The Academic
International Journal of Multidisciplinary Research

An Online Peer Reviewed / Refereed Journal
Volume 2 | Issue 11 | November 2024
ISSN: 2583-973X (Online)
Website: www.theacademic.in

Biogas Generation from Culinary Refuse

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ARTICLE DETAILS

Research Paper

Keywords:

Biogas production, Kitchen waste, Anaerobic digestion, Gas yield

DOI:

10.5281/zenodo.14315105

ABSTRACT

The research examines biogas generation from kitchen garbage through anaerobic digestion. Kitchen garbage, abundant in organic material, was treated in regulated conditions to assess gas yield and composition. Findings demonstrate that kitchen trash much exceeds traditional substrates such as cow dung in terms of gas production efficiency and economic feasibility. This paper highlights the viability of establishing biogas systems at institutional levels for sustainable energy solutions.

1. Introduction

The rising worldwide energy demand, along with the swift exhaustion of fossil fuel supplies, has made the exploration of sustainable and renewable energy sources imperative. Fossil fuels, which presently prevail in the energy sector, are limited in supply, and their combustion substantially adds to greenhouse gas emissions, resulting in environmental issues such as global warming and climate change. In contrast, renewable energy sources offer a feasible way to fulfill energy requirements while reducing environmental impact. Biogas has garnered significant interest among renewable energy options for its dual function in energy generation and waste management [1,2].

Biogas is a multifaceted and eco-friendly fuel produced via anaerobic digestion. This process entails the decomposition of organic waste by microbes in an anaerobic environment, yielding methane-rich gas suitable for cooking, heating, and energy generation. The residual residue, also known as digestate, is a nutrient-dense substance that can serve as an organic fertilizer, thus promoting sustainable agricultural practices. The diverse advantages of biogas highlight its importance as a renewable energy source with substantial potential to enhance a circular economy [3,4].

A notable advantage of biogas generation is its capacity to employ organic waste resources, such as agricultural wastes, animal manure, and kitchen garbage. Kitchen garbage is particularly notable as an efficient feedstock due to its substantial organic content and extensive availability. Households produce substantial quantities of kitchen garbage daily, comprising food remnants, vegetable skins, and uneaten meals. In numerous areas, this garbage is either burnt or disposed of in landfills, exacerbating environmental pollution and emitting deleterious gasses such as methane and carbon dioxide into the atmosphere. Utilizing kitchen garbage for biogas production offers a sustainable energy solution while simultaneously tackling significant waste management issues [5].

Utilizing kitchen trash as a feedstock for biogas generation is particularly beneficial in comparison to conventional substrates like cow manure. Cow dung is a fundamental substrate for anaerobic digestion in numerous rural regions; nevertheless, its accessibility may be restricted in urban environments where animal production is less common. Conversely, kitchen garbage is plentiful and easily obtainable in urban and suburban regions, rendering it an optimal solution. Furthermore, kitchen trash possesses a superior energy potential owing to its elevated biodegradable organic content. This not only improves the efficiency of biogas generation but also renders it economically feasible for homes and small communities to embrace biogas technology [6].

The incorporation of biogas systems into contemporary waste management procedures provides several environmental, economic, and social advantages. Biogas production substantially decreases the amount of waste directed to landfills, so alleviating the emission of methane, a powerful greenhouse gas, into the environment. It offers a cost-efficient option for energy production, diminishing reliance on traditional energy sources and decreasing household energy costs. It socially enables communities to sustainably manage garbage, hence enhancing cleaner and healthier living conditions [7].

Notwithstanding its clear benefits, the implementation of biogas technology is constrained in specific areas due to insufficient awareness, technical proficiency, and infrastructure. Initiatives to advance biogas systems should concentrate on enhancing public understanding of their advantages, provide technical training for installation and maintenance, and giving financial incentives to facilitate widespread adoption. The effective deployment of biogas technology can revolutionize societal approaches to energy production and waste management, promoting a more sustainable and ecologically responsible future [8-9].

This introduction underscores the critical significance of biogas in tackling urgent global issues, particularly focusing on the viability of kitchen waste as a feedstock for sustainable energy production. This discussion seeks to highlight the significance and applicability of biogas generation by examining its technological, environmental, and social components within contemporary energy and waste management frameworks.

2. Review of Literature

Numerous research experts have evidenced the benefits of utilizing kitchen garbage for biogas generation. Karve (2007) asserts that utilizing starchy or sugary feedstocks, such as kitchen trash, markedly increases methane output in contrast to traditional biogas systems dependent on cow dung. His tiny biogas system utilizes food waste, producing a higher methane yield per unit of feedstock and completing the reaction in about 52 hours, far faster than traditional processes that take up to 40 days. Igoni (2008) found that biogas yield improves geometrically with elevated total solids concentrations in the feedstock, rendering kitchen garbage an optimal substrate for maximum biogas production. Shalini Singh (2000) discovered that incorporating microbial stimulants into organic waste, such as kitchen garbage, augments gas production by boosting microbial activity. These research collectively substantiate the notion that kitchen garbage can serve as an effective and sustainable feedstock for biogas production [10-12].

3. Methodology

The experiment utilized two distinct digesters: Setup (O) for cow dung digestion and Setup (N) for kitchen waste digestion. Both configurations were supplied with suitable feedstock combined with inoculum to commence the anaerobic digestion process. The experiment was conducted in a controlled laboratory environment, with daily assessments of gas generation, pH levels, and volatile fatty acids (VFA). Gas output was quantified in milliliters on a daily basis, while pH levels were assessed to maintain optimal circumstances for the methanogens responsible for methane synthesis. VFA concentrations were quantified to evaluate the intermediate phases of digestion.

3.1 Experimental Setup

The digesters employed in the investigation were as follows:

1. Setup (O): Cow dung-based digester (2.5 liters of cow dung combined with water and inoculum).

2. Setup (N): Digester utilizing kitchen waste (kitchen waste combined with inoculum, augmented with NaOH for pH regulation).

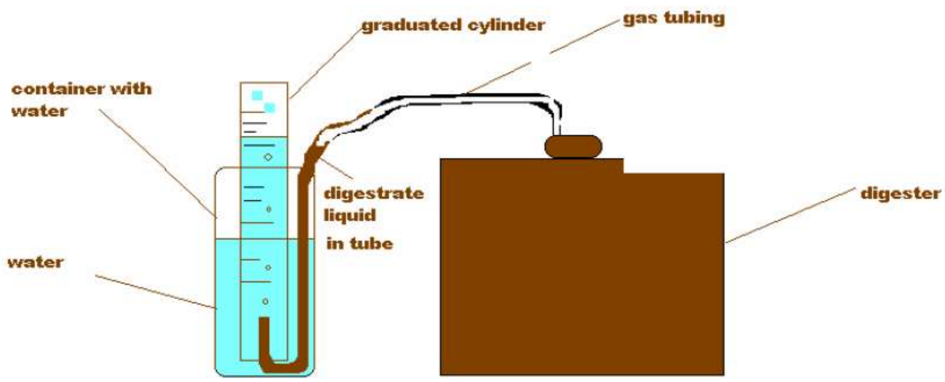

Fig. 1. Anaerobic disgestor

The feedstock in Setup (O) was created by combining 2.5 liters of cow manure with water to produce a slurry. In Setup (N), cooking waste was gathered from the hostels and combined with water and inoculum. Sodium hydroxide was introduced to sustain the pH at ideal values for methanogenic bacteria is shown in Fig. 1.

4. Results and Discussion

4.1 Natural Gas Production

Gas production was monitored daily for both configurations. Setup (N), employing kitchen waste, generated greater biogas than Setup (O), which employed cow dung as feedstock. Setup (N) had a peak biogas output of 12,850 ml on day 12, whereas Setup (O) attained a maximum of 7,500 ml on day 19. Setup (N) generated almost 60% more biogas than Setup (O), demonstrating that kitchen garbage serves as a more effective feedstock for biogas generation. The elevated calorific value and nutritional density of the kitchen trash likely facilitated this enhanced production is shown in Fig. 2.

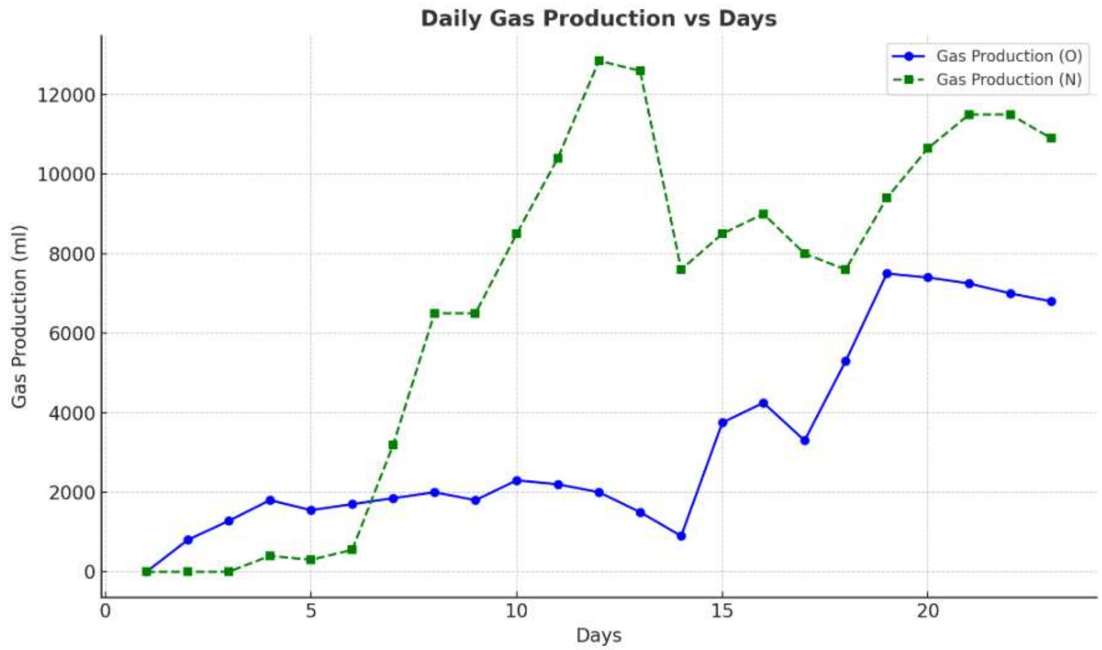

Fig 2. Gas Production Rate

4.2 Variations in pH

Setup (N) sustained a consistent pH range of 7.0 to 7.5, optimal for methanogenic activity. Setup (O) exhibited variable pH levels, signifying a more unstable digestive process. The consistent pH in Setup (N) signifies a robust anaerobic environment, essential for optimal biogas generation. Is shown in Fig. 3.

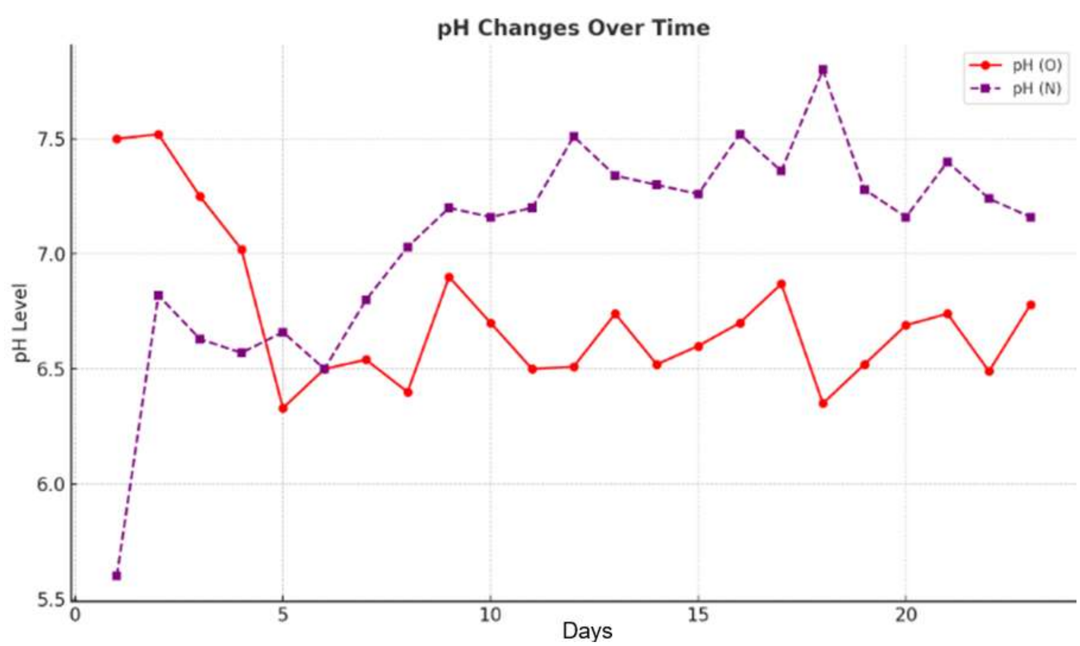

Fig.3 pH variation during the experiment in setup O and N

4.3 Volatile Fatty Acids and Efficacy

Volatile fatty acids (VFA), an intermediate by-product of anaerobic digestion, were quantified to assess the efficiency of the digesters. Setup (N) had a more accelerated decline in VFA content, indicating a swifter and more effective digestive process. The accelerated decrease of VFA in Setup (N) correlates with increased gas production, affirming that kitchen waste is digested more efficiently than cow dung is shown in Fig 4.

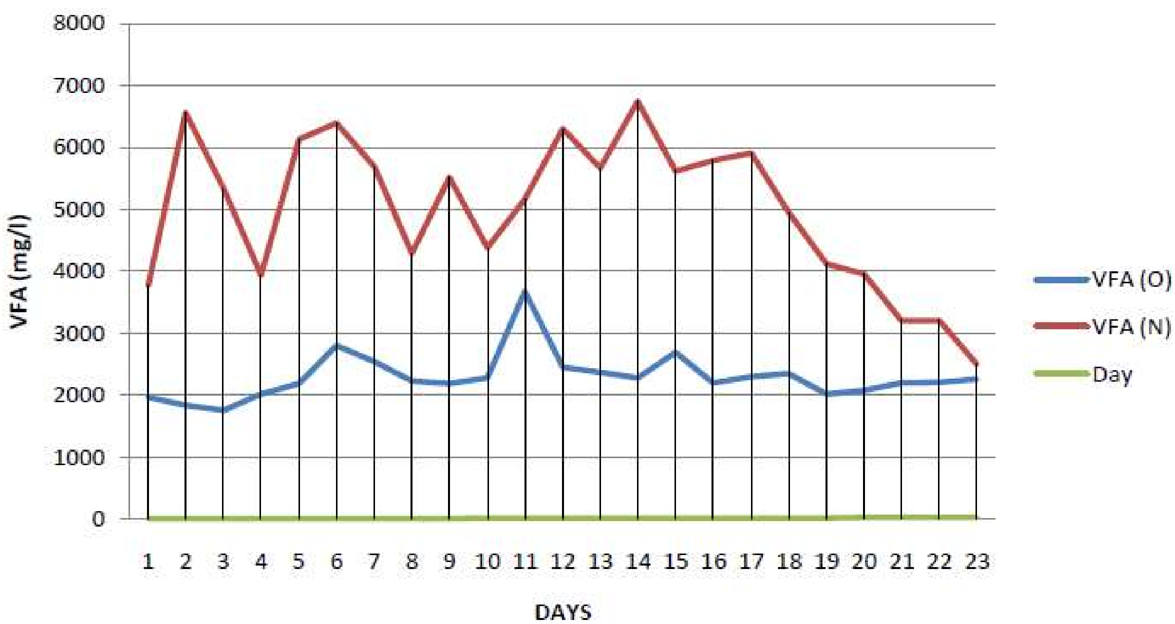

Fig.4 Daily VFA Change

4.4 Economic and Environmental Effects

From an economic standpoint, the biogas generated from kitchen trash provides substantial savings. Utilizing biogas for culinary purposes can substitute LPG usage, resulting in a savings of up to 13 LPG cylinders monthly for each 1,000-liter digester. The environmental advantages of utilizing kitchen garbage for biogas production are significant. It mitigates methane emissions from landfills and facilitates the management of organic waste, hence decreasing the necessity for landfill disposal.

5. Conclusion

This study illustrates that kitchen trash serves as an exceptionally effective feedstock for biogas production, providing considerable benefits compared to conventional biogas systems dependent on cow dung. The increased gas output, accelerated digestion process, and consistent pH levels noted in Setup (N) underscore the advantages of kitchen waste as a renewable energy resource. Expanding these systems could yield substantial environmental and economic advantages, particularly in institutional environments that produce considerable kitchen trash. This study advocates for the broader implementation of biogas technology, facilitating waste minimization and sustainable energy generation.

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