



Estimation and Uncertainty Analysis of CH₄ emissions from Landfills

Environmental Management Corporation
Presented by Dr. Kyoung-Sik Choi

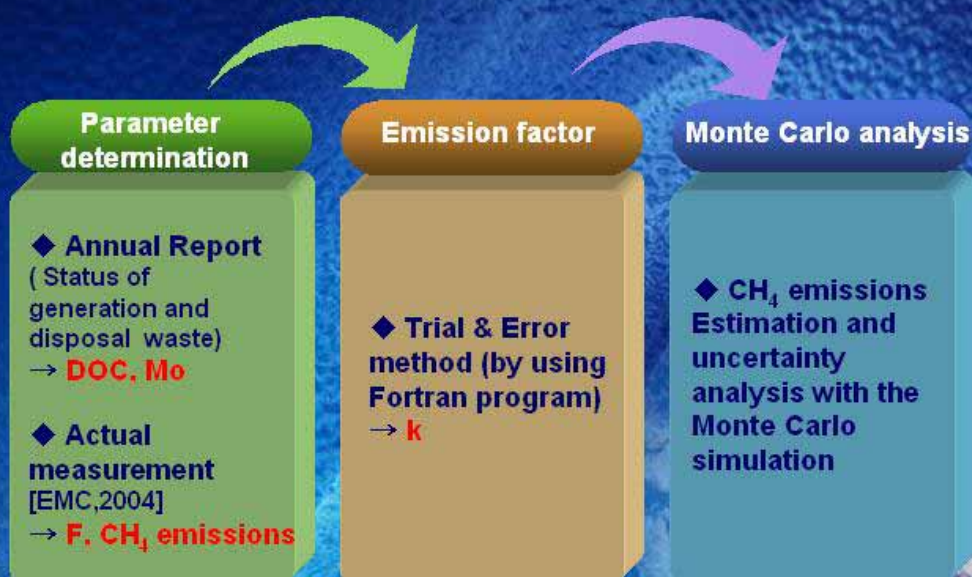
Contents

1. Estimation of CH₄ emissions by using Tier2 methodology
2. Uncertainty Analysis with the Monte Carlo Simulation
3. Standard Operating Procedure for the estimation of GHG emissions in Landfill

1. Estimation of CH₄ emissions by using Tier2 methodology

2. Uncertainty Analysis with the Monte Carlo Simulation
3. Standard Operating Procedure for the estimation of GHG emissions in Landfill

Tier 2 Method & Uncertainty analysis



Case Study : Y landfill

□ Status of Y landfill ('02)

Province	Total Area (m2)	Total volume (m3)	Waste (m3)	Starting Year	Closing Year
Kyonggi	83,043	1,435,000	538,000	'96	'08

□ CH4 emissions

(Unit: ton/yr)

	Extraction well	Surface	Total
Y landfill	836	2232~8507	2,385~9,343

Parameter Determination

Tier 2
Eq.

$$Q_{CH_4}(t) = \sum_{i=1}^N M_0(i) L_0(i) [\exp\{-k(t-i)\} - \exp\{-k(t-i+1)\}]$$

$M_0(i)$ = Total amount of solid waste landfilled (from MoE)

$L_0(i)$ = $MCF \times DOC \times DOC_F \times F \times 16/12$

$MCF(1), DOC_F(0.55)$: Default value

DOC, F : Calculated from annual data

DOC

$$DOC (\%) = CCF \times FW_f + CCP \times PA_f + CCW \times WO_f + CCR \times RU_f$$

F

Extraction well : Volume ratio (CH_4 : CO_2)

Surface : The ratio of slope of regression line (CH_4 and CO_2)

■ Key parameters for k-value estimation

DOC

Year	1996	1997	1998	1999	2000	2001	2002
DOC	0.12	0.17	0.12	0.14	0.13	0.14	0.14

F

CH₄ emissions (Unit:ton/yr)

F-value		Point	Surface	well	Total	Remarks			
Extraction well	0.59	1	2231.86	835.6	3067.46	2 wells measured and summed up			
	0.60								
Surface	0.57						2	3489.17	4324.77
	0.47								
	1.00								
	0.76	3	8507.44	9343.04					
					4	1549.42	2385.02		

K-value (Y landfill)

F	Actual CH ₄ emissions (A)	k	Simulation results of CH ₄ emissions (B)	(A) - (B)
0.47	3067.46	0.51837	2085.59	981.871
	4324.77	0.51837	2085.59	2239.181
	9343.04	0.51837	2085.59	7257.451
	2385.02	0.51837	2085.59	299.431
0.57	3067.46	0.51837	2562.62	504.835
	4324.77	0.51837	2562.62	1762.145
	9343.04	0.51837	2562.62	6780.415
	2385.02	0.26844	2385.03	0.008
0.59	3067.46	0.51855	2624.35	443.106
	4324.77	0.51855	2624.35	1700.416
	2385.02	0.24548	2385.02	0.004
0.60	3067.46	0.51845	2689.81	377.654
	4324.77	0.51845	2689.81	1634.964
	9343.04	0.51845	2689.81	6653.234
	2385.02	0.22647	2385.01	0.007
0.76	3067.46	0.31933	3067.46	0.002
	4324.77	0.51839	3180.14	1144.626
	2385.02	0.15121	2385.02	0.004

Several problems in estimating k-value

The lack of confidence in k-value

Errors in measurement

Lack of information on MSW landfilled previously

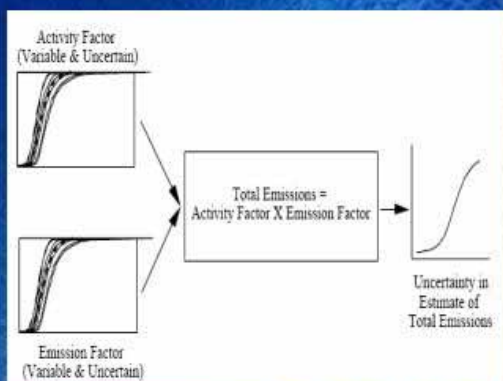
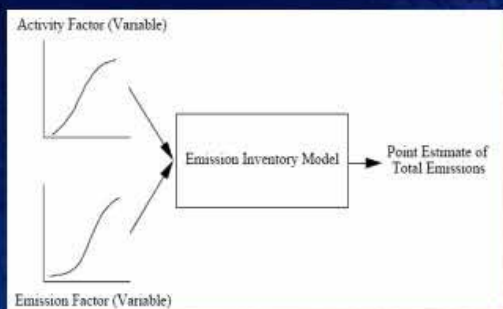
Solution

- QA/QC of measurement
- Exact record of waste landfilled

◆ Re-derivation of k	F	Actual CH4 emissions (A)	k	Simulation results of CH4 emissions (B)	(A) – (B)
	0.47		3067.46	0.190	3067.49
		4324.77	0.370	4324.75	0.015
		9343.04	1.000	6669.14	2673.897
		2385.02	0.127	2385.00	0.018
0.57		3067.46	0.139	3067.44	0.015
		4324.77	0.250	4324.81	0.043
		9343.04	1.000	8088.11	1254.930
		2385.02	0.097	2385.07	0.049
0.59		3067.46	0.132	3067.47	0.008
		4324.77	0.234	4324.76	0.013
		9343.04	1.000	8371.90	971.136
		2385.02	0.092	2385.01	0.010
0.6		3067.46	0.129	3067.47	0.009
		4324.77	0.227	4324.74	0.030
		9343.04	1.000	8513.80	829.239
		2385.02	0.090	2385.00	0.022
0.76		3067.46	0.092	3067.52	0.058
		4324.77	0.152	4324.75	0.017
		2385.02	0.067	2384.88	0.142
		9343.04	0.709	9343.05	0.015

1. Estimation of CH₄ emissions by using Tier2 methodology
2. **Uncertainty Analysis with the Monte Carlo Simulation**
3. Standard Operating Procedure for the estimation of GHG emissions in Landfill

Tier 2 – Probabilistic Approach – Monte Carlo



Probabilistic Assessment

- Probability of all available data

- Generation : matching all the data with probability

Distribution of generation : variability, uncertainty



Tier 2 – Uncertainty Estimate

(Probability Distribution)

Assumption of probability distribution on parameters affecting CH₄ emissions
(Normal, Lognormal, Weibull, Gamma)



(Monte Carlo Simulation)

Repetition of random sampling with the assumed probability distribution



(Uncertainty analysis of CH₄ emissions)

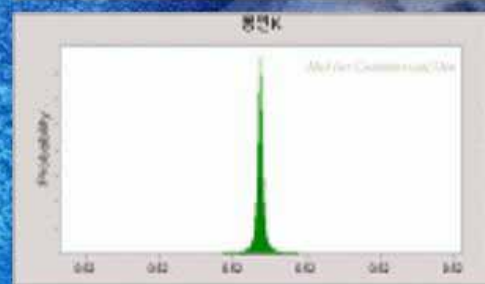
Distribution Analysis of Uncertainty derived from Monte Carlo Simulation



Uncertainty Review

Probability distribution of key parameters : Y landfill

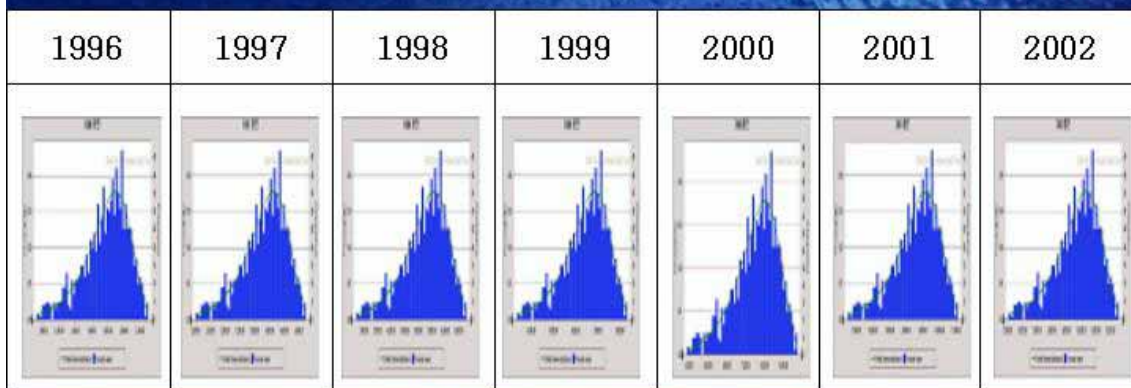
Parameter	Probability Distribution
Assumption: F	Minimum Extreme distribution Likeliest : 0.67 Scale : 0.08
Assumption: k	Student's distribution Midpoint : 0.52 Scale : 0.00 Deg. Freedom : 1



Estimation results of CH₄ emissions

Statistics	1996	1997	1998	1999	2000	2001	2002
Trials	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Mean	1,759	3,816	5,190	6,378	7,440	8,508	9,607
Median	1,818	3,942	5,362	6,589	7,686	8,791	9,825
S.D	302	654	889	1,093	1,275	1,458	1,646
Min.	316	686	933	1,146	1,337	1,529	1,727
Max.	2,301	4,989	6,786	8,339	9,728	11,126	12,562

Estimation results of CH₄ emissions : Y landfill



1. Estimation of CH₄ emissions by using Tier2 methodology
2. Uncertainty Analysis with the Monte Carlo Simulation
- 3. Standard Operating Procedure for the estimation of GHG emissions in Landfill**

Scheme for the provision of SOP



Development Plan of SOP



Development Plan of SOP

Placement of SOP in Korean Standard Method



Improvement of reliability on emissions measurement and estimation

Conclusion

- **Monte Carlo analysis makes possible to estimate GHG emissions considering uncertainty despite the limitation of data**
- **Tier2 method requires historic waste quantities and composition, disposal practices until the time measured**
- **QA/QC and SOP can improve reliability in emission estimation**

Thank you

- *UNFCCC GHG Inventory workshop in Seoul to be on the September*
- *email promote@emc.or.kr for more information*