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Comparison of Greenhouse Gas Emission Methodologies for Landfills

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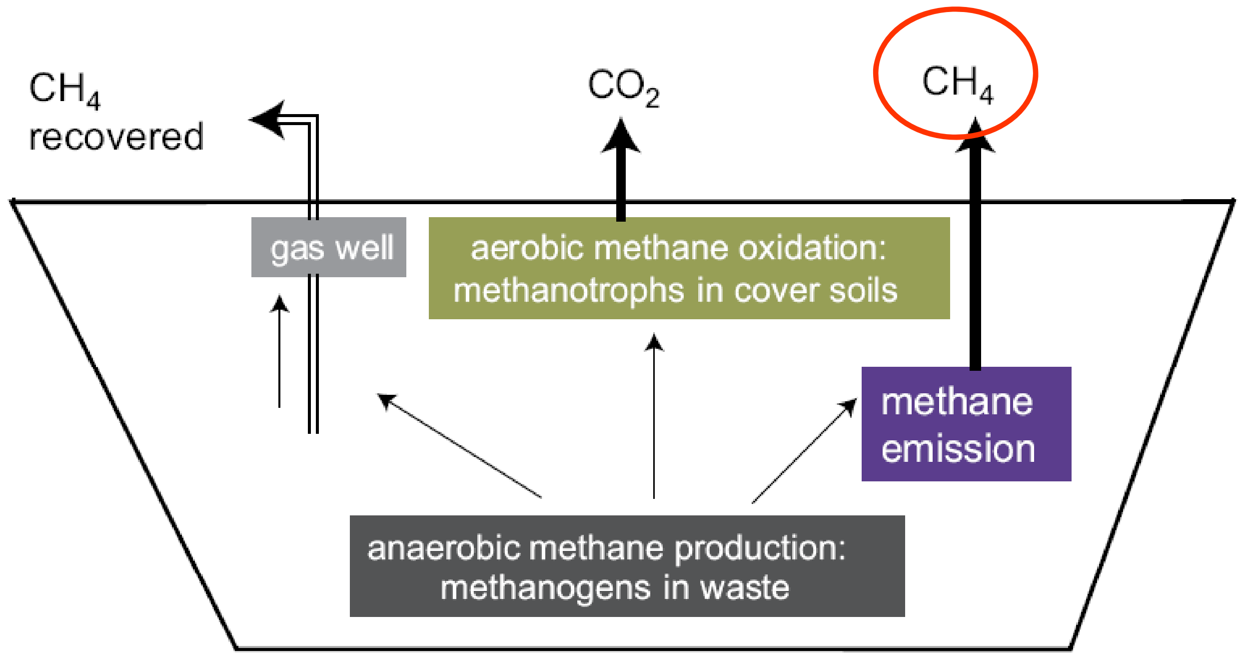
Overview

- Goal is to summarize and quantitatively compare different GHG calculation methods for landfills and factors that are important
  - Quantization methods as practiced “in the field”
  - Look at what factors impact method design and results
- Only concerned with methane (biogenic carbon dioxide is excluded)
- Quantitative example for two sites

Basis – Methane Balance

- Methane balance
- Methane generation minus methane destruction and oxidation
  - Generation cannot be directly measured
- FOD Model
  - Calculates methane generation based on FOD model
  - Critical parameters include methane generation potential and decay rate
- Methane Recovery
  - Bases calculated methane generation based on methane recovery
  - Critical parameters include collection efficiency
  - Cannot be used on sites without collection (must use FOD model)
- Large difference in default parameters used by methods
  - Collection efficiency
  - Methane oxidation
  - Destruction Efficiency

Basis -Simplified Methane Balance



Simplified Landfill Methane Mass Balance

Methane (CH_4) produced (mass/time) = Σ(CH_4 recovered + CH_4 emitted + CH_4 oxidized)

(from Bogner et al, 2007)

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Basis - Flux

- Methane Flux Method (CALMIM Model)
  - Doesn't rely on methane balance
  - Doesn't calculate methane generation
  - Calculates methane flux and oxidation based on climate and cover type

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Summary of Methods

Method	Basis	Purpose	Scale
USEPA MRR	Recovery	Regulatory	Small
USEPA MRR	FOD	Regulatory	Small
IPCC	FOD	Inventory	Large
USEPA Inventory	FOD	Inventory	Large
CARB Inventory	Recovery	Inventory	Large
TCR LGOP	Recovery	Voluntary	Small
SWICS	Recovery	Voluntary	Small
CALMIM	Flux	Voluntary	Small

USEPA MRR

- First annual reports were due September 30, 2011
- USEPA estimated 13,000 facilities would report
- Calculations have been incorporated into some state reporting regulations including Oregon and California
- Calculates methane generation two ways
  - Uses FOD and methane recovery methods, requires the reporting of the highest value
    - Recovery method assumes flow of methane through cover equal to collection rate when GCCS is not operating
    - Calculated generation cannot exceed methane recovery
- Default values derived using national level data
  - Little flexibility to use custom values or site-specific data

USEPA MRR Advantages and Disadvantages

- Advantages
  - Provides a uniform method for GHG reporting in the United States
  - Allows some site specific data to be used when estimating LFG collection efficiency
- Disadvantages
  - If one of the two methods produces an unreasonably high result, that is the reported value
  - Assumes LFG flow passes through cover when GCCS is down
    - Has a large relative impact on sites which do not produce sufficient LFG to run a flare constantly
  - Methane oxidation factor not reflective of current research

IPCC Inventory Process

- Intergovernmental group charged with assessing climate change
- FOD Methane balance
  - L_0 dependent on climate and waste stream
  - K dependent on climate
- National default collection efficiency of 20% for countries with collection
  - Countries may use data to justify higher collection efficiency
    - USEPA low-end estimate of 54% of methane generated is recovered
- A methane oxidation rate of 10%, and a methane destruction rate of 100%

IPCC Inventory Advantages and Disadvantages

- Advantages
  - Global scope
  - Flexible
  - International standard
- Disadvantages
  - Default values are not appropriate for United States (e.g. 20% LFG recovery for collection systems, k = 0.05, etc.)
  - Intended for use at an international level, not on individual landfill basis
  - National default values are frequently inappropriate for individual landfills
  - Methane oxidation factor not reflective of current research

USEPA Inventory Process

- FOD methane balance
  - Engine and flare data collected from USEPA LMOP and vendors to estimate LFG recovery
  - USEPA states it believes the collection value is biased low
- Advantages
  - Representative of US landfills
  - Reasonable in aggregate
- Disadvantages
  - National data may not reflect individual site conditions
  - USEPA's own AP-42 list of emission factors states that 10% methane oxidation in the landfill cover is a conservative value, not reflective of research
  - USEPA data on methane recovery is incomplete

CARB Inventory Process

- Methane recovery method when possible
  - Assumes 75% collection efficiency when LFG collection is present
  - Uses FOD model when no recovery data is available
- Advantages
  - More complete data than EPA
  - Recovery method more reasonable for individual sites
- Disadvantages
  - Relies on several default factors that may not be applicable to many sites
    - 75% collection efficiency is not appropriate for all systems
    - Methane oxidation factor not reflective of current research

TCR LGOP Method

- TCR is a voluntary GHG reporting registry
- Methane recovery method assumes collection efficiency of 75% for areas with LFG recovery
- Allows site specific values
- Advantages
  - Flexible
  - Well suited for single sites
- Disadvantages
  - Not as uniform
  - Scalability

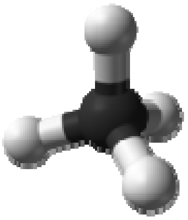
SWICS Method

- Method developed by industry group comprised of public and private service providers
- Methane recovery method
- No single default value for collection efficiency, oxidation, or methane destruction
- Advantages
  - Flexible
  - Well suited for single sites
  - Most site-specific
- Disadvantages
  - Requires substantial professional judgment
  - Scalability
  - Data requirements

CALMIM Model

- Only method discussed that does not rely on methane balance
- Developed with the support of California Energy Commission
- Advantages
  - Can be used when no LFG collection is present
  - Initial field tests are promising
  - Unique approach may reduce problems with FOD or methane recovery based methods
- Disadvantages
  - Still beta version
  - Requires large amount of site data
  - Limited to California sites

Quantitative Comparison



Quantitative Comparison - Background

- Quantitative comparison of two sites using the GHG calculation methods shown
- Sites were chosen to show problems that could arise
  - Both are unusual situations but not unique
- Site 1 is a Northern California MSW landfill
  - LFG recovery exceeds modeled methane generation
- Site 2 is a Southern California MSW landfill
  - LFG generation is not sufficient to run a flare constantly
- Only methane is calculated and shown
- IPCC Method assumes 54% LFG collection efficiency

Site 1 Methane Generation

Method	Methane Recovery (Mg)	Methane Recovery Rate	FOD Methane Generation	Recovery Method Methane Generation (Mg)
USEPA MRR (Recovery)	30,000	**77%**		**39,000**
USEPA MRR (FOD Model)	30,000	Not applicable	**21,000**	**30,000**
IPCC	**11,000**	54%	**21,000**	**21,000**
USEPA Inventory	30,000	Not applicable	**21,000**	**21,000**
CARB Inventory	30,000	75%		**40,000**
TCR	30,000	75%		**40,000**
SWICS	30,000	**94%**		**32,000**

Bold values indicate calculated values

Site 1 Methane Emissions

Method	Methane Emitted Through Cover (Mg)	Methane From Combustion Device (Mg)	Total Methane Emissions (Mg)
USEPA MRR (Recovery)	8,100	300	8,400
USEPA MRR (FOD Model)	0	300	300
IPCC	9,000	0	9,000
USEPA Inventory	-9,000	300	-8,700
CARB Inventory	9,000	300	9,300
TCR	9,000	300	9,300
SWICS	1,300	12	1,300
CALMIM	164	1.4	165

Site 1 Conclusions

- Methane recovery exceeds FOD modeled methane generation
  - USEPA MRR traps that error
  - USEPA Inventory does not trap error
- Most emissions are fugitive
  - Collection efficiency is critical

Site 2 Methane Generation

Method	Methane Recovery (Mg)	Methane Recovery Rate	FOD Methane Generation	Recovery Method Methane Generation (Mg)
USEPA MRR (Recovery)	71	**75%**		**190**
USEPA MRR (FOD Model)	71	NA	**1,800**	**1,800**
IPCC	**1,000**	54%	**1,800**	**1,800**
USEPA Inventory	71	NA	**1,800**	**1,800**
CARB Inventory	71	75%		**95**
TCR	71	75%		**95**
SWICS	71	**54%**		**131**

Bold values indicate calculated values

Site 2 Methane Emissions

Method	Methane Emitted Through Cover (Mg)	Methane From Combustion Device (Mg)	Total Methane Emissions (Mg)
USEPA MRR (Recovery)	107	0.7	108
USEPA MRR (FOD Model)	1,700	0.7	1,700
IPCC	800	0	800
USEPA Inventory	1,700	0.7	1,700
CARB Inventory	24	0.7	25
TCR	24	0.7	25
SWICS	60	0.003	60
CALMIM	15	0.003	15

Site 2 Conclusions

- FOD model overestimates generation
  - Model parameters
- IPCC method overestimates capture
- Some methods show higher emissions than Site 1
- Important to use same methods and assumptions when comparing values

Conclusions

- Appropriate model is critical
- Vast differences are possible
  - 165 to 9,300 metric tons for Site 1
  - 15 to 1,700 metric tons for Site 2
- Methods that produce reasonable values in the aggregate may not produce reasonable numbers when applied to individual sites (negative emissions for Site 1 using USEPA inventory method)
- Default values are not always applicable to individual sites (i.e. IPCC default global collection efficiency of 20%)
- Site specific methodologies can require more information than is available, but the USEPA MRR may change that

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