Toward Sustainable Municipal Solid Waste Management: Biogas Generation in Middle Tennessee Landfills

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Engineering Technology

Introduction

Municipal Solid Waste (MSW) management has become a serious issue around the world considering the global population growth. Total MSW generated in the United States was 292.4 million tons in 2018, and the World Bank projected a waste generation of 396 million tons in 2050 in North America.

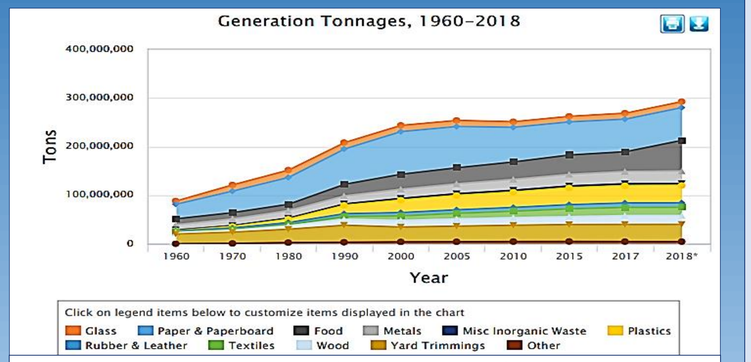

Figure 1: MSW Generated in the United States from 1960 to 2018

MSW landfills are potential sources of producing renewable energy via collecting and processing biogas, mainly consisting in methane gas. Anaerobic Digestion (AD) is the process of using bacteria to transform organic components of the waste into bioenergy.

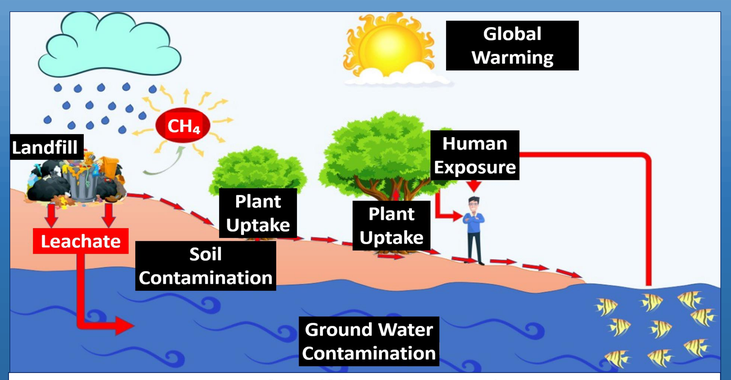

Figure 2: Impacts of Landfill Emissions on the Environment

Objectives

The objective of this research was to quantify the potential of Middle Point Landfill in Murfreesboro, Tennessee, to produce biogas as a source of bioenergy using LandGEM Model, which was developed by the Environmental Protection Agency (EPA).

Model Introduction and Data Collection

- **LandGEM:** Microsoft Excel-based software developed by EPA, used to predict the emission rates for methane, carbon dioxide, nonmethane organic compound, total landfill gas, and individual air pollutants.
- **Model input variables:** The software needs 4 initial inputs provided by the user and specific of the studied landfill, which are, 1. Open year, 2. Closure year, 3. Waste design capacity, and 4. Yearly waste acceptance rates.
- **Calculations:** LandGEM software utilizes a First-Order Decay Equation, which takes into consideration variables related to both the analyzed landfill as well as EPA and Clean Air Act (CAA) default parameters. The variables for the equation are the following: Annual methane generation in the year of the calculation (Q_{CH4}), 1 year time increment (i), Year of the calculation minus Initial year of waste acceptance (n), 0.1-year time increment (j), Methane generation rate (k), Potential methane generation capacity (L_o), Mass of waste accepted in the i^{th} year (M_i), and Age of the j^{th} section of waste mass M_i accepted in the i^{th} year (t_{ij}).

$$Q_{CH4} = \sum_{i=1}^{n} \sum_{j=0.1}^{1} k\, L_0\, (M_i/10)\, (e^{-kt_{ij}})$$

First-First Order Decay Equation

- **Data Collection:** The input variables required to run a LandGEM analysis of the Middle Point Landfill were acquired directly from the landfill database, as well as from official reports from the Tennessee Department of Environment and Conservation.

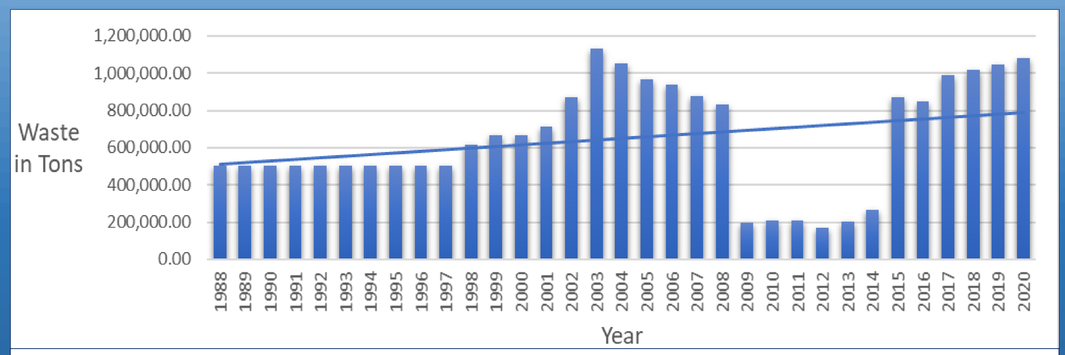

Figure 3: Middle Point Landfill Waste Acceptance Rates

Results

After running the LandGEM software with the collected data, the results showed that in 2020 there was 18.5 million Megagrams (Mg) of waste-in-place, out of which there was a generation of 86.6 million cubic meters of total landfill gas, where methane gas represented 50% of the emissions. LandGEM also predicted that by the closure year (2029), the amount of waste-in-place, total landfill gas generated, and methane gas fraction will be 30.0 million Mg, 119.7 million cubic meters, and 50%, respectively.

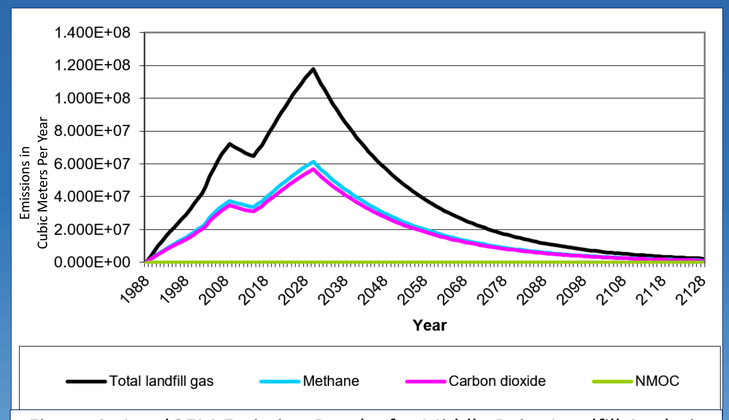

Figure 4 : LandGEM Emission Results for Middle Point Landfill Analysis

Conclusion

LandGEM analysis results revealed that Middle Point Landfill has a high potential of producing bioenergy (60 million cubic meters per year in 2029). The acquired results from this study can be compared to the total marketed production of natural gas in Tennessee in 2019 (i.e., 79.3 million cubic meters). Generation and collection of methane gas and other types of biogas from Middle Tennessee landfills can reduce the greenhouse gas emissions and climate change and serve as a source of renewable energy.

References

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