Green Circular Valorization of Organic Waste through Hydrothermal Treatment and Anaerobic Digestion Coupling

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Abstract

The diversified utilization of biomass energy has gained substantial attention in recent years. Among various technologies, hydrothermal treatment (HTT) is highly effective for processing organic solid waste with high moisture content and low biodegradability while facilitating the fixation of organic carbon. However, HTT produces hydrothermal wastewater (HTWW) as a by-product, which differs from conventional wastewater due to its high concentrations of phenols, ketones, pyridines, and other refractory compounds that are challenging to degrade. Addressing this issue is critical for advancing sustainable waste management.

To achieve dual resource and energy recovery in organic solid waste treatment, we propose integrating HTT with anaerobic digestion (AD) to enable comprehensive waste processing. This study systematically investigated the characteristics of HTWW under varying raw material types and hydrothermal conditions. The results revealed that higher hydrothermal temperatures and longer residence times generate more refractory compounds, which adversely affect the efficiency of subsequent anaerobic digestion.

To enhance the performance of coupled AD technology, we evaluated four strategies: optimization of process conditions, separation of refractory compounds, hydrochar enhancement, and coagulation-adsorption pretreatment. Each approach demonstrated potential in improving anaerobic digestion efficiency to varying degrees. This work provides a theoretical framework for optimizing HTWW treatment through AD and offers practical insights for enhancing biomass conversion efficiency.

Keywords
Organic Waste; Hydrothermal wastewater; Anaerobic Digestion; Biorefinery

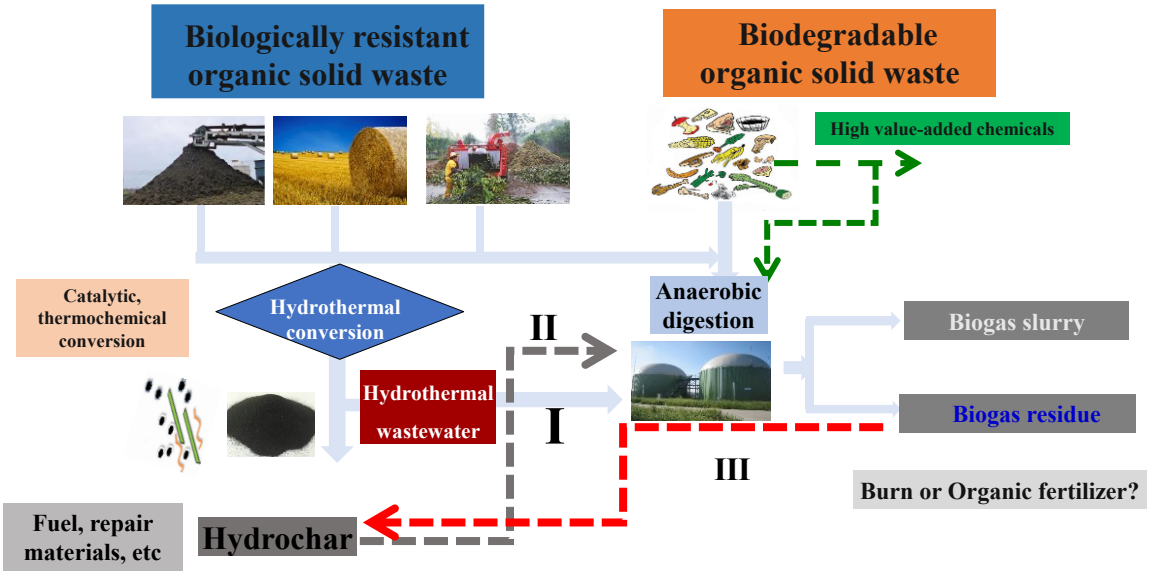

Figure 1. Schematic of the Hydrothermal Conversion and Anaerobic Digestion for Sustainable Biorefining of Organic Waste

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References

1. Chen, H.H., Hao, S.L., Chen, Z., O-Thong, S., Fan, J.J., Clark, J., Luo, G., and Zhang, S.C. Mesophilic and thermophilic anaerobic digestion of aqueous phase generated from hydrothermal liquefaction of cornstalk: Molecular and metabolic insights. *Water Research*, 2020, 168: 115199.
2. Usman, M.#, Chen, H.H.#, Chen, K.F., Ren, S., Clark, J.H., Fan, J.J., Luo, G., and Zhang, S.C. Characterization and utilization of aqueous products from hydrothermal conversion of biomass for bio-oil and hydro-char production: A Review. *Green Chemistry*, 2019, 21: 1553-1572.
3. Chen, H.H., Rao, Y., Cao, L.C., Shi, Y., Hao, S.L., Luo, G., and Zhang, S.C. Hydrothermal conversion of sewage sludge: Focusing on the characterization of liquid products and their methane yields. *Chemical Engineering Journal*, 2019, 357: 367-375.
4. Chen, H.H., Zhang, C., Rao, Y., Jing, Y.H., Luo, G., and Zhang, S.C. Methane potentials of wastewater generated from hydrothermal liquefaction of rice straw: focusing on the wastewater characteristics and microbial community compositions. *Biotechnology for Biofuels*, 2017, 10: 140.
5. Chen, H.H., Wan, J.J., Chen, K.F., Luo, G., *Fan, J.J., Clark, J.,* and Zhang, S.C. Biogas production from hydrothermal liquefaction wastewater (HTLWW): Focusing on the microbial communities as revealed by high-throughput sequencing of full-length 16S rRNA genes. *Water Research*, 2016, 106: 98-107.