Recent Development on Korea's Inventories with regard to Waste

Byong-Bok Jin, Cheon-Hee Bang

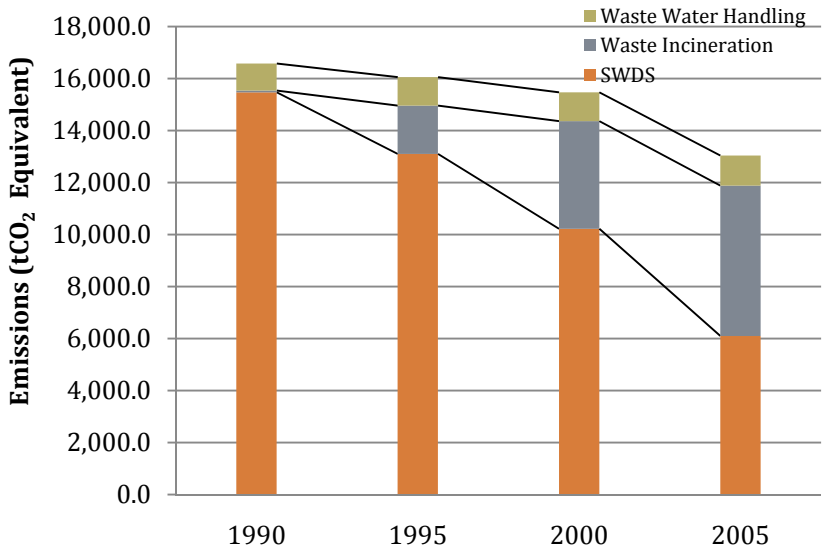
Environmental Management Corporation, Korea

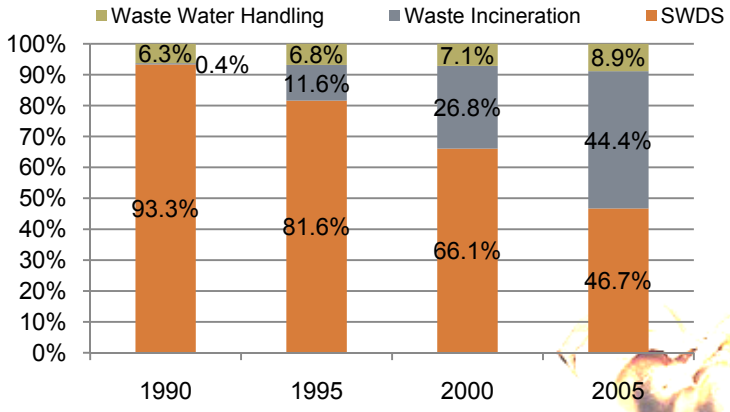
GHG Emission from Waste Sector

(Unit : tCO_2 Equivalent)

Year	SWDS	Waste Incineration		Waste Water Handling		Total
	CH_4	CO_2	N_2O	CH_4	N_2O	tCO_2
1990	15,469.3	46.6	21.3	78.3	962.1	16,578.1
1992	17,244.7	149.6	37.8	96.6	940.9	18,469.4
1993	14,220.4	93.5	41.1	97.6	931.0	15,383.5
1994	16,294.7	872.3	115.5	125.9	931.0	18,339.2
1995	13,102.1	1,694.7	162.4	138.2	958.8	16,056.3
1996	14,164.7	2,102.5	166.8	94.3	968.0	17,496.2
1997	13,505.8	2,028.0	183.7	90.9	977.5	16,786.0
1998	11,275.7	2,308.2	179.7	81.2	995.9	14,840.5
1999	11,656.0	3,032.7	207.5	120.3	1,003.6	16,020.0
2000	10,221.2	3,883.4	260.7	91.0	1,012.7	15,468.9
2001	9,676.7	4,699.6	265.8	104.2	983.8	15,729.6
2002	9,795.1	4,594.0	255.9	113.0	988.2	15,746.5
2003	9,309.7	4,687.1	271.0	114.0	994.4	15,376.2
2004	8,386.0	5,086.4	242.4	120.0	1,030.0	14,864.7
2005	**6,095.5**	**5,588.0**	**200.9**	**123.7**	**1,034.4**	**13,042.3**

Note) The above value is estimated by Tier 1 method





Solid Waste Disposal on Landfill

Plan to estimate the emissions of landfill gas the following,

- Methodology (IPCC GPG 2000, First Order Decay)

$$CH_4 \text{ emissions (t/yr)} = \sum [(A \cdot k \cdot MSW_T(X) \cdot MSW_F(X) \cdot L_O(X) \cdot e^{-k(t-x)}) - R] \cdot (1 - OX)$$

t = year of inventory

x = years for which input data should be added

$A = (1 - e^{-k}) / k$; normalization factor which corrects the summation

k = Methane generation rate constant (1/yr)

MSW_T (x) = Total municipal solid waste (MSW) generated in year x (t/yr)

MSW_F (x) = Fraction of MSW disposed at SWDS in year x

L_0 (x) = Methane generation potential (t CH_4 / t waste)

R = Recovered CH_4 in inventory year t (t/yr)

OX = Oxidation factor (fraction)

Solid Waste Disposal on Landfill

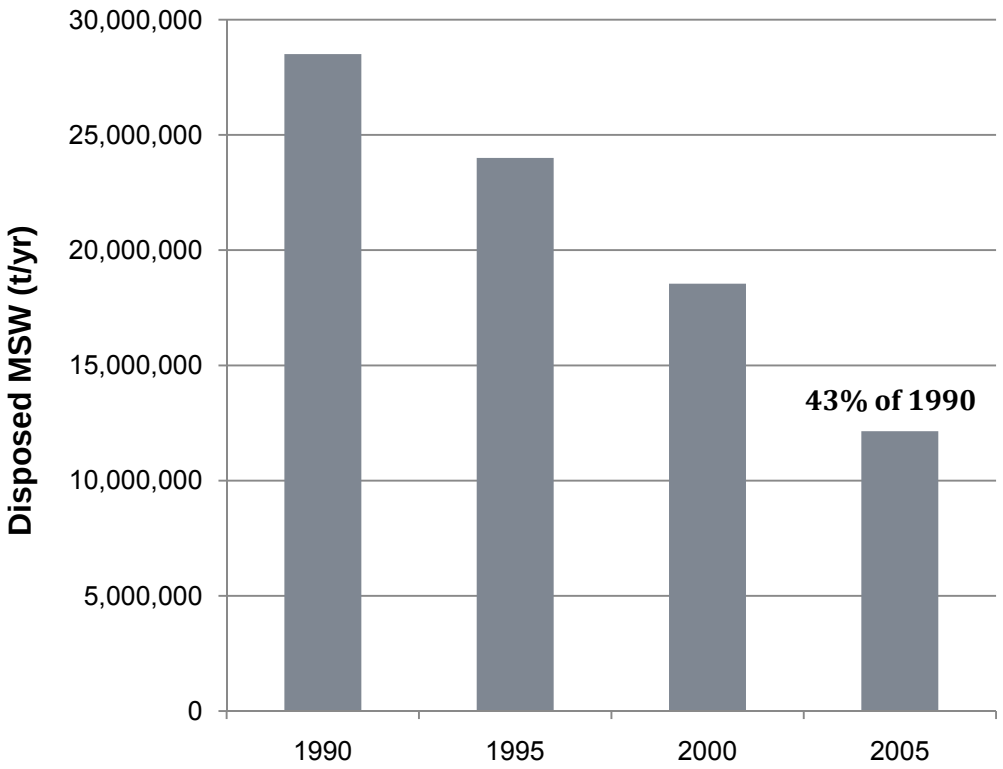
- Recent Landfill of Korea (2005)

Type of Site	Landfill (Open)			Landfill (Closed)		
	MSW	Industrial Waste	Hazardous Waste	MSW	Industrial Waste	Hazardous Waste
Total	**1,616**					
Subtotal	**271**			**1,345**		
Managed SWDS	231	26	13	198	49	33
Unmanaged SWDS	1	0	0	1,065	0	0

Solid Waste Disposal on Landfill

- Amount of MSW disposed at SWDS

Year	Amount of MSW disposed at SWDS (ton/yr)
1990	28,508,690
1991	30,079,891
1992	31,780,185
1993	26,207,000
1994	27,840,302
1995	23,998,239
1996	25,493,389
1997	27,031,389
1998	14,399,546
1999	19,474,502
2000	18,547,220
2001	19,139,469
2002	19,579,914
2003	17,667,825
2004	15,035,044
2005	12,145,193



Ref. : National Waste Statistics (Ministry of Environment, Korea)

Solid Waste Disposal on Landfill

- Parameters Determination

1	Methane generation potential (L_o)	$MCF \times DOC \times DOC_F \times F$ (t CH_4/t Waste)		
		Parameters	Values	Remark
		MCF	1.00	(Methane Correction Factor) 1: anaerobic, 0 : aerobic
		DOC	Calculation	(Degradable organic carbon) :
		Food waste(%) **0.114**, Paper(%) **0.320**, Wood(%) **0.366** etc		
		DOC_F	0.55	(Fraction of DOC dissimilated) : IPCC GPG(2000) default value
		F	0.50	(Fraction by volume of CH_4 in landfill gas) : IPCC GPG(2000) default value
		16/12	-	Conversion from C to CH_4
2	R(=0.13)	Recovered CH_4(t/yr) : 'Surveying GHG emissions from waste, Ministry of Environment, 2000'		
3	OX(=0.10)	Oxidation factor(fraction) : IPCC GPG(2000) default value		

- DOC is calculated from 'National Waste Statistics, Ministry of Environment, 1996'

Solid Waste Disposal on Landfill

- Process for k-value estimation

  - Selecting objective landfills for measuring CH_4 emissions

    (In 2007, measuring in Ansung and Gapyung landfill)

  - Estimate k-value using the fortran program of trial-error method

    (Program is made from 2002 by EMC)

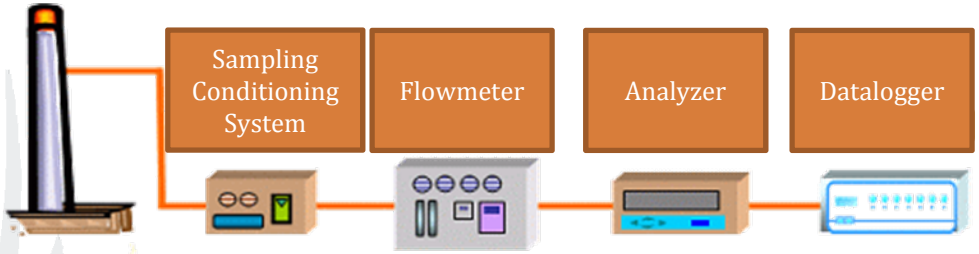
Solid Waste Disposal on Landfill

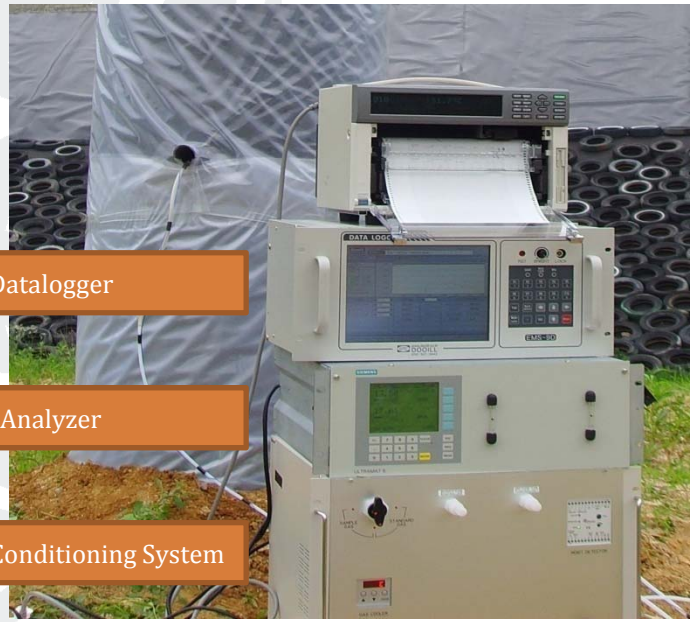
- Measurement System

Type	Measurement Method
Extraction well	- Measurement Method : Non-dispersive infrared absorption - Measurement Time : 24hour (continuously) per each well
Landfill Surface	- Sampling : Static Chamber Method (Chamber→Filter→Pump→Gauge→Analyser→Data Logger) - Measurement Method : Non-dispersive infrared absorption - Measurement Time : 3 times per each site ×2 hour per day

Solid Waste Disposal on Landfill

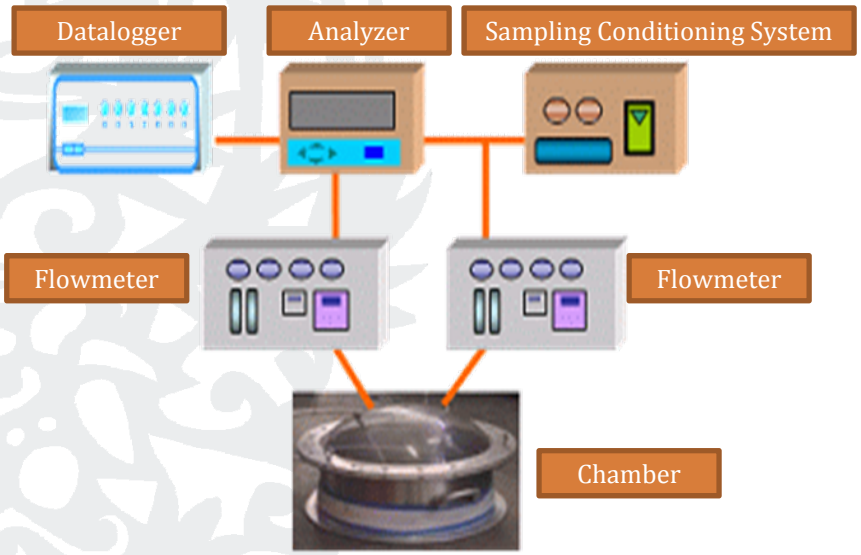
- Measurement System (Extraction well)

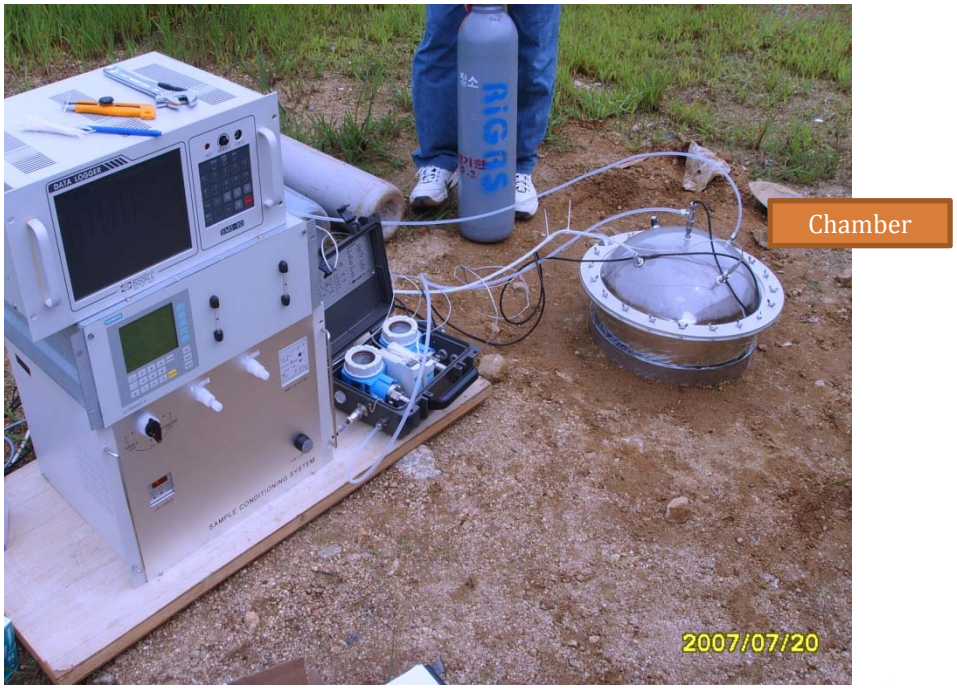




Solid Waste Disposal on Landfill

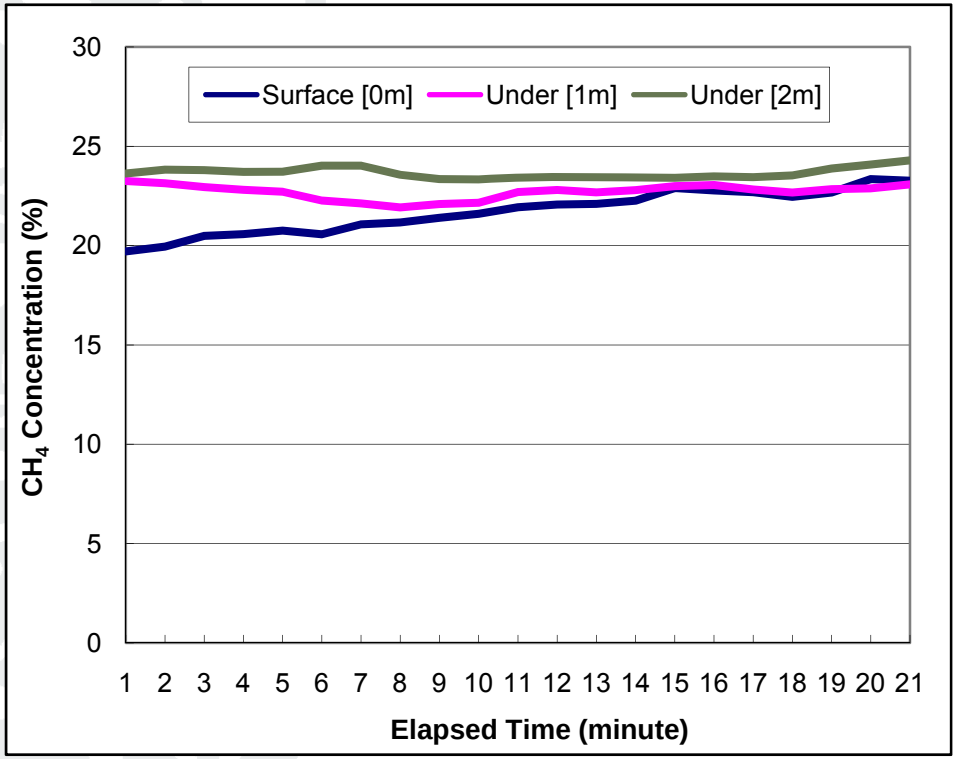
- Measurement System (Landfill Surface)



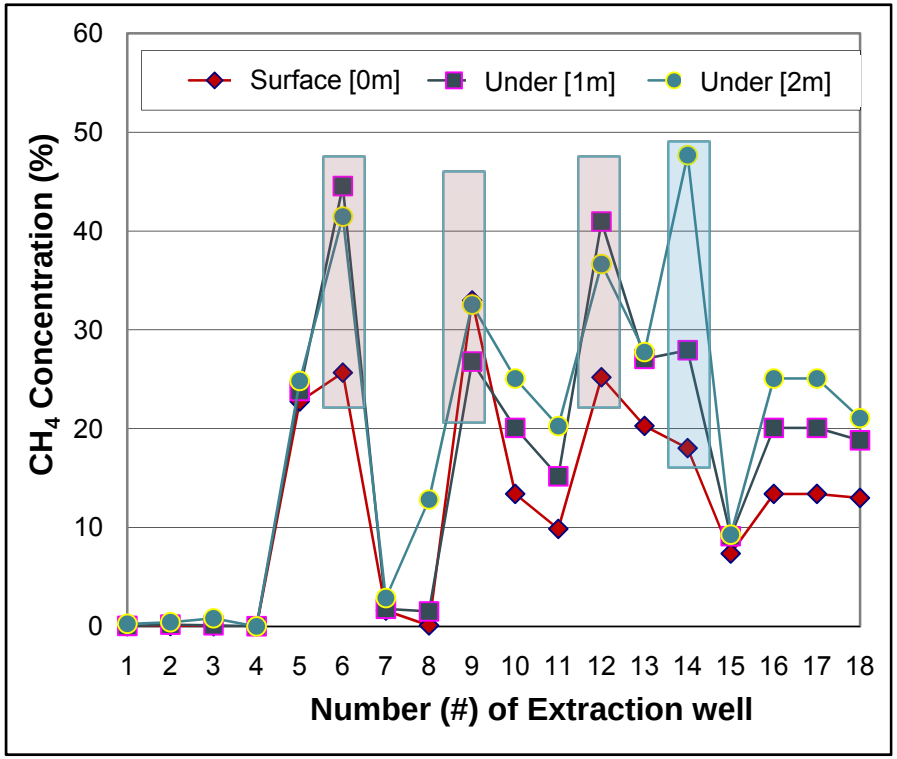


Solid Waste Disposal on Landfill

- CH_4 Concentration at Extraction well (For Ansung Landfill)



Well #5 of Ansung landfill

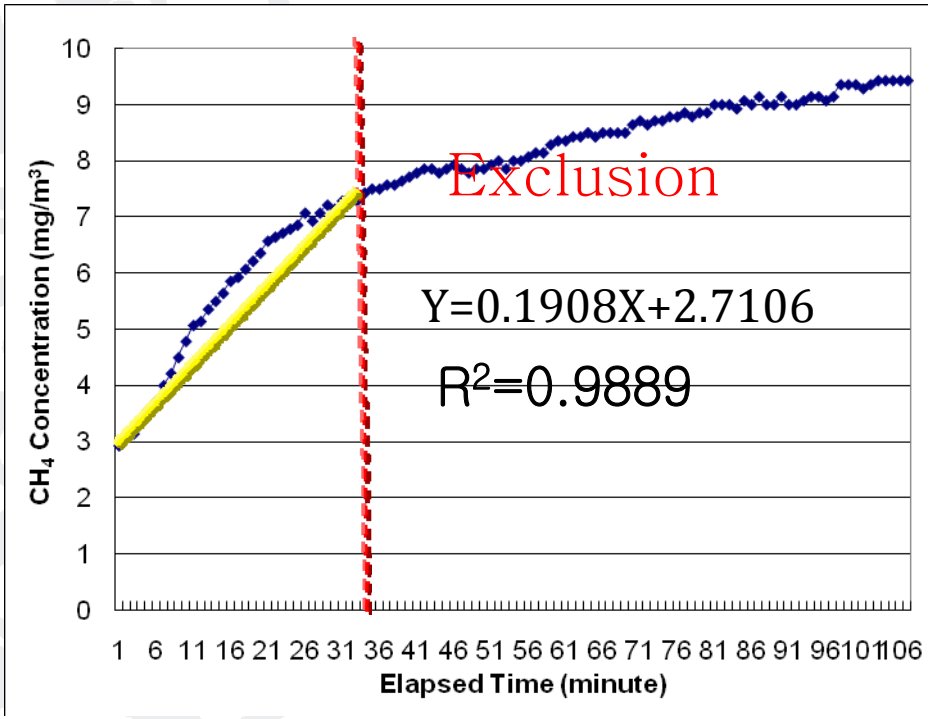


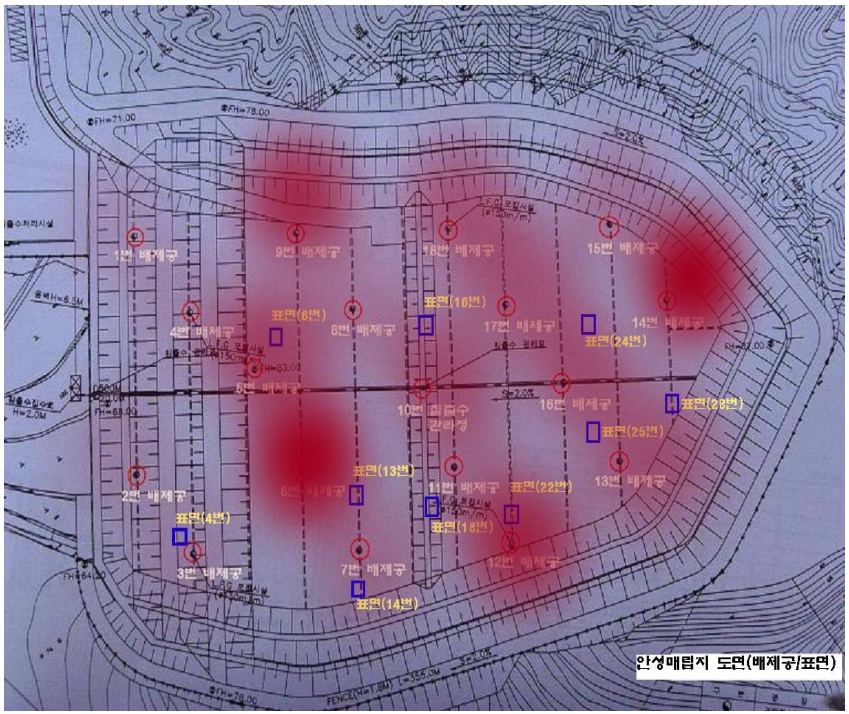
: reversed concentration by depth

: large concentration difference by depth

Solid Waste Disposal on Landfill

- CH_4 Concentration at Landfill Surface (For Ansung Landfill)





Estimation to Section R^2>0.95

high low

Solid Waste Disposal on Landfill

- Result of k-value estimation (For Ansung landfill)

	Measuring Depth (Extraction Well)	Total Emission (ton/year)	k value	IPCC default
Ansung landfill	Surface [0m]	255.6328	**0.080**	0.02 - 0.2
	Under [1m]	355.7603	**0.131**	
	Under [2m]	422.3432	**0.184**	

Solid Waste Disposal on Landfill

- Estimated Emission using k value

Landfill name	k value	2002	2003	2004	2005	2006	2007
Ansung landfill	**0.080**	30.012	115.429	208.842	250.820	253.498	255.970
	0.131	47.929	182.138	323.127	376.133	365.024	355.279
	0.184	65.605	246.340	428.535	483.374	450.145	422.500

Waste Incineration

- Methodology (IPCC GPG 2000) (Targeting Tier 2)

CO_2 emissions (t/yr) = ∑ (IW • CCW • FCF • EF • 44/12)

IW = Amount of incinerated waste (t/yr)

CCW = Fraction of carbon content in waste

FCF = Fraction of fossil carbon in waste

EF = Burn out efficiency of combustion of incinerators for waste (fraction)

N_2O emissions (t/yr) = ∑ (IW • EF • 10^{-6})

IW = Amount of incinerated waste (t/yr)

EF = Aggregate N_2O emission factor for waste (g N_2O/ t)

Waste Incineration

- Recent Waste Incineration of Korea (2005)

	Total	Type of Technology					
		Subtotal	**Stoker**	Fixed bed	Fluidized bed	Decomposition	Other
Total	**310**	**230**	**121**	90	5	7	7

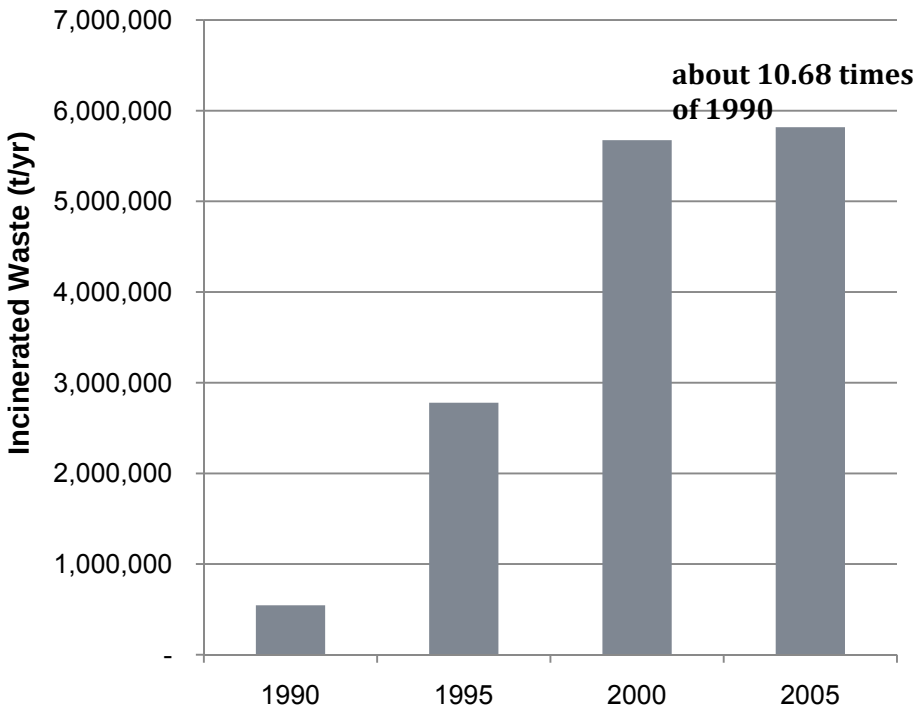
	Total	Type of incineration				Waste Treatment Corp.
		Subtotal	**Continuous**	Batch	Semi-continuous	
Total	**310**	**230**	**60**	147	23	80

- **Model incinerator : Stoker-Continuous type incinerating MSW of 300 t/day (Operated by EMC)**

Waste Incineration

- Amount of Incinerated Waste

Year	Amount of incinerated waste
1990	544,945
1991	546,456
1992	1,045,360
1993	921,628
1994	2,166,859
1995	2,778,745
1996	3,368,804
1997	3,492,221
1998	3,765,982
1999	4,486,385
2000	5,673,998
2001	6,159,302
2002	6,127,000
2003	6,320,194
2004	6,280,008
2005	5,818,465



Ref. : National Waste Statistics (Ministry of Environment, Korea)

Waste Incineration

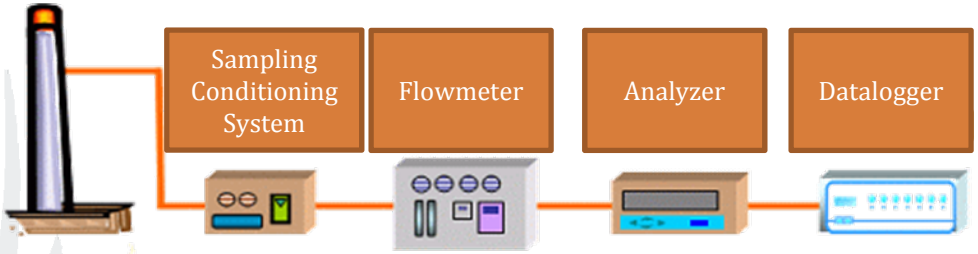
- Parameters Determination

Parameter	MSW component (%)					
	Food waste	Paper, Nappies	Wood	Textiles	Plastics	Incombustibles
Composition Data	27.2	37.1	3.7	6.9	20.7	4.4
Carbon Content in Waste (CCW)	47.3	52.1	51.0	52.6	78.7	-
Fraction in Fossil Carbon (FCF)	-	1	-	20	100	-
Burn out efficiency of combustion of incinerators (EF)	100					

Note) 1. Management data of model incinerator on June~August
2. FCF , EF use 2006 IPCC default

Waste Incineration

- N_2O Measurement System



Sampling

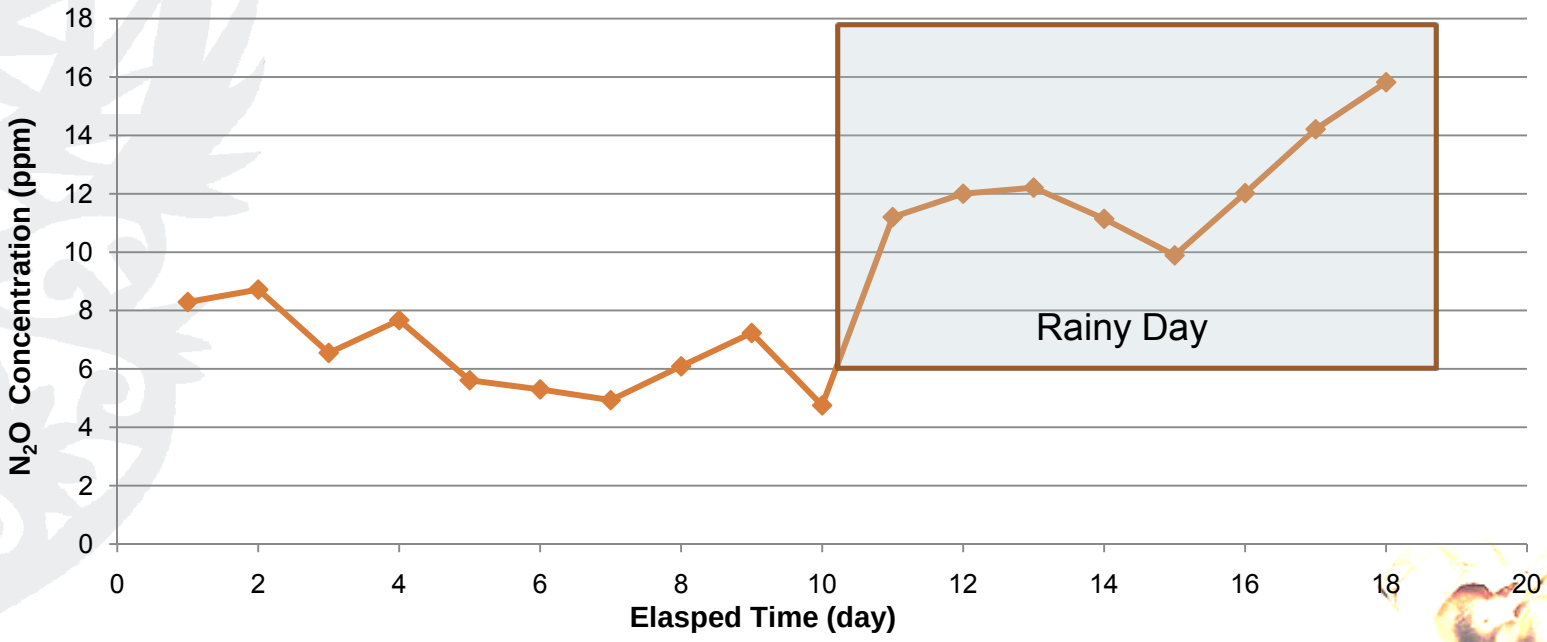
Flowmeter

Measurement System

Waste Incineration

- N_2O Emission Concentration of Waste Incineration

Measuring Day	N_2O Concentration (ppm)	Incinerated Waste (ton/day)	Flow (m^3/day)
18	9.09 (4.75 ~ 15.82)	238.325 (212.085 ~ 267.345)	1,898,004 (1,660,934~2,204,194)



Waste Incineration

- Emission Estimation

Greenhouse gas	Amount of Incinerated Waste (ton/day)	Emission Factor	Emissions (t/yr)
CO_2	238.325	0.512 (t CO_2/t)	37,568.16
N_2O	238.325	135.431 (g N_2O/t)	12.544

Future Planning

- Solid Waste Disposal on Landfill (SWDS)
  - Expansion of landfills to measure according to IPCC guidelines up to 2012
  - Decision of standard operating procedure (SOP) for measuring landfill gas
  - Estimation of greenhouse gas as to Tier 2 (First Order Decay) up to 2012

- Waste Incineration
  - Expansion of waste incineration to measure according to incineration type or technology up to 2012
  - Estimation of greenhouse gas as to Tier 2 up to 2012