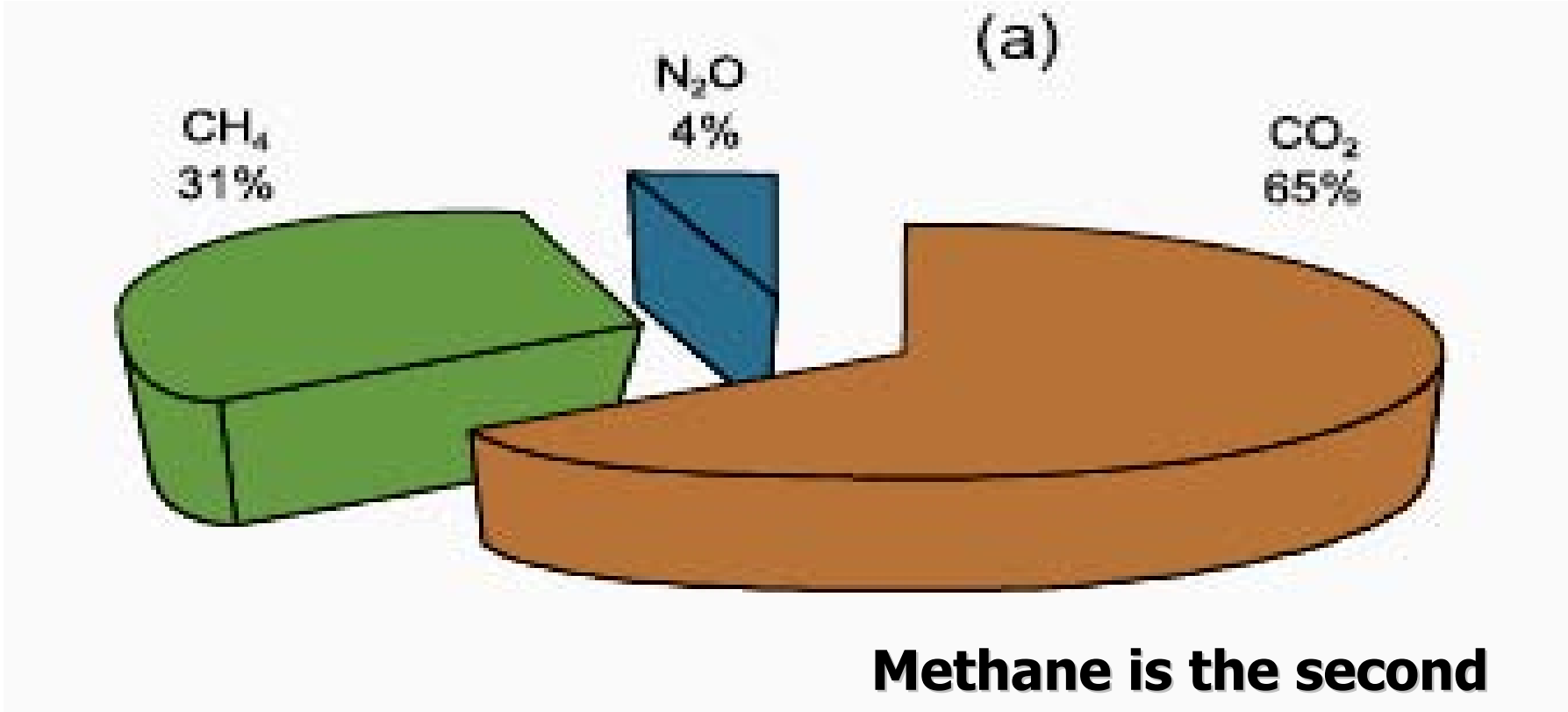
Landfill M2M Workshop
Delhi, 9 March, 2006

Modelling LFG Generation in India Sites

Dr. Sukumar Devotta
Director
National Environmental Engineering Research Institute, Nagpur - 440 020
Email:director@neeri.res.in

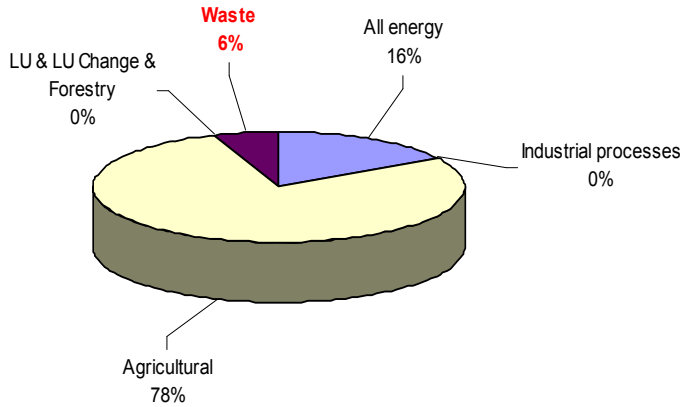
Indian GHG emissions (1994)



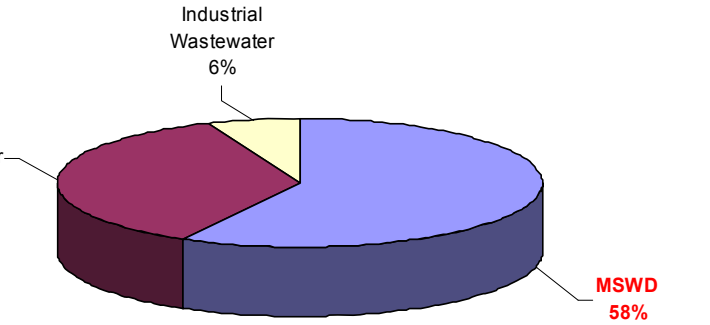
Methane is the second dominant GHG for India

Indian CH_4 Emission (Gg)

Total national CH_4 Emission in Gg	18083
1. All Energy	**2896**
Transport	9
Fuel combustion	
Biomass burnt for energy	1636
Fugitive Fuel Emission	
Oil and natural gas system	601
Coal mining	650
2. Industrial Processes	**2**
Production of carbon black and styrene	2
3. Agriculture	**14175**
Enteric fermentation	8972
Manure management	946
Rice cultivation	4090
Agricultural crop residue	167
4. Land use, Land-use change and Forestry	**6.5**
Trace gases from biomass burning	6.5
5. Waste	**1003**
Municipal solid waste disposal	582
Domestic waste water	359
Industrial waste water	62

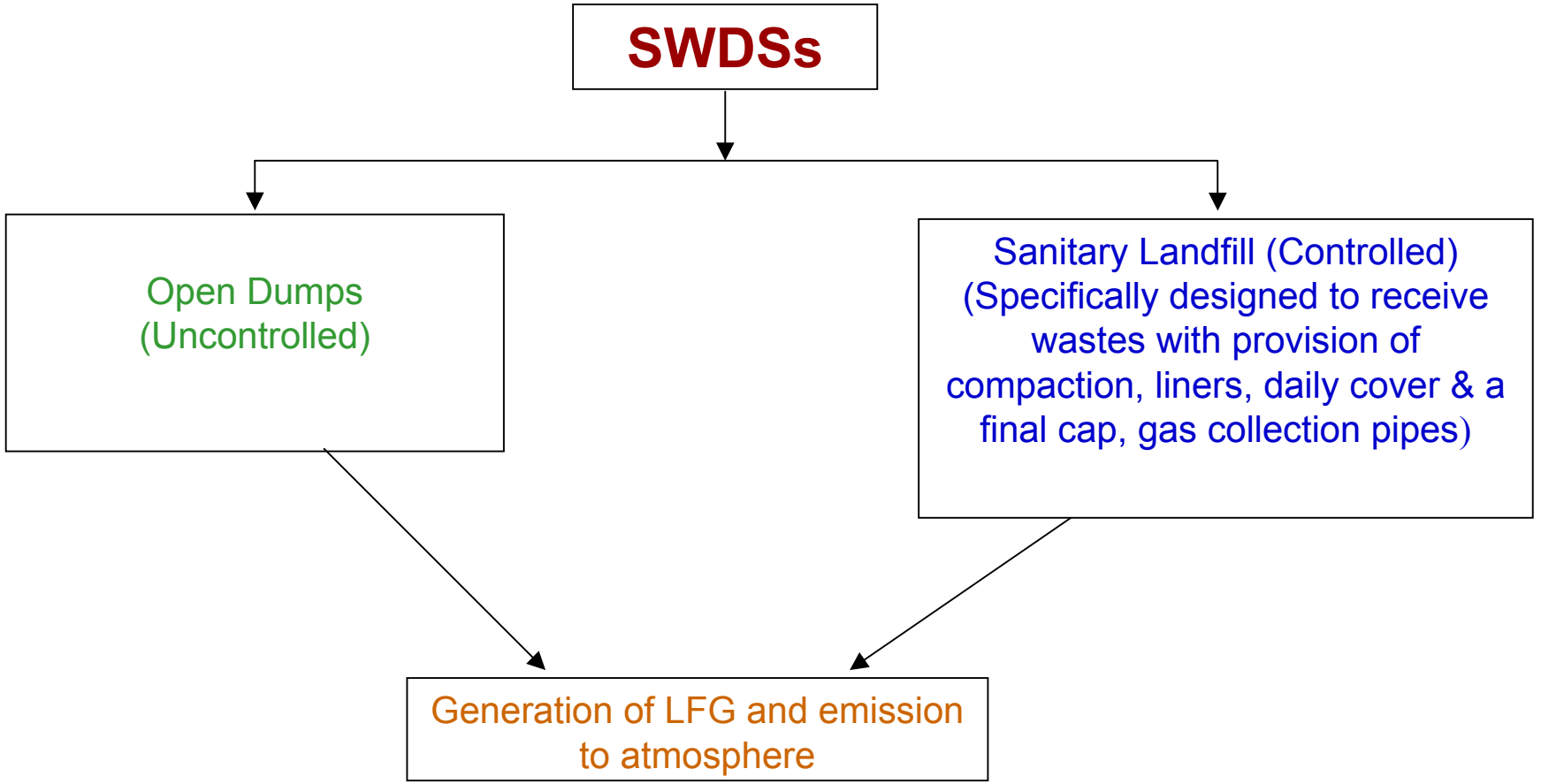


Methane – All Sources

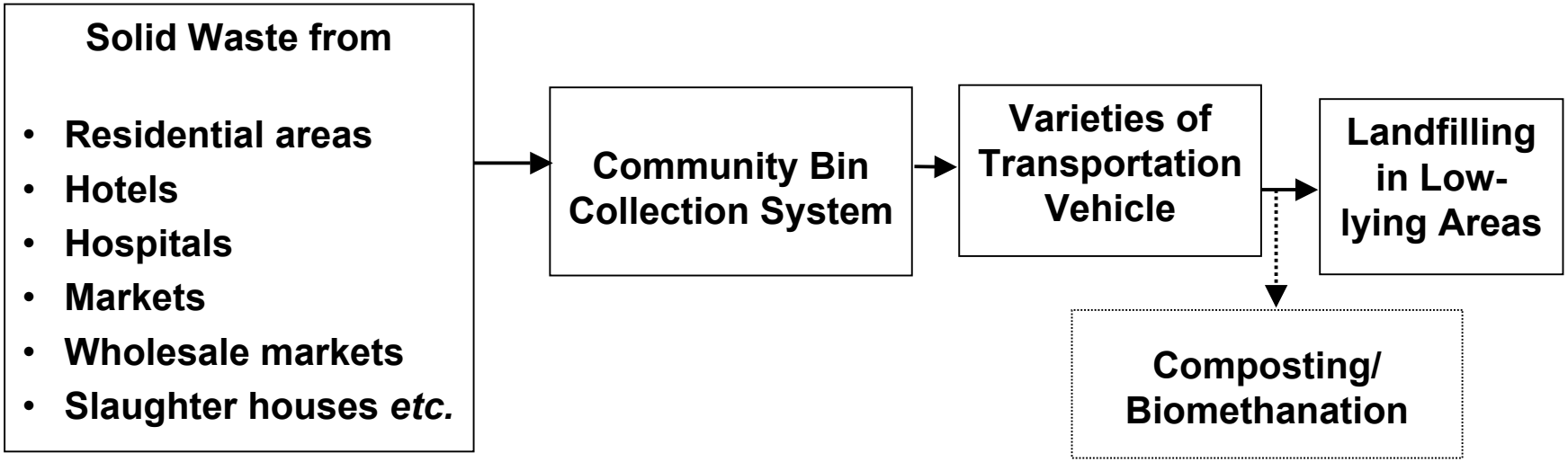


Methane – Waste Sources

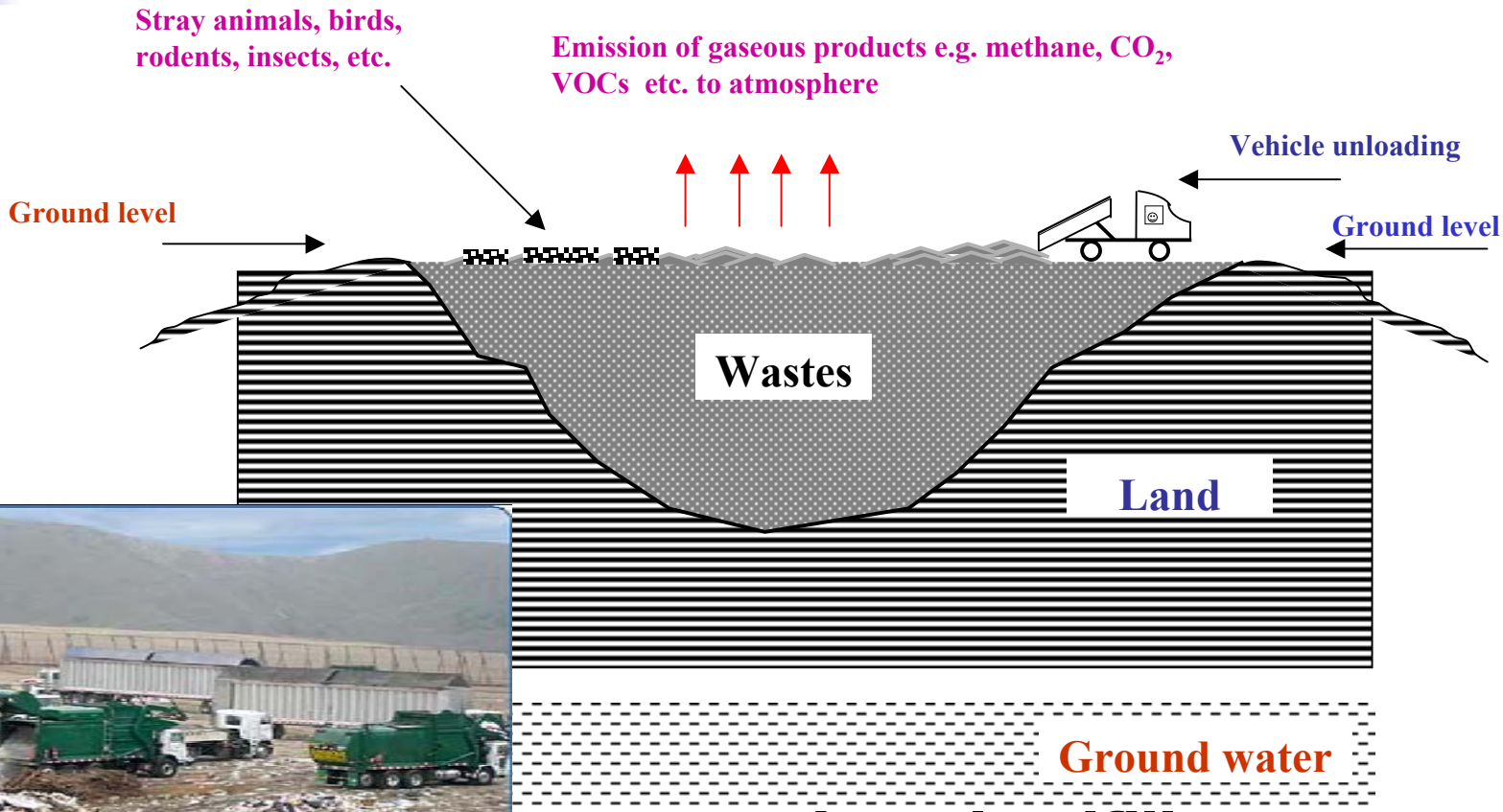
Methane Emission from Solid Waste Disposal Sites (SWDSs)



Current Practices of MSWM in India

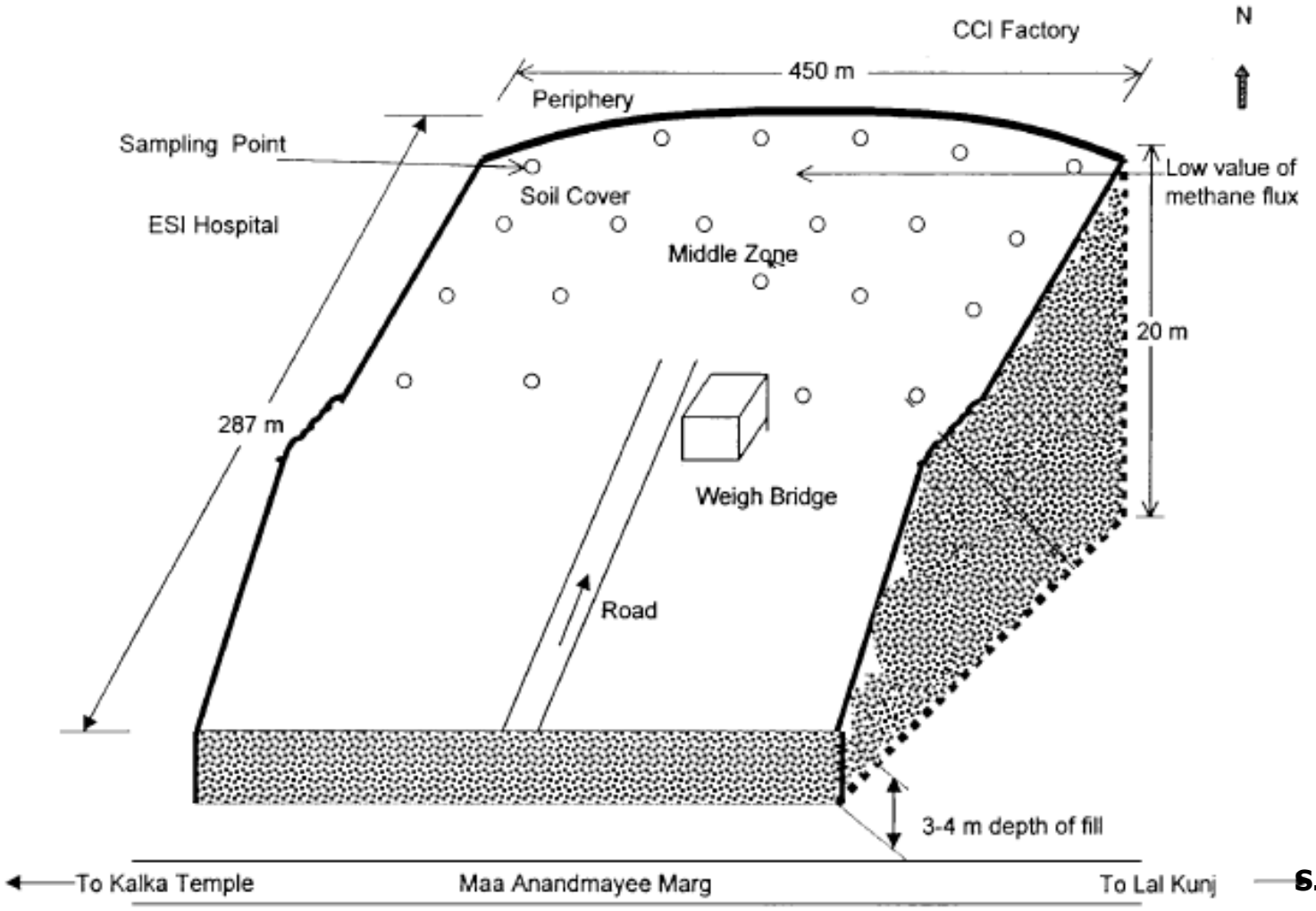


MSW Landfills in India



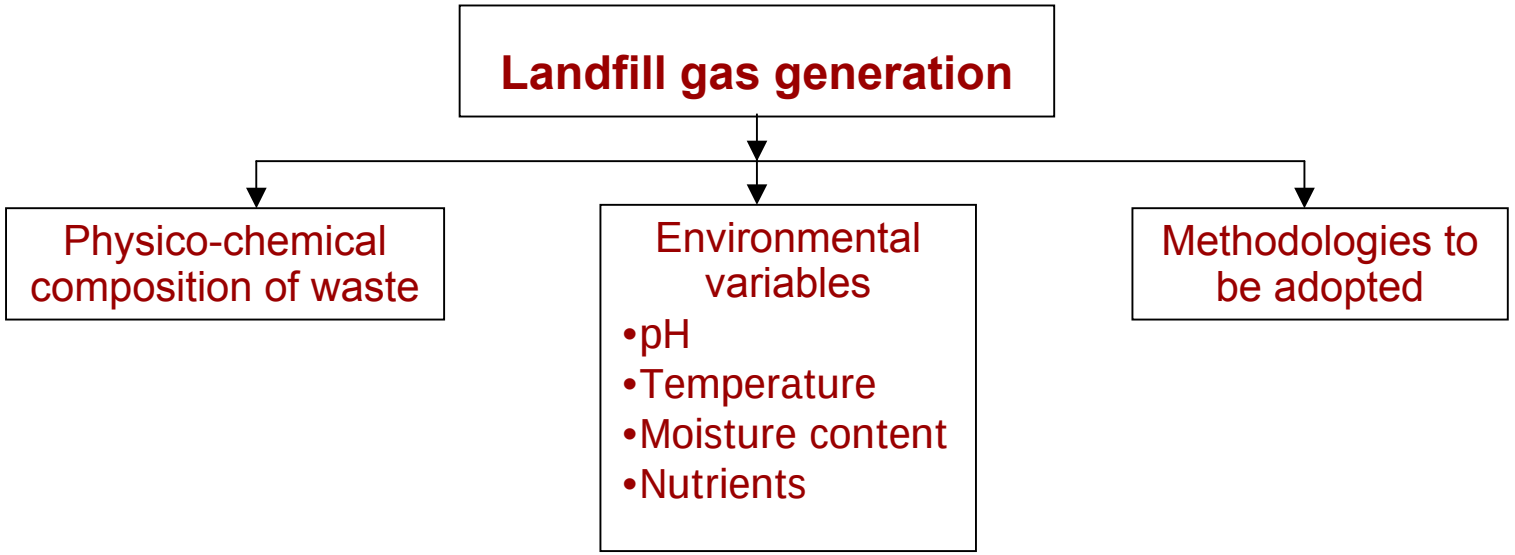
Sanitary landfills are yet to be implemented in most of the cities

Typical Structural Features of the Okhla MSW Site

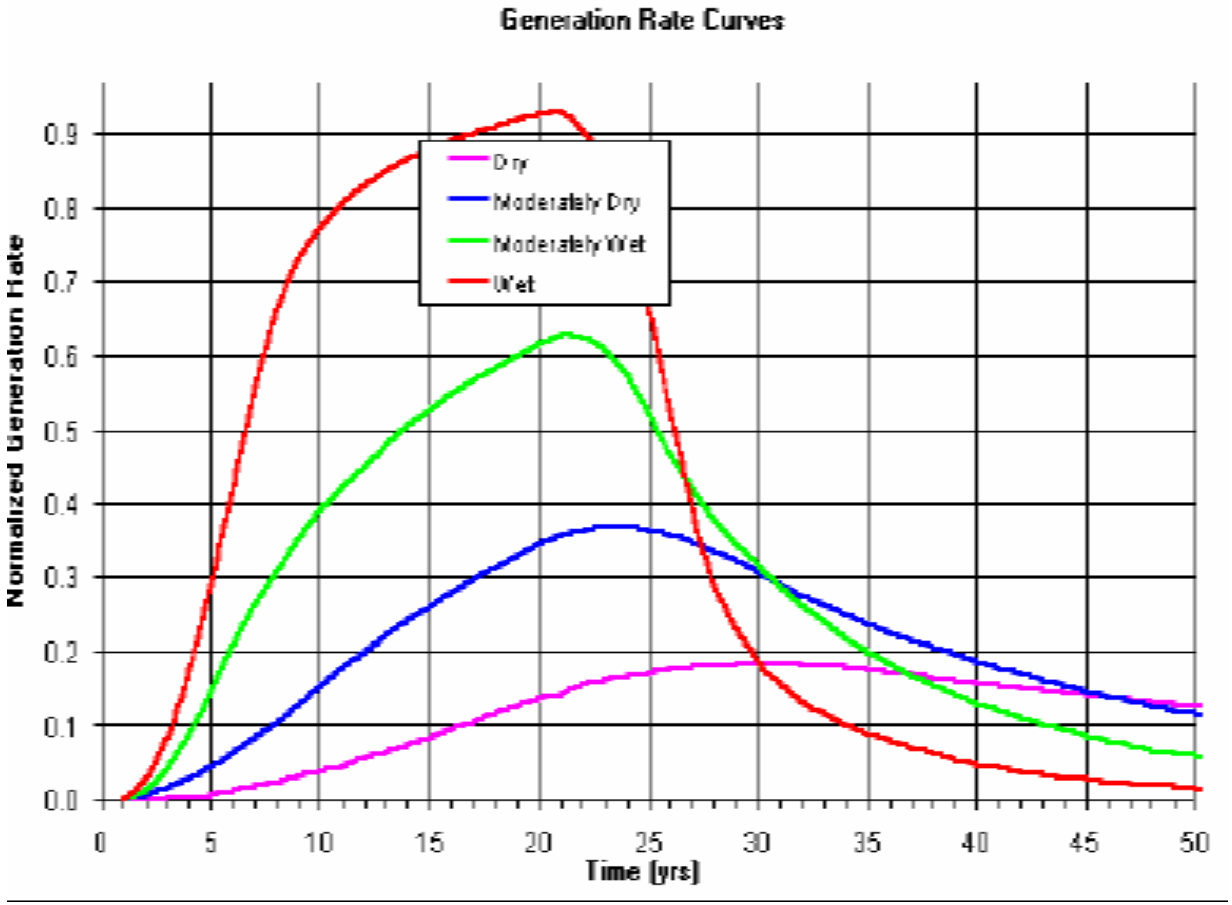


S. Kumar et al., 2004

Factors Affecting LFG Generation



LFG Production



Estimates of Gas Production Rates

- Rapid degradation conditions: 3 to 7 years (4 to 10 l/kg/yr)
- Moderate degradation conditions: 10 to 20 years (1.5 to 3 l/kg/yr)
- Slow degradation conditions: 20 to 40 years (0.7 to 1.5 l/kg/yr)

IPCC Methodology for LFG Estimation

Estimation of Methane Emission from Landfills

Default methodology
(Tier - I method)

IPCC document 1996 recommended

Widely accepted methodology for computation of country specific methane emission

Limitations

Assumed that all potential methane released in the year of waste deposition which may not be realistic

1st order decay methodology
(Tier - II method)

Need historical data on waste generation and management practices like landfill coverage/capping, leachate drainage improvement compacting, etc.

Estimation of methane is difficult due to non-availability of data for Indian condition

IPCC Methodology for the Estimation of Methane Emission from Landfills

Methane emission (Gg yr^{-1}) = (MSW_T x MSW_F) x MCF x DOC x DOC_F x *F* x (16/12 – *R*) x (1 – OX)

Where 1 Gg yr^{-1} = 1000 tonnes yr^{-1}

MSW_T = Total municipal solid waste (MSW) generated (Gg yr^{-1})

MSW_F = Fraction of MSW disposed of at the disposal sites

MCF = Methane correction factor (fraction)

DOC = Degradable organic carbon (fraction)

DOC_F = Fraction DOC dissimilated

F = Fraction of methane in LFG (default is 0.5)

R = Recovered methane (Gg yr^{-1})

OX = Oxidation factor (default is 0)

MSW_T, MSW_F, and DOC – estimated by NEERI for Indian condition

Remaining factors – as per IPCC guidelines

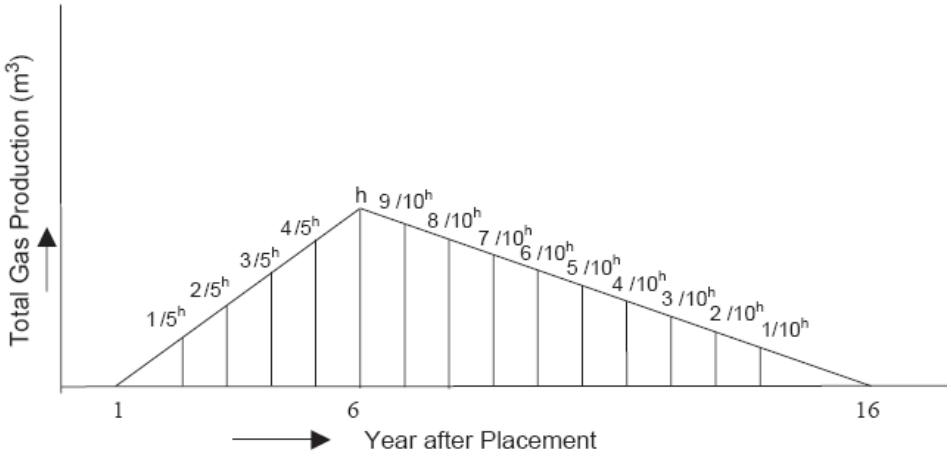
NEERI's Methodology for the Estimation of Methane Emission from Landfills

Methods for Estimation of Methane Emission by Triangular Method

- Biogas release based on first order decay in a triangular form
- Area of triangle equivalent to the gas released over the period by the total solid waste deposited at the start
- Computation of volume of gas (area of triangle) using default methodology
- Degradation takes place in 2 phases based on average waste composition of rapidly and slowly biodegradable waste
- First phase starts after one year of deposition and rate increases which continues till peak is reached
- Second phase starts when gas generation rate decreases and becomes zero after 15 years

S. Kumar et al., 2004

Estimation of Methane Emission by NEERI Triangular Method

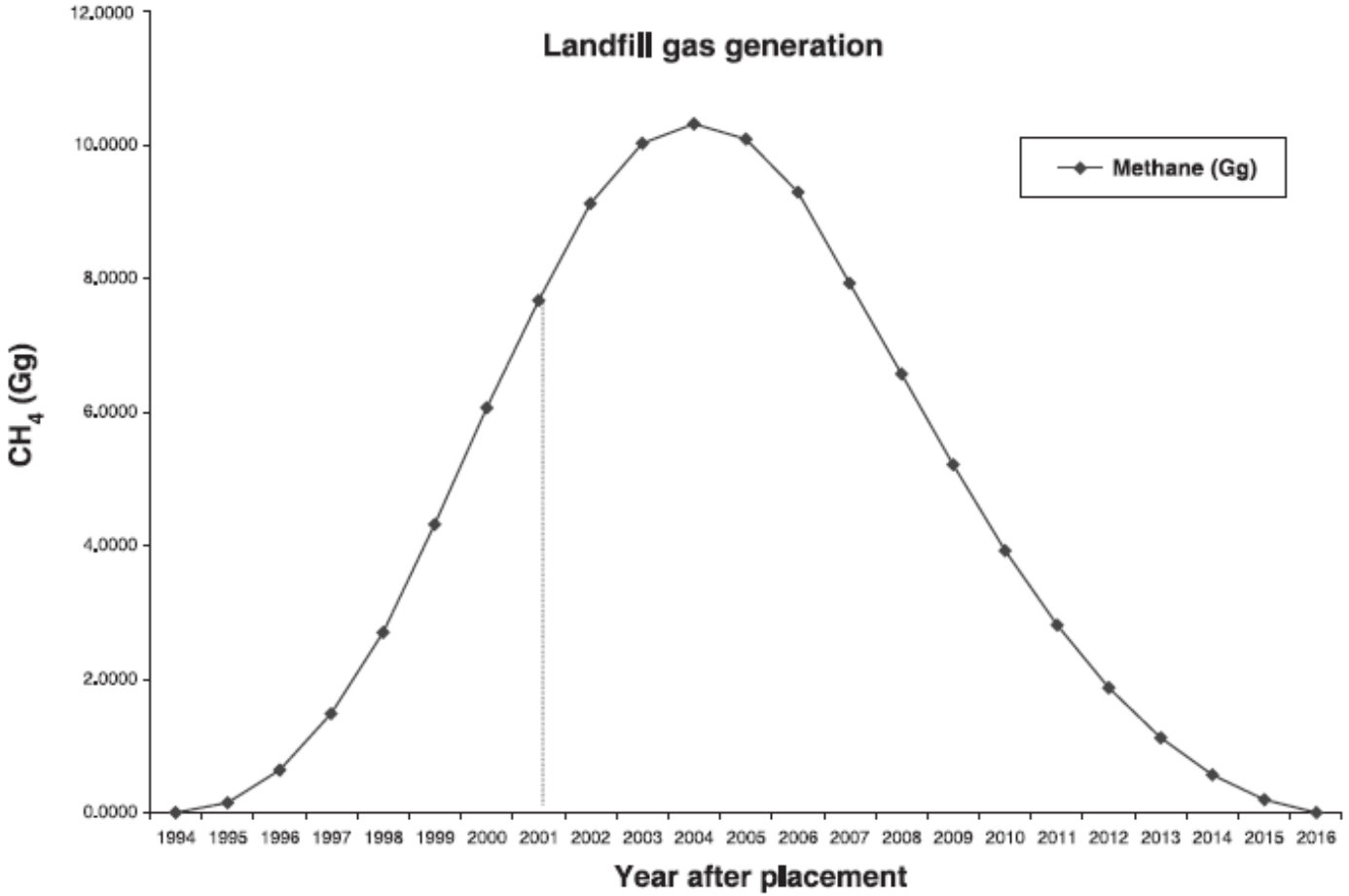


Landfill gas release is based on first order decay method (Tier II) in a triangular form and the area of the triangle would be equivalent to the gas released gas released over the period by the SW deposited at the start. In absence of the detailed data, this area (volume of the gas) was assumed to be equal to the volume computed using the default methodology

- Degradation takes place in **2 phases**
- First phase starts after one year of deposition and rate increases; this continues till the peak is reached in 6 years
- Second phase starts when the gas generation rate decreases and ends when the gas generation becomes zero after 15 years

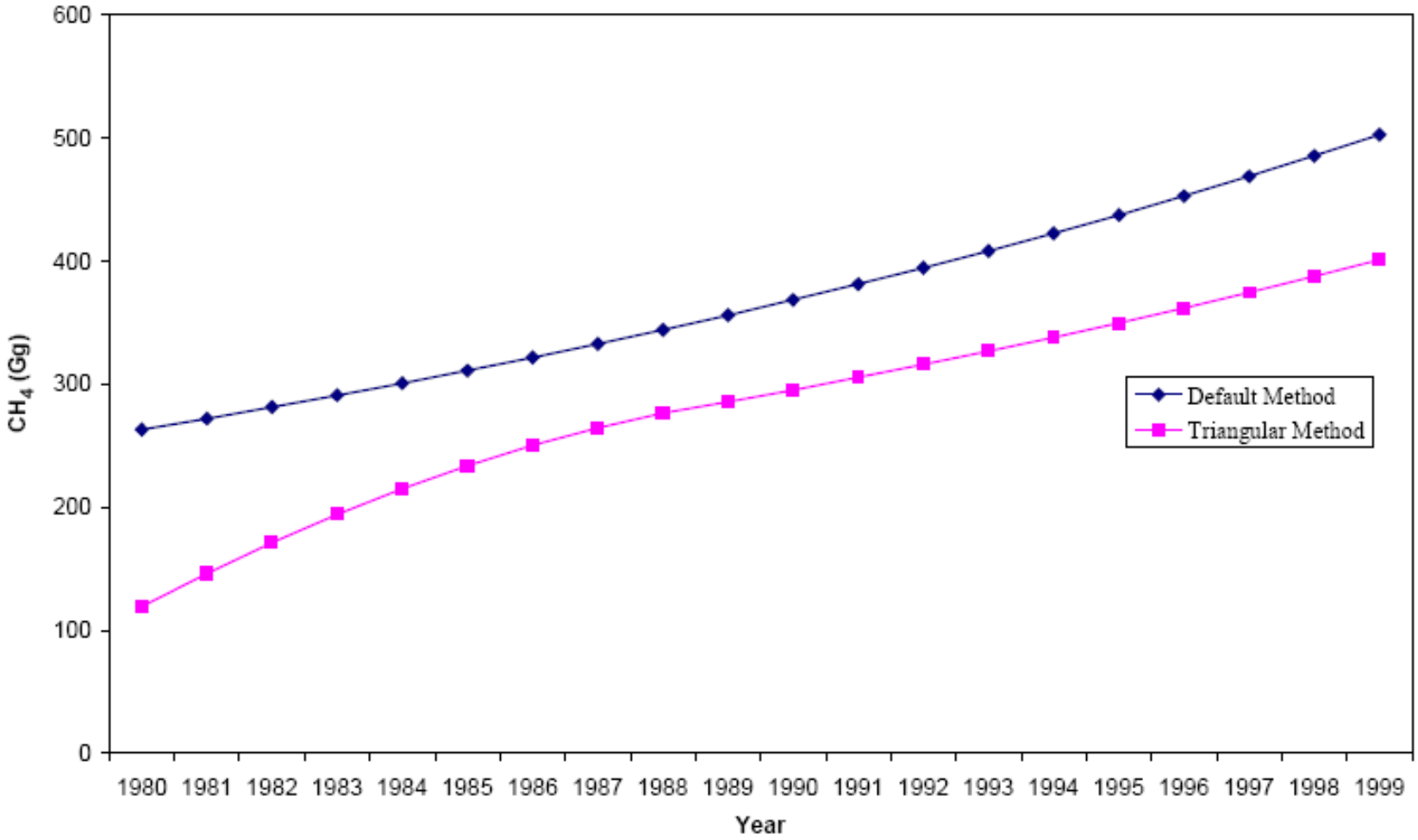
S. Kumar et al., 2004

Estimation of Methane Emission for Okhla Site



S. Kumar et al., 2004

Comparison between IPCC and NEERI estimates



Approach for NATCOM I Study

- Questionnaire survey and field studies to quantity reaching MSW Disposal Sites (MSWDSs) and characterise the MSW for representative cities (14 Nos.)
- Categorization of the cities and towns based on demographic status; population 1 – 2.5 lakh; 2.5 – 10 lakhs; > 10 lakh and > 50,000 < 1.00 lakh; geographical status like plain, hilly and coastal
- Identification of representative cities for study (14 Nos.)
- Data extrapolated for each range of population
- Using default methodology assuming emission coefficients, as indicated in IPCC document (1996), the state and national level methane emissions were computed
- Improved Default Methodology was devised by NEERI and methane emissions from Landfill was estimated using this method

MSW: Demographic and Geographic Status

National level status	Class - I Cities												Class - II Cities			
	Population 1.0 - 2.5 Lakhs				Population 2.5 - 10 Lakhs				Population 10 Lakhs and more				Population 50,000 - 1,00,000			
	Plain	Hilly	Coastal	Total	Plain	Hilly	Coastal	Total	Plain	Hilly	Coastal	Total	Plain	Hilly	Coastal	Total
No. of Cities	209	8	14	231	80	2	6	88	19	-	3	22	299	7	31	337
Population	312.67	13.85	22.21	348.73	364.6	9.86	34.59	409.14	434.81	-	161.02	595.83	252.19	4.84	22.12	279.15
Average Population	1.49	1.73	1.58	1.50	4.55	4.93	5.76	4.64	22.88	-	53.67	27.08	0.84	0.69	0.71	0.83
Identified City	Ramagundam (A.P.)	Shillong (Meghalaya)	Port Blair (A&N Isl-and)	-	Varanasi (UP) Guwahati (Assam) Chandigarh (UT) Amritsar (Punjab)	Kota (Rajasthan)	Thiruvananthapuram	-	Delhi Hyderabad (AP) Kolkata (W.B.) Jaipur (Rajasthan)	-	Mumbai (Maharashtra) Chennai (TN)	-	Bhandara (Maharashtra)	-	Kolam (Kerala)	-
Quantity of waste (Gg)	2004.1	116.7	170.2	2291.2	3402.3	123.8	455.6	3981.7	**4777.1**	-	1645.7	6422.8	1417.6	18.5	113	1549.2
Organic carbon (DOC)	0.16	0.15	0.11	-	0.16	0.14	-	-	0.15	-	0.14	-	0.12	-	0.13	-

0.16

MSW Data for some Cities (2002)

Name of the city	Population (in million)	Quantity (TPD)	Physical composition in percent by weight				
			Rapidly biodegradable matter (%)	Paper & cardboard (%)	Plastic (%)	Glass (%)	Inert (%)
Ramagundam	0.247	70	37.67	6.17	3.66	0.197	52.29
Hyderabad & Secunderabad	4.5	2100	55.84	31.13	4.90	0.34	35.79
Varanasi	1.352	580	30.98	4.20	3.50	-	61.32
Jaipur	2.436	1100	52.02	8.05	3.84	0.37	35.72
Kota	0.704	245.6	23.91	0.64	7.66	0.29	67.49
Thiruvanan-thapuram*	0.741 (coastal)	300	62.95	12.0	14.61	-	8.70
Port Blair	0.105	82	37.50	10.84	9.65	5.85	34.47
Shillong (1990)	0.124 (1990)	34.72	41	10.94	0.96	-	28.48
Mumbai (1993-94)	10.20	5001	38.6	6	6	-	35.00
Kolkata	4.58	2500	61.83	10.32	8.95	0.07	18.82
Guwahati	0.8	280	47.03	17.88	16.42	0.39	18.28
Chennai	4.216	2040	40.25	6.45	7.0	-	46.30
Chandigarh	0.85	290	71.20	8.39	9.59	Nil	10.80
Amritsar	0.97	470	67.52	4.98	9.30	1.04	17.14

* Contains 1.74 percent of rubber and leather

Methane Emissions Using IPCC & NEERI Methods for 1994

Population ranges	Default Methodology **(IPCC Method)** CH_4 Emission (Gg)			Triangular Method **(NEERI's Approach)** CH_4 Emission (Gg)		
	Plain	Hilly	Coastal	Plain	Hilly	Coastal
0.5-1 lakh	43.66	0.83	3.48	34.89	0.64	3.05
1-2.5 lakhs	65.61	3.59	3.84	51.88	2.52	3.31
2.5-10 lakhs	80.64	2.39	11.61	63.51	1.88	10.11
>10 lakhs	147.13	-	59.55	117.05	-	48.99
Total	337.04	6.81	78.48	267.33	5.04	65.46
Grand Total	**422.33**			**337.83**		

Data gaps

- Landfill gas estimation depends on quantity of SW dumped, its composition, moisture content and landfill details, etc. These details are not available; needs extensive investigation
- Solid waste degradation under aerobic and anaerobic conditions in the Indian dumped sites needs to be studied
- Various parameters used in the IPCC methodologies need to be established instead of using default values

Future Study

- Large variations observed in the estimations using IPCC and NEERI methodologies and field experiments due to inadequate data
- Studies with more sample size, in few other cities, where records for landfill sites are properly maintained, need to be taken
- Selected long term studies to arrive at reliable and accurate estimation
- MW Rules and their implementation would improve the quality of SWM in India very soon; this would definitely change the future emission coefficient
- Detailed studies required to determine the factors used in IPCC methodology suitable to Indian conditions, as determined by some developed countries


Thank You