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DESIGN AND IMPLEMENTATION OF A BIOGAS PILOT PLANT FOR BIOAUGMENTATION STRATEGIES IN A RURAL MUNICIPALITY

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1. INTRODUCTION

The challenge of addressing climate change and advancing towards global sustainability underscores the urgency of transitioning to cleaner and renewable energy systems. Biogas stands out as a promising energy solution to mitigate climate change [1] and reduce dependence on fossil fuels [2]. In this field, EU-funded project: Natural and Synthetic Microbial Communities for Sustainable Production of Optimised Biogas (Micro4Biogas - Ref.: 1010004706) [3], aims to optimize biogas production through bioaugmentation strategies [4]. The project includes the design and construction of an experimental pilot plant to carry out bioaugmentation tests aiming to enhance sustainability and operational efficiency in biogas systems. This work focuses on the experimental work carried out by the GEDER group of the Universitat Politècnica de València (UPV) with the collaboration of the municipality of Aras de los Olmos.It describes the design of the pilot plant, the initial experiments, the future operation of the plant and draws conclusions from the work presented.

2. THE MUNICIPALITY OF ARAS DE LOS OLMOS

Aras de los Olmos is a small municipality in the northwest of the province of Valencia, Spain (Fig. 1). The municipality has ideal characteristics for the implementation of biogas pilot plant:

- There is free land available.
- A large part of the economy is livestock-based.

Fig. 1. Aras de los Olmos location [3]

3. DESCRIPTION OF THE BIOGAS PLANT

In the continuous search for sustainable solutions to address environmental challenges, the M4B project seeks to improve the biogas production process. This section details the fundamental elements that make up the installation of a biogas plant, consisting of two independent digesters of 3.4 m3 each.

3.1. Feedstock Tank

The feedstock tank serves as a reservoir for accumulating and mixing organic waste, ensuring a continuous supply of material to the digester. Fig. 2 illustrates the feedstock tank.

- Measures:
  100 x 150 x 300 cm
- Maximum capacity:
  4,500 liters

Fig. 2. Feedstock tank in construction phase

3.2. Biogas digesters

Anaerobic digestion process occurs within two independent digesters: one as a reference, and the other for introducing the new microbiome. They are located within thermally insulated enclosures (Fig. 3) to maintain optimal temperatures above 30°C. Gas sensors inside the enclosures detect any leaks, activating safety measures.

- Measures:
  195x156x120 cm
- Volume: 3.4 m^3
  2.0 m^3 fermentation
  1.4 m^3 storage volume

To ensure accurate analysis, separate filling and emptying systems are employed for each digester, and their biogas installations are isolated to prevent interaction.

Fig. 3. Thermally insulated enclosure where the digesters are located

3.3. Biogas treatment and storage

Biogas treatment comprises three key stages: dehydration, desulfurization, and storage in bags.

- Dehydration: Remove excess moisture, improving gas quality and preventing corrosion in distribution and storage systems.
- Desulfurization: Made of iron oxide (Fe2O3) pellets, acts as a filter to efficiently remove sulfur, enhancing gas quality for broader applications.
- Storage: Treated biogas is directed to 2 m³ storage bags. They ensure constant biogas availability for utilization.

This process prepares the biogas for its application. Fig. 4 illustrates the desulfurizers, storage bags, flow meters and biogas pumps for each digester, with separate facilities to prevent cross-contamination of the biogas.

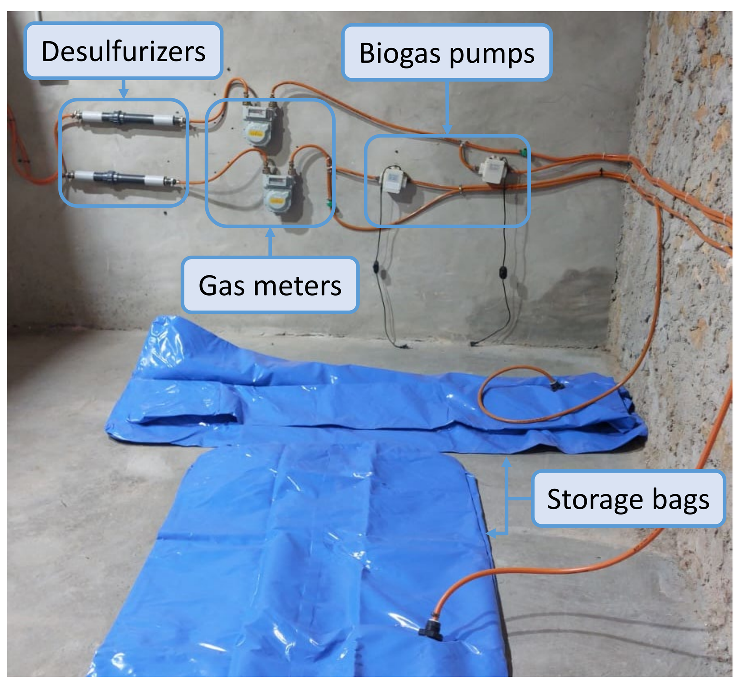

Fig. 4. Desulfurizers, gas meters, pumps and storage bags.

3.4. Biogas equipment

Once the biogas is treated and ready for use, it can be utilized in the equipment
- 2,8 kW Burners
- 1,5 kW Biogas electrical generator

3.5. Measurement equipment

It is necessary to quantify the quality of this biogas
- pH meter: Monitor and control the acidity or alkalinity level
- Biogas analyzer: Monitoring the gas composition
- Energy analyzer: Analyze and monitor the electrical energy

3.6. Biogas plant layout

The plant layout plan includes the arrangement of all the mentioned equipment, as depicted in Fig 5.

This layout includes both the biogas and liquid organic matter installations within the pilot plant, ensuring the proper connection of all elements while preventing any cross-contamination.

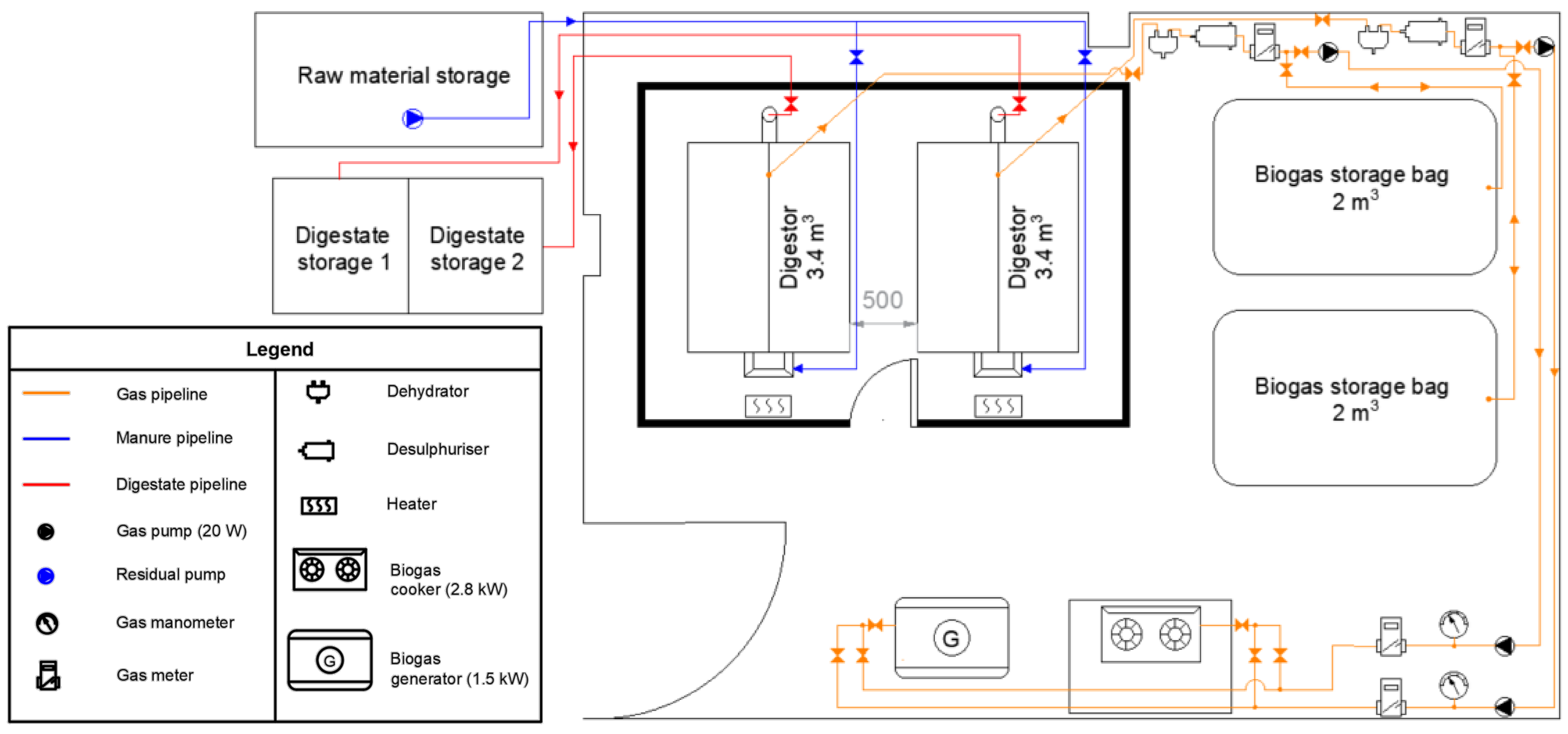

Fig. 5. Biogas plant layout

4. FIRST TEST CONDUCTED

Matter used in the first test:

- 800 L pig manure
- 800 L rabbit manure
- 400 L cow manure

Experiment only conducted in one of the two digesters, which the heating system was not yet in place. The production is not under optimal conditions. They will improve by implementing temperature control and by adding the M4B microbiomes

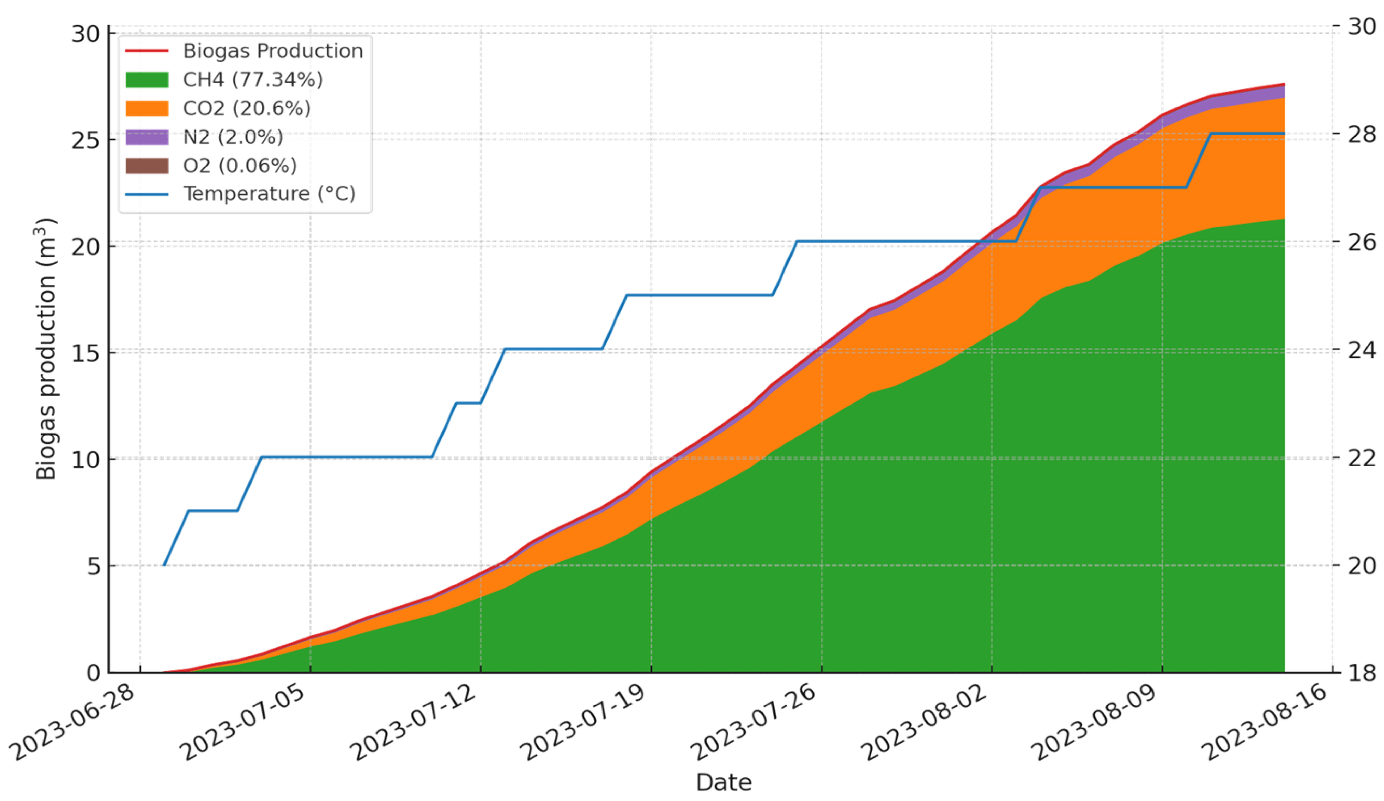

Fig. 6. Evolution of accumulated biogas production and temperature evolution during the first test

5. DESIGN DECISIONS AND FUTURE OPERATION

The critical design decisions made for the pilot plant are:

- **Digesters Size**: The chosen size balances practical experimentation with real-world relevance.
- **Storage Bag Size**: Tailored for 2-4 days of biogas storage, acknowledging intermittent plant operation and the need for efficient resource management by a limited workforce.
- **Safety Equipment**: CO and CH4 alarms near motor and digesters prioritize a secure working environment.
- **Dual Digesters**: Enables comparative studies between bioaugmented and non-bioaugmented processes.
- **Burner and Generator** : The power of the burner and generator are chosen to support experiments lasting 2-3 hours.
- **Measurement Equipment**: pH and biogas analyzers are selected based on typical ranges observed in biogas digesters.

Future operation: Assess the effectiveness of bioaugmentation in boosting biogas production

6. CONCLUSIONS

Technical components of a biogas plant, which can be replicated by any have been detailed. The challenges encountered during the initial trial and the subsequent improvements have been discussed. By sharing these details, we aim to contribute to the broader application and understanding of biogas plant operations, offering a template for future projects and research in renewable energy sources. This biogas plant will serve as a crucial tool for analyzing the impact of bioaugmentation strategies within the framework of the Micro4Biogas project in the coming months.

References: **[1]** Sieborg, M. U., Oliveira, J. M. S., Ottosen, L. D. M., & Kofoed, M. V. W. (2024). Flue-to-fuel: Bio-integrated carbon capture and utilization of dilute carbon dioxide gas streams to renewable methane. Energy Conversion and Management, 302, 118090. **[2]** Singh, A. K., Pal, P., Rathore, S. S., Sahoo, U. K., Sarangi, P. K., Prus, P., & Dziekański, P. (2023). Sustainable utilization of biowaste resources for biogas production to meet rural bioenergy requirements. Energies, 16(14), 5409. **[3]** Natural and Synthetic Microbial Communities for Sustainable Production of Optimised Biogas (Micro4Biogas - Ref.: 1010004706) https://micro4biogas.eu/. **[4]** Nzila, A. (2017). Mini review: Update on bioaugmentation in anaerobic processes for biogas production. Anaerobe, 46, 3-12.

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