*Proceedings of the 9th World Congress on Civil, Structural, and Environmental Engineering (CSEE 2024)*
*London, United Kingdom – April 14-16, 2024*
*Paper No. ICEPTP 154*
*DOI: 10.11159/iceptp24.154*

# Kinetic Enhancements in Anaerobic Digestion for Biogas Production: The Effect of Microwave Pretreatment

**Yuxuan Li[1], Luiza C. Campos[1], Yukun Hu[1]**
[1]Department of Civil, Environmental & Geomatic Engineering, University College London, London WC1E 6BT, United Kingdom
yuxuan-li.21@ucl.ac.uk; l.campos@ucl.ac.uk; yukun.hu@ucl.ac.uk

## Extended Abstract

The kinetics of sludge biogas generation plays a pivotal role in the sustainable management of wastewater treatment processes and the production of renewable energy. Biogas, primarily comprising methane and carbon dioxide, emerges from the anaerobic digestion of organic matter in waste activated sludge. The efficiency and rate of biogas production are crucial in evaluating the sustainability and feasibility of biogas as an energy source. With the growing global energy demands and the pressing need for sustainable waste management, understanding these factors becomes paramount in optimising biogas production systems. Among the various strategies explored to enhance biogas generation efficiency, microwave pretreatment has garnered attention. This method employs microwave radiation to modify the physical and chemical properties of sludge [1], potentially increasing its biodegradability by disrupting cell membranes and releasing intracellular materials.

In this study, the Modified-Gompertz (MG) model is utilized for the analysis and prediction of the effects of microwave pretreatment on sludge biogas generation. The MG model, known for its accuracy in describing the sigmoidal pattern of biogas production, is particularly suitable for assessing the impact of microwave pretreatment on biogas generation rates and lag phase duration [2]. Data from five recent research papers [3–7], covering a range of sludge types, forms the basis of this investigation, ensuring a comprehensive analysis across various treatment conditions. The findings from the analysis are significant. The MG model demonstrates high predictive accuracy post-microwave pretreatment, with correlation coefficients consistently above 0.95 and a minimal percentage error of 4.67%. This indicates the model's robustness in forecasting biogas yield in the context of microwave pretreatment. Additionally, the study reveals that the kinetics of biogas production are dependent on the sludge substrate, with municipal wastewater sludge showing notably enhanced biogas production compared to food or grease co-digested sludge.

One of the most notable outcomes of this study is the observed reduction in lag time following microwave pretreatment. The lag phase duration is reduced by about half compared to conventional heating, dropping from 7-10 days to just 2-5 days. This accelerated onset of biogas production indicates a more efficient process overall. In conclusion, the research highlights the effectiveness of microwave pretreatment in improving sludge biogas generation kinetics, particularly by speeding up the lag phase. These findings offer valuable insights into the potential applications of microwave pretreatment in enhancing wastewater treatment and biogas production processes. As the quest for sustainable energy and waste management solutions intensifies, further research in this domain could focus on optimizing microwave pretreatment parameters, examining scalability for industrial applications, and evaluating the long-term economic and environmental benefits of integrating such technologies into wastewater treatment infrastructures.

**Keywords:** Microwave pretreatment; Anaerobic digestion; Modelling; Biogas production; Optimization

## References

[1] A. Zaker, Z. Chen, X. Wang, Q. Zhang, Microwave-assisted pyrolysis of sewage sludge: A review, Fuel Processing Technology 187 (2019) 84–104. https://doi.org/10.1016/J.FUPROC.2018.12.011.

[2] A. Sedighi, M. Karrabi, B. Shahnavaz, M. Mostafavinezhad, Bioenergy production from the organic fraction of municipal solid waste and sewage sludge using mesophilic anaerobic co-digestion: An experimental and kinetic modeling study, Renewable and Sustainable Energy Reviews 153 (2022) 111797. https://doi.org/10.1016/J.RSER.2021.111797.

[3] J. Liu, M. Zhao, C. Lv, P. Yue, The effect of microwave pretreatment on anaerobic co-digestion of sludge and food waste: Performance, kinetics and energy recovery, Environ Res 189 (2020) 109856. https://doi.org/10.1016/J.ENVRES.2020.109856.
[4] J. Zhang, C. Lv, J. Tong, J. Liu, J. Liu, D. Yu, Y. Wang, M. Chen, Y. Wei, Optimization and microbial community analysis of anaerobic co-digestion of food waste and sewage sludge based on microwave pretreatment, Bioresour Technol 200 (2016) 253–261. https://doi.org/10.1016/J.BIORTECH.2015.10.037.
[5] A.V. Ebenezer, P. Arulazhagan, S. Adish Kumar, I.T. Yeom, J. Rajesh Banu, Effect of deflocculation on the efficiency of low-energy microwave pretreatment and anaerobic biodegradation of waste activated sludge, Appl Energy 145 (2015) 104–110. https://doi.org/10.1016/J.APENERGY.2015.01.133.
[6] R.M. Alqaralleh, K. Kennedy, R. Delatolla, Microwave vs. alkaline-microwave pretreatment for enhancing Thickened Waste Activated Sludge and fat, oil, and grease solubilization, degradation and biogas production, J Environ Manage 233 (2019) 378–392. https://doi.org/10.1016/J.JENVMAN.2018.12.046.
[7] S. Elagroudy, A.G. Radwan, N. Banadda, N.G. Mostafa, P.A. Owusu, I. Janajreh, Mathematical models comparison of biogas production from anaerobic digestion of microwave pretreated mixed sludge, Renew Energy 155 (2020) 1009–1020. https://doi.org/10.1016/J.RENENE.2020.03.166.