompose (default value:0.5)

5. Estimation of CH_4 from Waste Disposal Site

Equation

$$BE_{CH4,SWDS,y} = \varphi \cdot (1 - f) \cdot GWP_{CH4} \cdot (1 - OX) \cdot \frac{16}{12} \cdot F \cdot DOC_f \cdot MCF \cdot \sum_{x=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k_j \cdot (y-x)} \cdot (1 - e^{-k_j})$$

MCF	Methane correction factor (determined by types of SWDS)
$W_{j,x}$	Amount of organic waste type j disposed at the SWDS in the year x (tons)
DOC_j	Fraction of degradable organic carbon (by weight) in the waste type j
k_j	Decay rate for the waste type j
j	Waste type category
e	The base of natural logarithm (Napier's number: 2.718)
X	Year during the crediting period: x runs from the first year of the first crediting period (x=1) to the year y for which avoided emissions are calculated (x=y)
Y	Year for which methane emissions are calculated.

6. Case Example: Estimation CH_4 emission from SWDS in Sri Lanka

1. Preconditions

Items	Preconditions	
The amount of waste disposed		6,400 tons/day (2008)
Waste composition by types (% by weight)	Bio-degradable waste	62.0%
	Paper	6.5%
	Plastic	6.0%
	Wooden	6.0%
	Glass	2.0%
	Other waste	17.5%
Type of Waste Disposal Landfill	Unmanaged –deep (>5m) landfill	

(Source: National Policy on SWM in Sri Lanka, MENR)

Assumption: All the above waste are directly brought to the landfill above in Sri Lanka.

6. Exercise: Estimation CH_4 emission from SWDS

$$BE_{CH4,SWDS,y} = \varphi \cdot (1-f) \cdot GWP_{CH4} \cdot (1-OX) \cdot \frac{16}{12} \cdot F \cdot DOC_f \cdot MCF \cdot \sum_{x=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k_j \cdot (y-x)} \cdot (1-e^{-k_j})$$

5.67 (constant)

Choose the factor from below

Type of Waste disposal (Landfill)	Methane Correction Factor (MCF)
Managed – anaerobic	1.0
Managed – semi-aerobic	0.5
Unmanaged – deep (>5 m waste) and/or high water table	0.8
Unmanaged – Shallow (<5 m waste)	0.4
Uncategorised waste disposal	0.6

Need to estimate

6. Exercise: Estimation CH_4 emission from SWDS

$$\sum_{x=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k_j \cdot (y-x)} \cdot (1 - e^{-k_j})$$

Total amount of DOCs (Degradable Organic Carbons) decayed in the year

Amount of Waste A	×	DOC content of A	×	Decay rate of DOC A
Amount of Waste B	×	DOC content of B	×	Decay rate of DOC B
Amount of Waste C	×	DOC content of C	×	Decay rate of DOC C
Amount of Waste D	×	DOC content of D	×	Decay rate of DOC D

6. Exercise: Estimation CH_4 emission from SWDS

Step 1: Total amount of waste disposed per year

Amount of waste disposed (tons/day)	Amount of waste disposed (tons/year)
6,400	2,336,000

Step 2: Amount of waste disposed by type of waste

Amount of waste disposed (tons/year)	Waste composition by types (%)		Amount of Waste by types (tons/year)
2,336,000	Bio-degradable waste	62.0	1,448,320
	Papers	6.5	151,840
	Plastic	6.0	140,160
	Wooden	6.0	140,160
	Glass	2.0	46,720
	Other wastes	17.5	408,800

6. Exercise: Estimation CH_4 emission from SWDS

Step 3: Total amount of DOCs

Amount of Waste by types (tons/year)			Content of DOC (% on weight basis)	Total amount of DOCs (tons/year)
Bio-degradable waste	Food	724,160	15	108,624
	Garden/Park	724,160	20	144,832
Papers		151,840	40	60,736
Plastic		140,160	0	0
Wooden		140,160	43	60,268
Glass		46,720	0	0
Other wastes		408,800	0	0
			Total	**374,460**

Remark: The percentage of food and garden/park waste in bio-degradable waste is assumed at 50% for each.

6. Exercise: Estimation CH_4 emission from SWDS

Step 3: Total amount of DOCs

Amount of Waste by types (tons/year)		Amount of DOCs (tons/year)	Fraction of DOCs decayed in 10 years (tons/year)	Amount of DOCs decayed in 10 years (tons/year)
Bio-degradable waste	Food	108,624	57.3	62,241
	Garden/Park	144,832	47.8	69,229
Papers		60,736	36.2	21,986
Plastic		0	0	
Wooden		60,268	22.1	13,319
Glass		0	0	
Other wastes		0	0	
			Total	**166,775**

6. Exercise: Estimation CH_4 emission from SWDS

Step 4: Total emission of CH4 from SWDS in 10 years if the total

$$BE_{CH4,SWDS,y} = \varphi \cdot (1-f) \cdot GWP_{CH4} \cdot (1-OX) \cdot \frac{16}{12} \cdot F \cdot DOC_f \cdot MCF \cdot \sum_{x=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k_j \cdot (y-x)} \cdot (1-e^{-k_j})$$

5.67 (constant)	×	MCF (0.8)	×	Total amount of DOCs decayed in 10 years (826,284)

Answer	3,748,024 Ton CO2

Remark: The above calculation assumes that the amount and composition of solid waste generation will not change in 10 years.