Chapter 12
Biogas Plants for Sustainable Municipal Waste Management: A Brief Review

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ABSTRACT

Municipal waste management is a critical issue for sustainable development, and traditional methods are becoming unsustainable. Biogas plants offer a promising solution using organic waste to produce biogas for electricity or fuel. This review examines the benefits and challenges of biogas plants for municipal waste management, including the complex biochemical process, factors affecting efficiency, and challenges like high costs, etc. Biogas production diverts waste from landfills, reduces greenhouse gas emissions, and creates economic opportunities. Successful case studies from Germany, India, South Africa, etc. are also highlighted in this chapter. Future research directions are also discussed to optimize the process, assess environmental impacts, and evaluate economic viability. Overall, biogas plants represent a promising approach to sustainable municipal waste management that can contribute to the transition toward a more circular and sustainable economy.

INTRODUCTION: MUNICIPAL WASTE MANAGEMENT AND THE NEED FOR SUSTAINABLE SOLUTIONS

Municipal solid waste management (MSWM) is an essential service provided by municipalities and other public entities to manage solid waste generated by households, businesses, and institutions within their jurisdiction. Effective MSWM is crucial for protecting public health and the environment, conserving natural resources, and promoting sustainable development. This section provides an overview of the background, history, and current practices of MSWM (Brunner & Rechberger, 2015; Kulkarni, 2020; Shah et al., 2021; Vyas et al., 2022).

DOI: 10.4018/978-1-6684-8117-2.ch012

Background

MSWM has been a concern for humans since the beginning of civilization. Historically, people disposed of waste by throwing it into rivers, burying it in pits, or burning it. In ancient Rome, waste was thrown onto the streets, while in medieval Europe, waste was burned in large pits. However, with the rise of industrialization and urbanization in the late 19th and early 20th centuries, MSWM became more complex and challenging (Brunner & Rechberger, 2015; De Feo et al., 2014; Karak et al., 2012; Sandhu, 2014; Wilson, 1976).

In the United States, the first municipal dump was established in New York City in 1895. Other cities followed suit by creating their own landfills. However, landfills began to reach capacity, and the public became increasingly aware of the environmental and health hazards associated with improper waste disposal. In the 1960s and 1970s, the U.S. government passed a series of laws and regulations to address these issues, including the Solid Waste Disposal Act of 1965 and the Resource Conservation and Recovery Act of 1976 (Kollikkathara, Feng, & Stern, 2009; Kollikkathara, Feng, & Stern, 2009; Lee & Huffman, 1989; Oakes & Shank, 1979; Wilson, 1976).

MSWM Practices

MSWM practices typically include several steps: collection, transportation, processing, and disposal. The following are the general steps followed for the same.

- **Collection:** Waste is collected from households, industries, and institutions by waste haulers using specialized trucks. In some cases, residents may need to separate recyclable materials from non-recyclable waste, while in other cases, the waste is collected mixed together.
- **Transportation:** Waste is transported to a transfer station, where it is sorted and loaded onto larger trucks for transport to a landfill or recycling facility. The transfer station is also where the waste is weighed, and the haulers are charged a fee based on the weight of the waste.
- **Processing:** Waste is processed at a landfill or recycling facility, depending on its composition. Landfills are designed to safely contain waste and prevent contamination of the surrounding environment. Landfills typically involve compacting and burying the waste under several feet of soil. Some landfills also generate electricity by burning methane gas produced by decomposing waste. Recycling facilities, on the other hand, separate recyclable materials from non-recyclable waste. Recyclable materials such as paper, plastic, glass, and metal are then turned into new products.
- **Disposal:** Non-recyclable waste is disposed of at a landfill, where it is buried and covered with soil to prevent odors and pests. Landfills must be carefully engineered to prevent groundwater contamination and protect air quality. Modern landfills are required to have liners, leachate collection systems, and methane gas management systems.
- **Recycling:** Recyclable materials such as paper, plastic, glass, and metal are separated and sent to recycling facilities, where they are processed and turned into new products. Recycling helps conserve natural resources, reduce the amount of waste sent to landfills, and reduce greenhouse gas emissions.

As depicted in Figure 1, there are different kinds of biomass available. However, to ensure the safe and effective handling of waste, it is crucial to implement proper municipal solid waste management