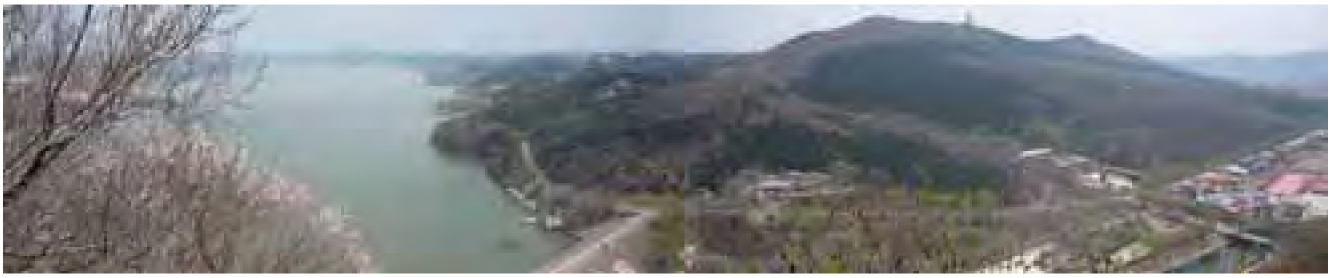

Estimating GHG emissions from landfills and organic waste treatment

Baasansuren Jamsranjav
Technical Support Unit, IPCC Task Force on National Greenhouse Gas Inventories

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Contents

- GHG emissions from waste treatment and disposal
- Estimating the emissions
- Solid waste disposal sites (SWDS)
- Biological treatment of organic waste

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Emissions from waste

- Disposal and treatment of waste produce GHGs
  - CO_2, CH_4 and N_2O
- Typically, CH_4 emissions from SWDS are the largest source of GHGs in the Waste Sector
  - Decomposition of waste under anaerobic conditions by methanogenic microorganisms
  - Emissions continue several decades
- Emissions are expected to increase in developing countries
  - Rapid increases in population and urbanization

Emission estimation

- Estimating of GHG emissions is an important element of tackling with climate change
- IPCC NGGIP provides internationally accepted methodologies for estimating of national GHG emissions and removals
  - 2006 IPCC Guidelines for National Greenhouse Gas Inventories - the latest guidelines with updated/ improved methods and default data (http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html)

Emission Inventory

- Estimates of all emissions/removals of particular gases from given sources from a defined region in a specific period of time
- A key input to policy makers and also to developing the scientific understanding of climate change
- Good knowledge of emissions and removals of GHGs
  - enables reduction policies to be developed in a cost effective way
  - allows different policy options to be compared
  - provides a simple monitoring mechanism to monitor implementation of these policies
  - is a key input to scientific studies of many environmental issue

Estimating emissions

- Common methodological approach

$$Emissions = AD * EF$$

- ❖ Activity data (AD): Data on the magnitude of a human activity resulting in emissions or removals taking place during a given period of time (e.g. amount of solid waste open-burned, Gg/yr)
- ❖ Emission factor (EF): A coefficient that quantifies the emissions or removals of a gas per unit activity (e.g. kg CH_4/Gg of waste open-burned)

Time series of emission estimates

- It provides information on emissions trends and tracks the effects of policies to reduce emissions
- All emissions estimates in a time series should be estimated consistently
  - To ensure that inventory totals estimated for different years are comparable
  - General principle is to calculate the emission/removal using the same method and data sources
  - 2006 Guidelines give a number of techniques to ensure times series consistency (overlap, extrapolation, interpolation, surrogate data)

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Methods to ensure time series: Example

- Interpolation
  - Data needed are available for intermittent years during the time series
  - Estimates can be linearly interpolated for the periods when data are not available
  - The method is not applicable in the case of large annual fluctuations

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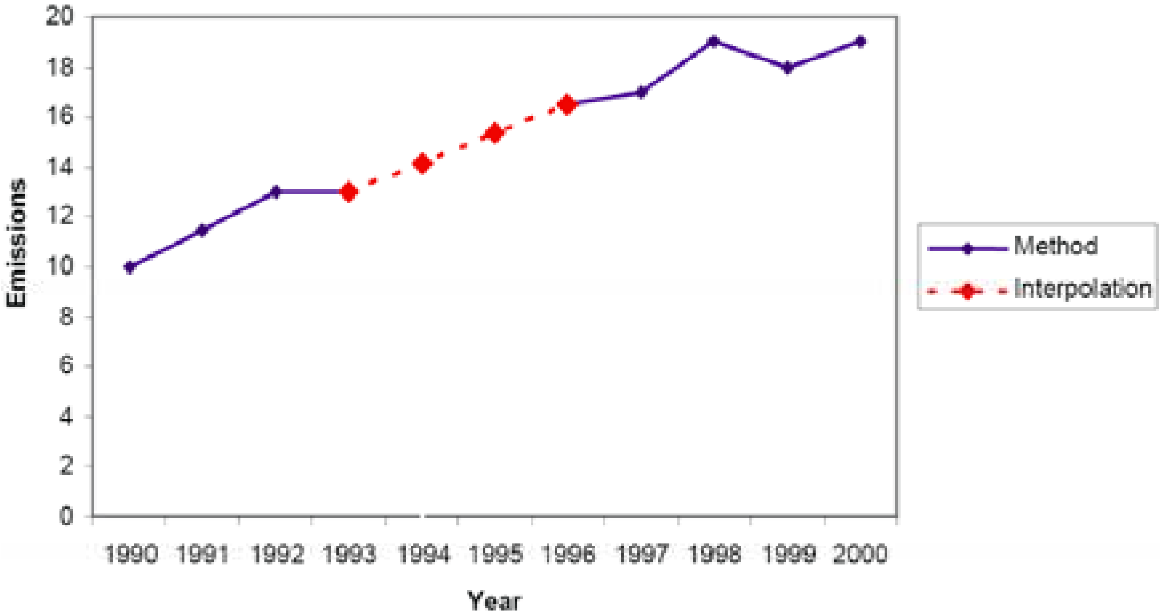
Methods to ensure time series: Example



Data for emission estimation

- Collection of data (AD, EF/parameters) is an integral part of emission inventory
- It is *good practice* that countries use country-specific data as the basis for their emission estimation
- The availability of solid waste data is a major issue in Waste Sector
  - Data on solid waste generation, composition and management etc.
- The 2006 Guidelines provide improved default data and detailed guidance on data collection

CH_4 Emissions from SWDSs

- CH_4 emissions or CH_4 emitted in year *T* from SWDS (Gg)

$$CH_4Emissions = \left[\sum_x CH_4generated_{x,T} - R_T \right] * (1 - OX_T)$$

T = inventory year

x = waste category or type/material

R_T = recovered CH_4 in year *T*, Gg

OX_T = oxidation factor in year *T*, fraction

CH_4 generation at landfills

- Decomposition of organic materials in waste under anaerobic conditions
  - slow and complex process
  - vary with the conditions in the SWDS
- The overall decomposition can be approximated by first order decay (FOD) reaction
  - Amount of product is proportional to the amount of reactant (mass of degradable organic carbon (DOC) decomposable under anaerobic conditions)
- The method in the 2006 Guidelines is based on FOD model
  - Simple spreadsheet model with step-by-step guidance is provided
- FOD method requires data for historical disposals of waste
  - The 2006 Guidelines provide guidance on how to estimate historical waste disposal data

Spreadsheet Model

- Available at
  - http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol5.html
- Two options for emission estimation from municipal solid waste (MSW) depending on data availability
  - Waste composition
  - Bulk waste
- Keeps a running total of the amount of decomposable DOC taking account of the amount deposited each year and the amount remaining from previous years
- Default regional AD and default parameters are included in the spreadsheet

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Spreadsheet Model

- Selection of appropriate region in the *"Parameters"* sheet will adjust the IPCC defaults in other sheets
- Allows selection of DOC and *methane generation rate constant* (*k*) for modeling by waste composition or bulk waste options
- Allows selection of appropriate IPCC default *k* value for the selected climate zone
- The input parameters are entered into cells colored yellow in the worksheets with yellow colored tabs. Other sheets- calculated automatically
- Calculates the amount of CH_4 generated from each waste component on a different worksheet

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Parameters

Country:
Region: Asia- Southeast

Please enter parameters in the yellow cells. If no national data are available, copy the IPCC default value.
Help on parameter selection can be found in the 2006 IPCC guidelines

	IPCC default value		Country-specific parameters	
			Value	Reference and remarks
Starting year		1950	1950	
DOC (Degradable organic carbon)	Waste by composition			
(weight fraction, wet basis)	**Range**	**Default**		
Food waste	0.08-0.20	0.15	0.15	
Garden	0.18-0.22	0.2	0.2	
Paper	0.36-0.45	0.4	0.4	
Wood and straw	0.39-0.46	0.43	0.43	
Textiles	0.20-0.40	0.24	0.24	
Disposable nappies	0.18-0.32	0.24	0.24	
Sewage sludge	0.04-0.05	0.05	0.05	
Industrial waste	0-0.54	0.15	0.15	
DOCf (fraction of DOC dissimilated)		0.5	0.5	
Methane generation rate constant (k)	Wet temperate			
(years^{-1})	**Range**	**Default**		
Food waste	0.1–0.2	0.185	0.185	
Garden	0.06–0.1	0.1	0.1	
Paper	0.05–0.07	0.06	0.06	
Wood and straw	0.02–0.04	0.03	0.03	
Textiles	0.05–0.07	0.06	0.06	
Disposable nappies	0.06–0.1	0.1	0.1	
Sewage sludge	0.1–0.2	0.185	0.185	
Industrial waste	0.08–0.1	0.09	0.09	
Delay time (months)		6	6	

Parameters | MCF | Activity | Amnt_Deposited | Recovery_OX | ... | Theory | Defaults | Food

Methane calculation from: Food waste

		National values
DOC	DOC	0.15
DOCf	DOCf	0.500
Methane generation rate constant	k	0.185
Half-life time ($t_{1/2}$, years)	h = ln(2)/k	3.7
exp1	exp(-k)	0.83
Process start in deposition year. Month M	M	13.00
exp2	exp(-k*((13-M)/12))	1.00
Fraction to CH4	F	0.500

Year	Amount deposited	MCF	Decomposable DOC (DDOCm) deposited	DDOCm not reacted. Deposition year	DDOCm decomposed. Deposition year	DDOCm accumulated in SWDS end of year	DDOCm decomposed	CH_4 generated
	W	MCF	D = W * DOC * DOCf * MCF	E = D * exp2	F = D * (1-exp2)	G = E + (G_{last year} * exp1)	H = F + G_{last year} * (1 - exp1)	Q = H * 16/12 * F
	Gg	fraction	Gg	Gg	Gg	Gg	Gg	Gg
1950	693	0.71	37	37	0	37	0	0
1951	693	0.71	37	37	0	67	6	4
1952	693	0.71	37	37	0	92	11	8
1953	693	0.71	37	37	0	113	16	10
1954	693	0.71	37	37	0	131	19	13
1955	693	0.71	37	37	0	146	22	15
1956	693	0.71	37	37	0	159	25	16
1957	693	0.71	37	37	0	168	27	18
1958	693	0.71	37	37	0	176	28	19
1959	693	0.71	37	37	0	183	30	20
1960	693	0.71	37	37	0	189	31	21
1961	693	0.71	37	37	0	193	32	21
1962	693	0.71	37	37	0	197	33	22
1963	693	0.71	37	37	0	201	33	22
1964	693	0.71	37	37	0	203	34	23
1965	693	0.71	37	37	0	206	34	23
1966	693	0.71	37	37	0	208	35	23
1967	693	0.71	37	37	0	209	35	23
1968	693	0.71	37	37	0	210	35	24
1969	693	0.71	37	37	0	212	36	24
1970	693	0.71	37	37	0	212	36	24
1971	693	0.71	37	37	0	213	36	24

Parameters | MCF | Activity | Amnt_Deposited | Recovery_OX | ... | Theory | Defaults | Food | Garden

Measures to reduce CH_4 emissions from SWDS

- Landfill CH_4 recovery and utilization
  - CH_4 generated at SWDS can be recovered and combusted in a flare or energy device
- CH_4 oxidation in cover soil
  - Oxidation is by methanotrophic micro-organisms in cover soils. Thickness, physical properties and moisture content of cover soils directly affect the oxidation
- Alternative waste management practices
  - Biological treatment of organic waste (e.g. food waste, garden and park waste and sludge), mechanical and biological treatment, incineration for waste-to-energy
- Waste reduction (e.g. through recycling and reusing)

Biological treatment of organic waste: Composting

- An aerobic process and a large fraction of DOC in the waste material is converted into CO_2
  - Reduced volume and more rapid waste stabilization
  - Some carbon storage also occurs in the residual compost
  - Depending on its quality, the compost can be recycled as a fertilizer or soil amendment (increased organic matter, higher water-holding capacity etc.)
- CH_4 and N_2O can both be formed during composting
  - CH_4 can be formed in anaerobic sections of the compost
  - Poorly working composts are likely to produce more both of CH_4 and N_2O

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Biological treatment of solid waste: Anaerobic digestion

- Natural decomposition of organic material without oxygen
- Produces biogas (CH_4+CO_2) and biosolid
  - Generated CH_4 can be used to produce heat and/or electricity
  - Biosolid (digestate) can be used as fertilizer or soil amendment
- N_2O emissions from the process are assumed to be negligible

Biological treatment of solid waste: CH_4 Emissions

- Estimation of CH_4 emissions in inventory year, Gg

$$CH_4 Emissions = \sum_i (M_i * EF_i) * 10^{-3} - R$$

M_i = mass of organic waste treated by biological treatment type *i*, Gg
(regional default values are given in Table 2.1, Chapter 2, Vol. 5, 2006 Guidelines)

EF = emission factor for treatment *i*, g CH_4/kg waste treated (default EFs are in Table 4.1, Chapter 4, Vol.5, 2006 Guidelines)

i = composting or anaerobic digestion

R = total amount of CH_4 recovered in inventory year, Gg

Biological treatment of solid waste: N_2O Emissions

- Estimation of N_2O emissions, Gg

$$N_2OEmissions = \sum_i (M_i * EF_i) * 10^{-3}$$

M_i = mass of organic waste treated by biological treatment type *i*, Gg

EF_i = emission factor for treatment *i*, g N_2O/kg waste treated (default EFs are in Table 4.1, Chapter 4, Vol.5, 2006 Guidelines)

i = composting or anaerobic digestion

Supporting tools and materials

- IPCC EFDB
  - Provides a wide variety of EFs and other parameters with background documentation or technical references so that users can select and use appropriate data on their own responsibility
  - Accessible at http://www.ipcc-nggip.iges.or.jp/EFDB/ and also available in CD ROM
- 2006 IPCC Guidelines Software
  - We aim to have a complete version available by the end of 2010
- Information on TFI website
  - FAQ
  - Presentations
  - Documents (meeting reports, brochures etc.)

Conclusions

- Emission estimations or emission inventories provide information on the level and trends of emissions and enable to monitor the implementation of policies to reduce emissions
- 2006 IPCC Guidelines for National Greenhouse Gas Inventories provide best globally applicable methods to estimate national emissions and removals
- Simple spreadsheet model with step-by-step guidance for estimation of CH_4 emissions from SWDS is available at

  http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol5.html
- Guidance for estimation CH_4 and N_2O emissions from biological treatment of solid waste is given in Chapter 4, Vol.5 of the 2006 Guidelines

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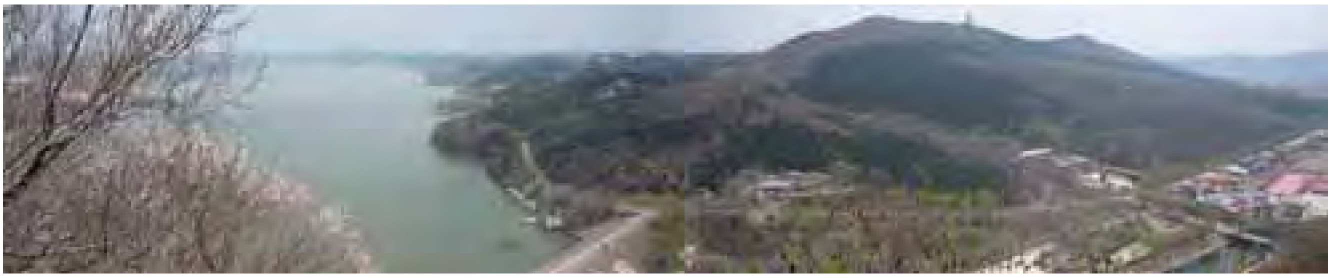

Thank you

Guidelines in all UN languages
can be downloaded from
http://www.ipcc-nggip.iges.or.jp

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