2025 10th International Conference on Energy Efficiency and Agricultural Engineering
5-7 November 2025, Starozagorski Bani, Bulgaria

Integrated Perspectives on Sludge and Biogas Management in Municipal Wastewater Management: A Case Study of the Bacau WWTP

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GOAL OF THE STUDY

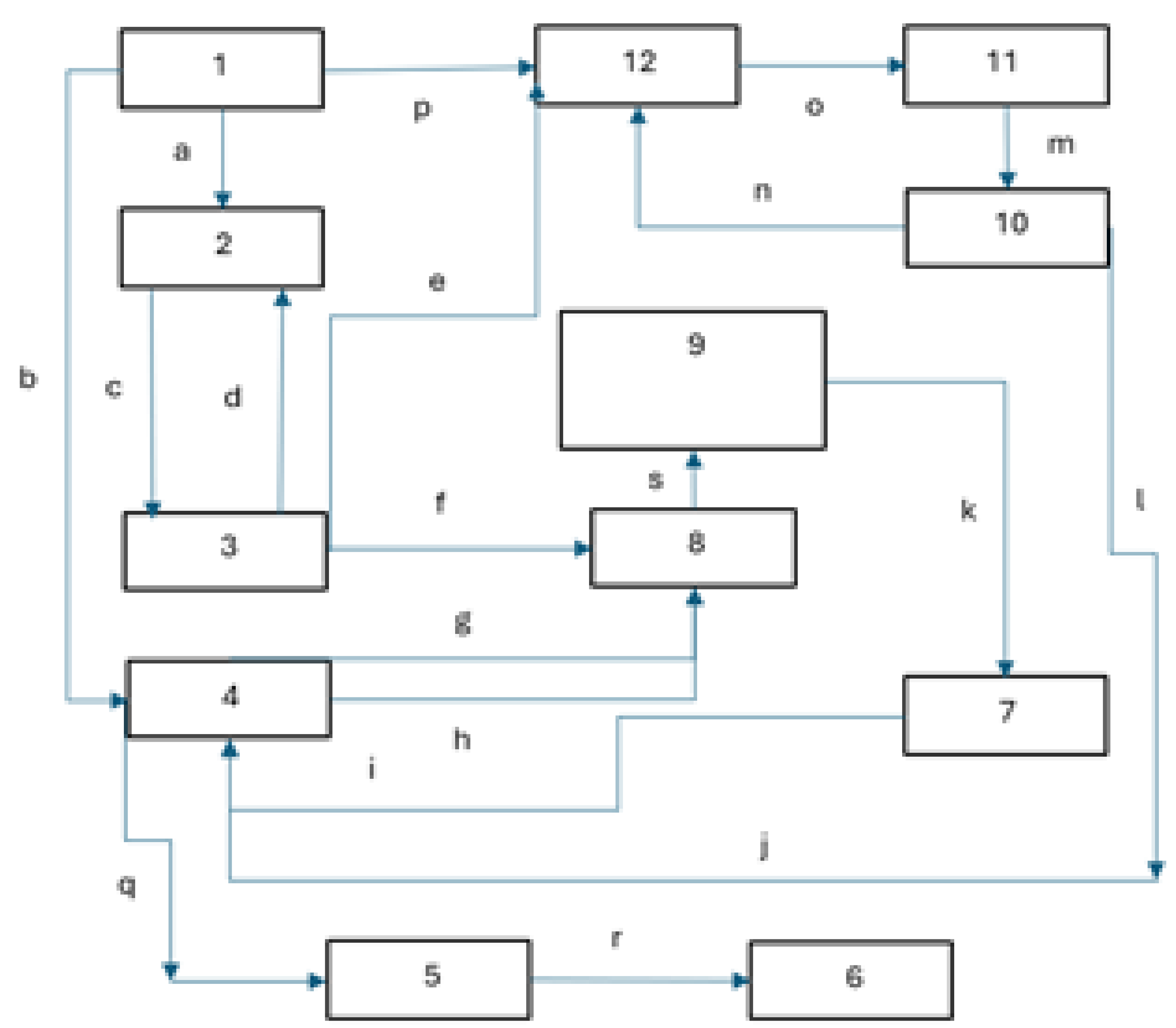
Inadequate sludge management not only increases financial burdens but also poses significant environmental risks, including soil and groundwater contamination, greenhouse gas emissions, and the accumulation of heavy metals and organic micropollutants [3].

Against this backdrop, the present study aims to evaluate over a six-month period the characteristics of fermented sludge and the biogas produced in a municipal wastewater treatment plant. Furthermore, the study explores the interrelation between sludge characteristics and biogas quality and quantity, providing insights into both technological performance and opportunities for process improvement.

METHODOLOGY OF THE INVESTIGATION

The studied wastewater treatment plant is in the southeast area of the Bacau City, on the right bank of the Bistrița outfall, at the GPS coordinates: 46.536980, 26.937250.

Main treatment stages: Two-stage acid fermentation and thickening of primary sludge; Thickening of excess activated sludge; Anaerobic digestion of concentrated sludge; Mechanical dewatering of anaerobically digested sludge; Stabilization and disinfection with quicklime, followed by storage. Primary sludge (2–4% dry matter) is thickened with polymers and directed to a two-stage fermentation–concentration system, where it is mixed with excess sludge from the secondary stage.



Wastewater Treatment Plant: 1. Primary Settling; 2. Aerobical Digester; 3. Gravitational Thickener; 4. Sludge Thickening, Treatment and Dewatering; 5. Desinfection; 6. Stabilized Sludge Deposit; 7. Digested Sludge Storage Tank; 8. Mixing Tank; 9. Anaerobic Digesters; 10. Secondary Settling; 11. Biological Reactor; 12. Distribution Chamber; a. Primary sludge to aerobic stabilization; b. Primary sludge to treatment; c. Digested Primary Sludge; d. Thickened Digested Sludge; e. Supernatant; f. Concentrated sludge; g. Thickened Primary Sludge; h. Thickened Excess Sludge; i. Digested Sludge; j. Exces sludge; k. Anaerobic stabilized sludge; l. Excess Sludge; m. Secondary Sludge; n. Recirculated Activated Sludge; p. Settled Water; q. Dewatered Sludge; r. Stabilized Disinfected Sludge; s. Feed to Digesters.

Fig. 1. Sludge treatment at Bacău Municipal

Biogas parameters (CH_4, CO_2, H_2S, O_2) were measured with a Sewerin Multitec 540 portable analyzer suitable for biogas and sewage applications (infrared + electrochemical sensors). Sludge pH was measured with a WTW ProfiLine pH meter. Dry substance was determined gravimetrically and confirmed by thermogravimetric analysis (TGA), in line with established approaches for sewage sludge.

MAIN RESULTS FROM THE STUDY

A. Characteristics of the digested sludge

From Figure 2, a progressive increase in the mineral fraction of the fermented sludge can be observed, reflecting the ongoing mineralization of organic matter.

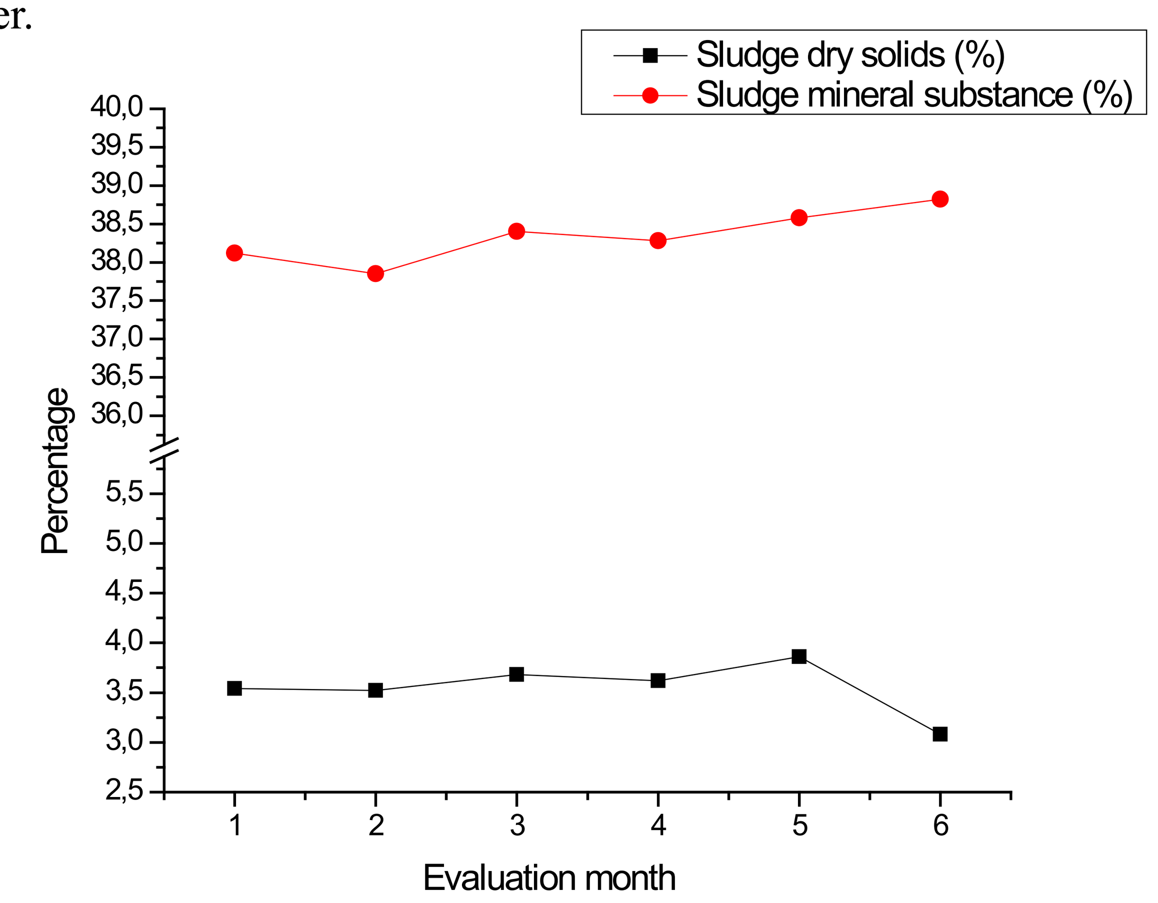


Fig. 2. The dry solids and mineral substance of the sludge during the evaluation period.

B. Quantitative Analysis of Biogas at SEAU Bacau

As illustrated in Figure 3, the methane concentration remained relatively stable during this period, reflecting well-regulated fermentation conditions and balanced microbial activity.

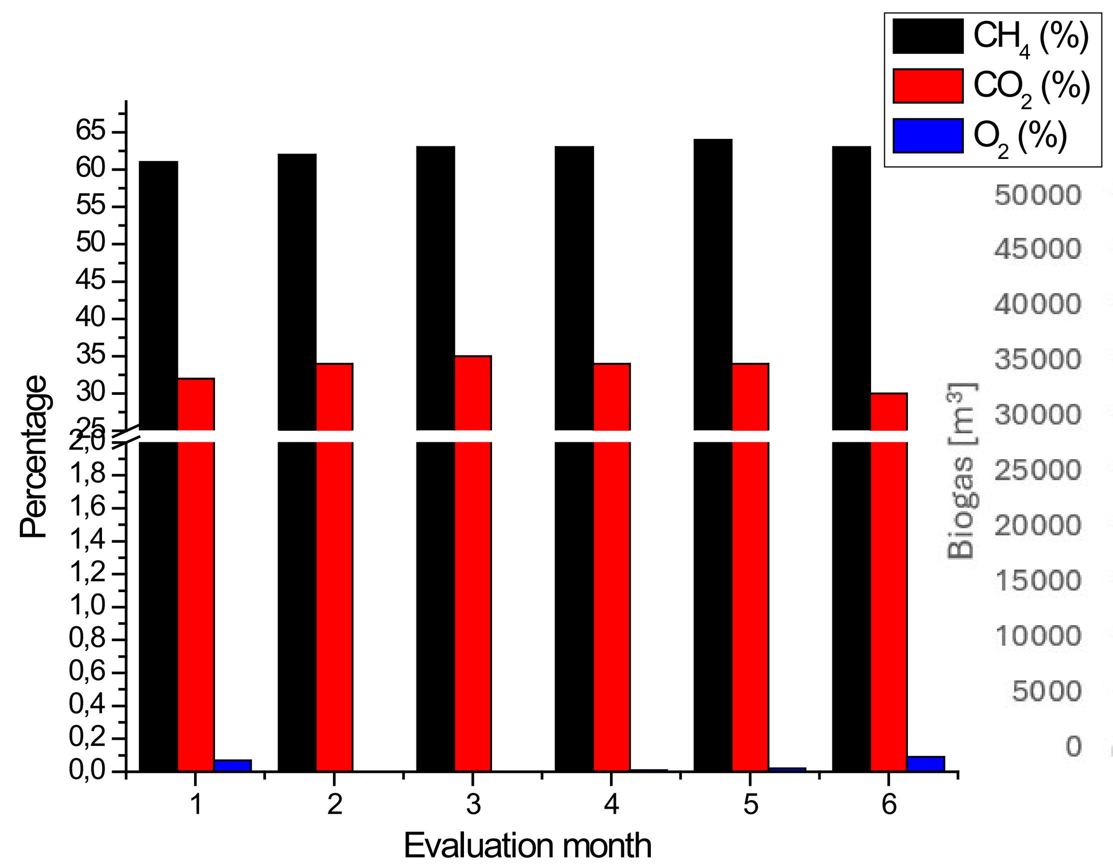


Fig. 3. The percentage of the gases from the produced biogas.

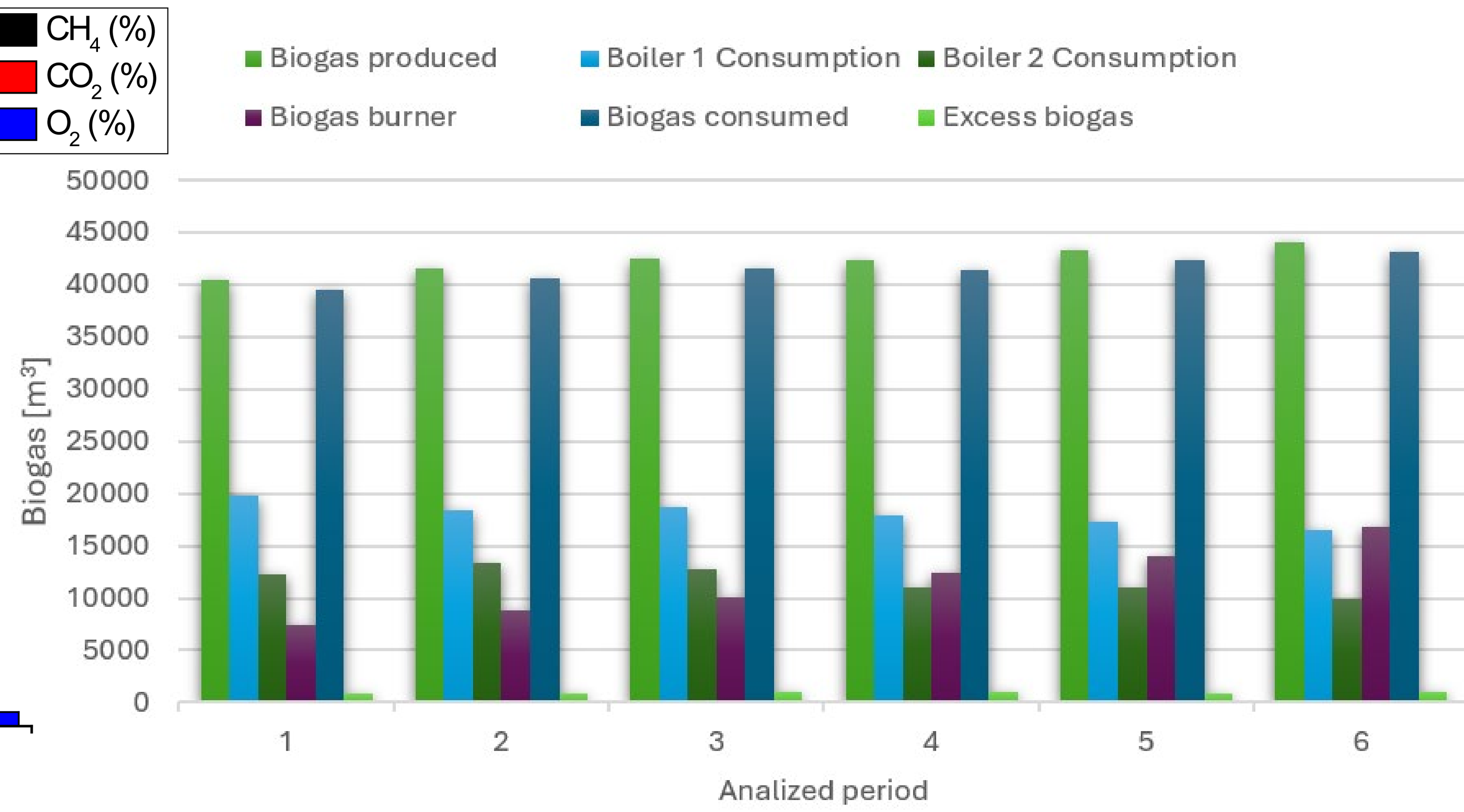


Fig. 4. Biogas Balance at Bacau WWTP.

CONCLUSIONS

Enhancing system performance requires efficient impurity removal, use of corrosion-resistant materials, and optimization of absorption and adsorption processes to protect equipment and improve energy efficiency. Complementary measures, including biogas compression, storage, and surplus gas management, are critical for reducing losses from flaring and maximizing renewable energy recovery. The Bacau facility illustrates the potential of integrated sludge and biogas management systems to support energy self-sufficiency and environmental protection.

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