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DESIGN OF MINIATURE PROTOTYPE FOR ORGANIC WASTE BASED COMPRESSED BIOGAS PRODUCTION AND PURIFICATION

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ABSTRACT

The prototype presented in this study harnesses organic waste to produce clean and renewable biogas through innovative biological processes. Purification techniques employing basic agents ensure the removal of impurities, while compression enhances storage and transportation capabilities. Initial tests indicate the system's viability, offering energy efficiency and cost-effectiveness compared to conventional methods. The prototype showcases a sustainable solution for organic waste management. Its integration of biological processes and purification techniques marks a significant advancement in biogas production. The promising results underscore the potential for widespread adoption of this eco-friendly technology.

Keywords: Biogas Production, Purification, Compression, Miniature Prototype, Organic Waste

INTRODUCTION

- The Design of Organic Waste-based Compressed Biogas Production and Purification Prototype innovatively utilizes organic waste, like kitchen scraps and cow dung, to generate clean and renewable biogas.
- Diverging from conventional methods, this project integrates biological processes for the conversion of raw biogas into a more efficient fuel source.
- It incorporates purification techniques using basic agents like steel wool, calcium hydroxide, and silica gel to remove impurities, ensuring a cleaner end product.
- Finally, the purified biogas is compressed into cylinders using a refrigerator compressor, enhancing its storage and transportation capabilities for versatile applications, offering energy efficiency and cost-effectiveness compared to traditional methods.

OBJECTIVES

- To Develop a small lab scale prototype for production of biogas
- To Maintain the optimum conditions for biogas production and storage
- To Purify the produced biogas with various techniques
- To Compress the purified biogas

MATERIALS & METHODS

Lab Scale Studies:

- Made slurry from kitchen waste, cow dung, and water
- Analyzed: Carbohydrates (Phenol-Sulphuric), protein (Lowry's), triglycerides (Phospho Vanillin), reducing sugars (DNSA)

Miniature Digester Construction:

- Built a miniature digester using a 30L plastic Can and prepared and added slurry
- Conducted phase determination of slurry using pH and Neutral $FeCl_3$ tests
- Analyzed evolved gas was stored using a tire tube and analyzed using flame tests Optimized the operation of a miniature digester for enhanced efficiency and performance.

Fig.1 Lab scale Studies

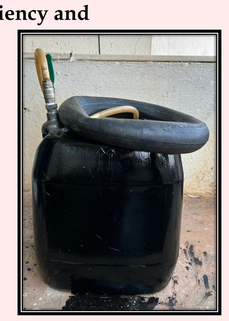

Fig.2 Miniature Digester

MATERIALS & METHODS

Prototype Construction:

- Upscaled to build the prototype using a supporting structure stand
- Built purification unit with plastic casings filled with purifying agents: steel wool, calcium hydroxide solution, and silica gel beads
- Built compression unit with a refrigerator compressor and pressure gauge connected to a gas cylinder
- Conducted optimization to ensure system integrity, addressing potential leakages for enhanced performance and safety.

Test Runs:

- Conducted test run using atmospheric air as a reference for comparison.
- Analyzed the results to establish baseline performance parameters.
- Conducted subsequent test run using biogas as the fuel source.
- Analyzed the results to assess biogas combustion efficiency and overall system performance.

METHODOLOGY

Analyze slurry composition

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Scale up experiments with Miniature Digester

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Monitor gas evolution and upgrade digester

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Purify and Compress biogas

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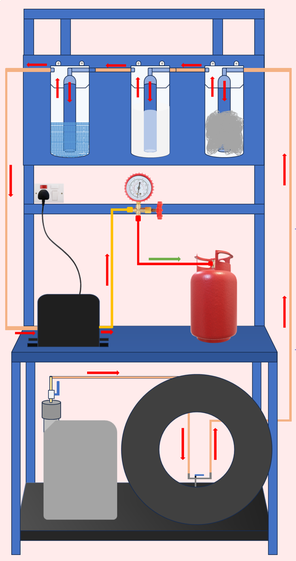
Store and utilize compressed biogas

PROTOTYPE



RESULTS & DISCUSSION

- Quantified carbohydrates, proteins, lipids, and reducing sugars in the organic waste slurry
- Proximate analysis guided fermentation process optimization for maximum biogas yield
- Continuous monitoring of gas evolution via flame tests and slurry analysis ensured the fermentation process maintained optimal biogas production rates through timely intervention and optimization
- The successful confirmation of biogas purification through various indicators such as color changes in silica gel beads, precipitate formation in calcium hydroxide, and rusting in steel wool, reaffirmed the effectiveness of our purification techniques in removing impurities and enhancing biogas quality

RESULTS & DISCUSSION

- Atmospheric air compression achieved a pressure of up to 7 bars in 8 minutes, subsequently, the compressed air-filled cylinder was emptied within just 1 minute
- The effective trial with atmospheric air offered insights, guiding the compression and release procedures for the following biogas test
- Continuous monitoring of gas evolution ensured efficient fermentation and timely adjustments
- Successful purification confirmed the effectiveness of removal techniques, enhancing biogas quality
- Air compression results provided a basis for the subsequent biogas test run
- Conducted combustion test to verify the efficiency and effectiveness of the purified biogas as a fuel source

Fig.3 Combustion Test of CBG

Fig.4 Miniature CBG Production Prototype

CONCLUSION

- Successful biogas production from organic waste validates its potential as a renewable energy source
- Effective removal of impurities ensures high-quality biogas for various applications
- Efficient compression and storage enhance usability and accessibility of biogas
- Initial testing assessed the efficiency and cost-effectiveness of compressed biogas, demonstrating its potential as an economically viable energy solution

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