The limitations of EPA's LandGEM and an alternative Solution

SWANA Solid Waste Student Design Competition, 2022

Sustainable Environmental Solutions

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Introduction

- Model based on data from 13 U.S. landfills and follow first-order decay rate equation.
- User may be able to input few site-specific values, but such data is limited.
- LandGEM is outdated, created in 1996 and last updated in 2005.
- Waste stream composition differs from 1980's and 90's.
- Alternative model necessary

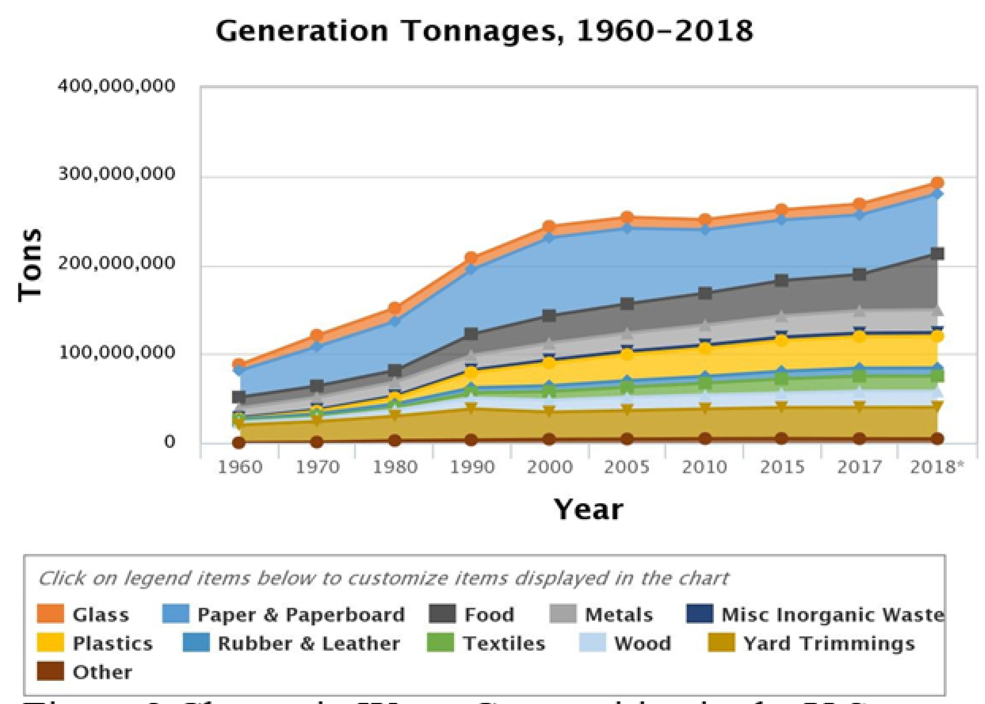

Figure 2 Change in Waste Composition in the U.S.

$$Q_{CH_4} = \sum_{i=0}^{n}\sum_{j=0}^{12} k \frac{M_i}{12} L_0 e^{-kt_{ij}} \quad \text{-------(a)}$$

Where,

$$\log_{10} {}^{\wedge}K = -3.02658 - 0.0067282R^2 + 0.069313R + 0.00172807(R \times F) + 0.01046T - 0.001152F + 0.00418TX + 0.00598Y \quad \text{-------(b)}$$

and

$$L_0 = (Food*60.19+Paper*274.9+Textile*173.4+Yard*69.08)/100 \quad \text{-------(c)}$$

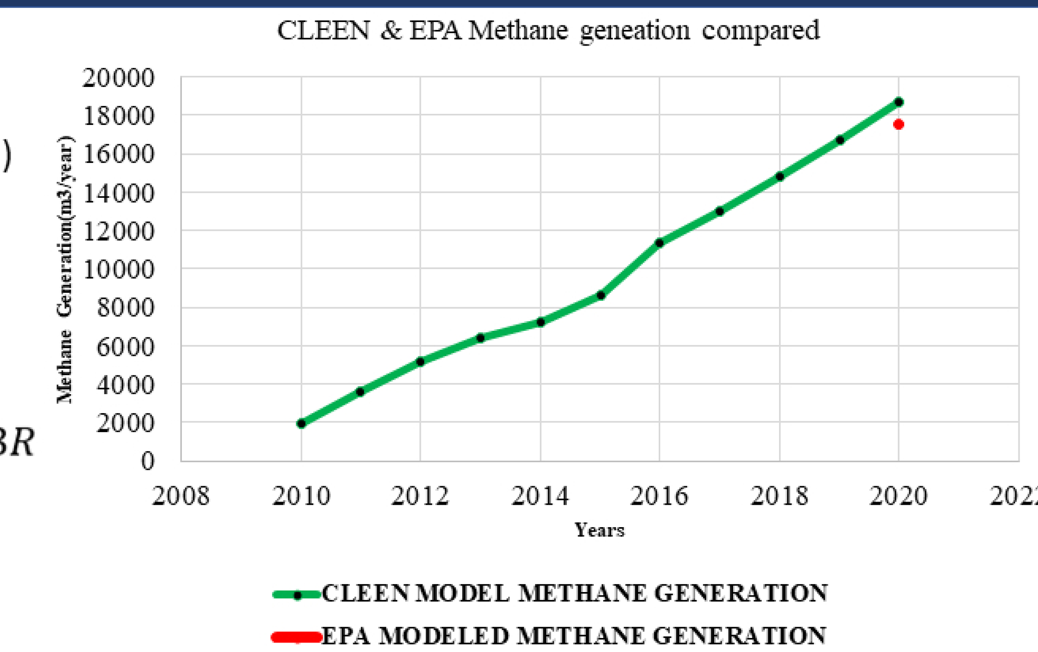

Figure 3: CLEEN & EPA methane generation comparison for Colorado state

Assumptions

- Waste is totally homogeneous.
- Methane generation rate is constant for all waste type.
- Default values account discretely for variations in moisture content due to rainfall or leachate recirculation
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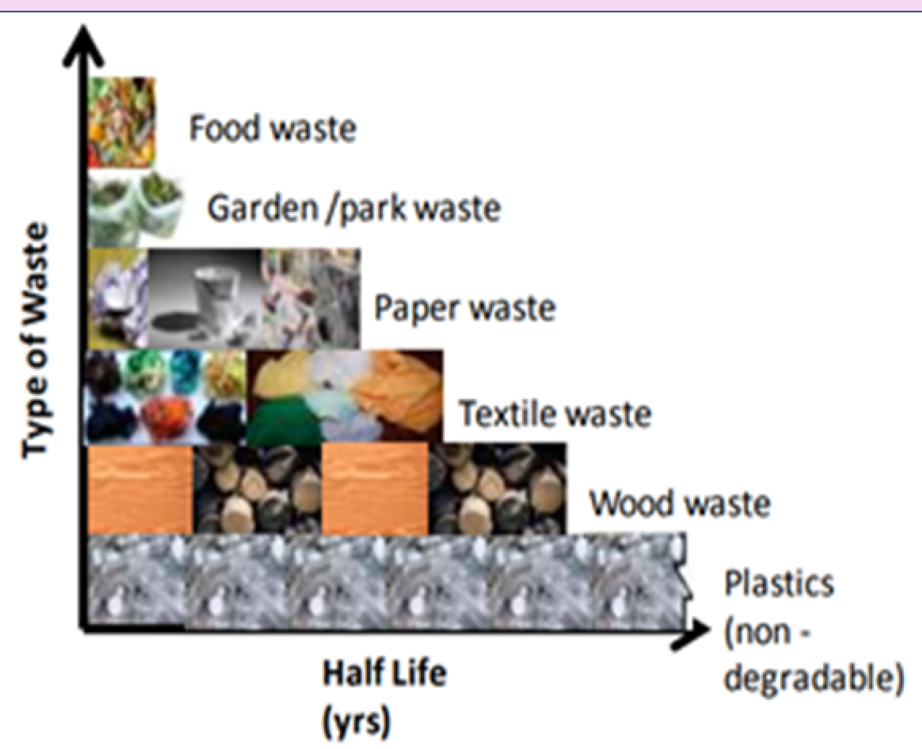

Figure 1 Graphical representation of rate of degradation of different waste components

Limitations of LandGEM

- Default values of k and L_0 do not account for variations in waste composition, moisture or temp.
- k and L_0 values are applicable to bulk waste, but not specific waste types.
- Losses occurring due to the recovery and oxidation not accounted.
- Does not account for variations in waste composition over time.
- Not all site-specific data can be used.
- Waste acceptance rates limited(80yrs)
- Assume single decay rate for waste.
- Default values might not work well with other countries as they are based on the US waste composition.
- Errors in data input can significantly over-estimates methane generation
- The assumption on LFG generation rate (Peaks after closure) limits the accuracy of LFG estimation.

The CLEEN Model

The Capturing of Landfill Emissions for Energy Needs (CLEEN)

- Excel-based model using a simple first-order decay equation developed by UTA.
- Allow users to input site specific data on temperature(68-98.6°F), rainfall(2-12mm/day) and waste compositions.
- Methane generation rate equation(a) is based on laboratory-scale methane generation data.
- Scale-up factor equation adjust the lab rates to values representative of field conditions.
- Allows user to input monthly waste accepted if available.
- Account for the methane losses due to recovery and oxidation
- Data collected from the landfills of high-income countries

Assumptions

- Assume a first-order decay equation
- Use a 1/12th of a mass instead of the 1/10th in the decay equation.
- Total methane generated in the landfill is not completely recovered by system due to oxidation and surface emission.
- Assumes a lag period of 6 months.
- Lo (equation c) is calculated using Biochemical Methane Potential values.

Limitations/ suggestions

- k value was developed from lab scale data, hence holds for conditions in the range studied in the lab.
- Does not have graphical output.
- The % CH_4 recovered and % CH_4 oxidized are sources of uncertainty in the model.
- Model validation is required for data outside the range of lab scale data.

Model Comparison

Parameter	LandGEM	IPCC	CLEEN
Equation	First-order decay Equation	Multiphase first-order decay (2006)	First-order decay Equation
Data used	U.S, Canada	International	Lab scale, Validated
Lag time	0-1 yr	0-0.5 yr	0-0.5yr
Waste composition	Ignored	User specific	User specific
Temperature	Ignored	4 combinations of values	User specific
Moisture content	3 sets value	4 combinations of values	User specific
k value	constant	Choose a default value depending on other parameters	Uses equation dependent on temp. , moisture content, waste composition
L_0	constant	Uses equation dependent on MCF, DOC, DOC_f, CH_4 fraction	Uses equation dependent on waste composition (i.e. user specific)
Oxidation	Ignored	Ignored	Considered
Site specific	No	Mostly	Yes

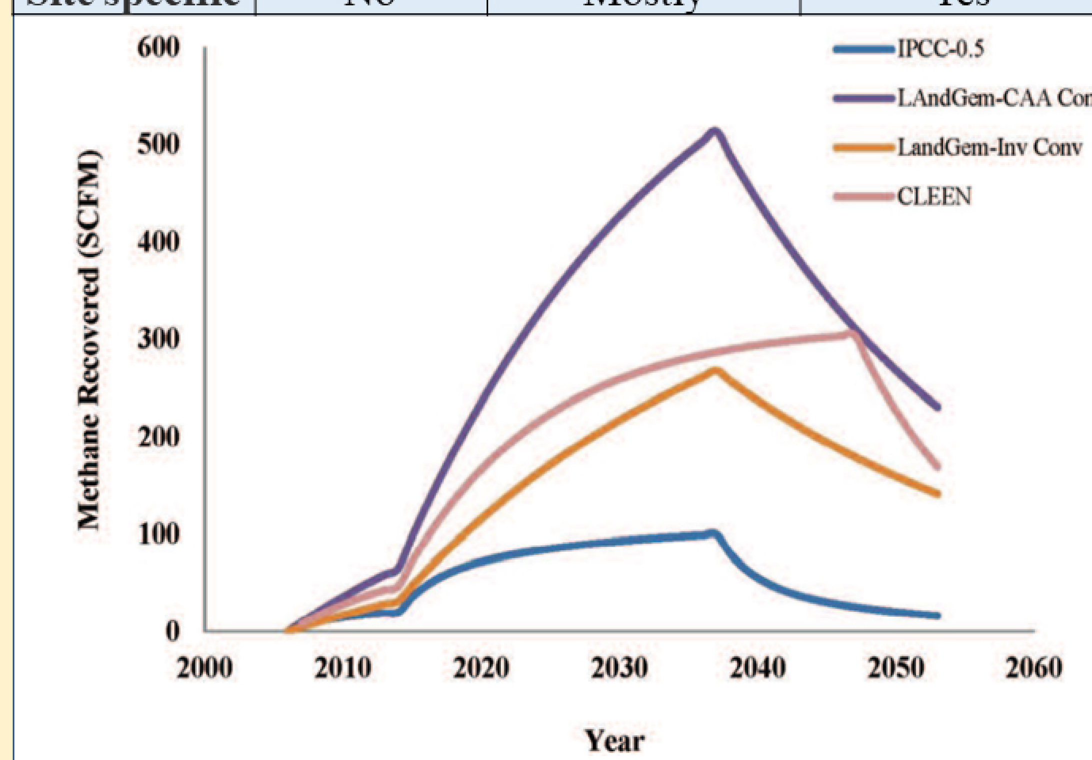

Figure 4: Conventional landfill methane recovery, Temale Landfill, Ghana. Source: University of Texas at Arlington.

References

- Karanjekar, R. V. (2013). An improved model for predicting methane emissions from landfills based on rainfall, ambient temperature and waste composition.
- United States Environmental Protection Agency (USEPA), 2005, "Landfill Gas Emissions Model (LandGEM) Version 3.02 User's Guide", Report no. EPA-600/R-05/047, U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC
- Dillah, D. D., Panesar, B., Gornto, M., & Dieleman, B. L. (2013). New and Improved Implementation of the First Order Model for Landfill Gas Generation or Collection. SCS Engineers. Available online: https://www. scsengineers. com/scs-white-papers/new-and-improved-implementation-of-the-first-order-model-for-landfill-gas-generation-or-collection
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