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Editorial: High-efficiency strategies for bioconversion of waste to bioenergy/resource toward toxicity elimination and carbon neutralization

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Editorial on the Research Topic
High-efficiency Strategies for Bioconversion of Waste to Bioenergy/Resource toward Toxicity Elimination and Carbon Neutralization

Introduction

The consensus has been achieved globally of pursuing bioresource/bioenergy harvest from organic solid waste (e.g., kitchen waste, excess sludge, biomass-waste, etc) via anaerobic fermentation/digestion (AF/AD). Some enhancing strategies for improving AF/AD treatment and bioresource/bioenergy recovery efficiencies were proposed for meeting high-efficiency bioconversion of waste to bioenergy/resources towards toxicity elimination and carbon neutrality, including multistage batch fermentation (Guo et al., 2018), coupling process with bioelectrochemical systems (BESs) (Xin et al., 2020), biochar addition (Pan et al., 2022), Direct Interspecies Electron Transfer (DIET) (Jin et al., 2022), etc. Nevertheless, the underlying enhancing mechanisms related to co-operations/interactions of core species, and mass transfer are still unclear deeply. Based on such background, this Research Topic (RT) focused on the enhancing mechanism elucidation of efficient strengthening measurements during the AF/AD process for better bioresource/bioenergy recovery toward toxicity elimination and carbon neutrality, including original research articles (3), brief research report articles (3) and a mini review.

How are the roles of enhancing strategies played in AF/AD process? The pretreatments [e.g., thermal hydrolysis (Barber, 2016), microwave (Kavitha et al., 2016), ultrasonication (Yan et al., 2010), biological enzymes (Yin et al., 2016), etc] contributed remarkably to improve AF/AD running performance through causing solid waste solubilization and accelerating hydrolysis (Zhao et al., 2017). On the other hand, the combination of AD with other treatment process [e.g., microbial fuel cells (MFCs) (Chandrasekhar and Ahn, 2017)] presented high merits in terms of treatment performance and bioresource/bioenergy recovery (Beegle and Borole, 2017; Xin et al., 2020). Thus this RT paid much attention on enhancing organic solid waste treatment/management with high-efficiency of recoverable resources/energy harvest and low (even zero)-carbon emission. Various themes, including the understanding of the mechanism of anaerobic microbial interactions, enhancing bio-energy/resource harvest via efficient pretreatments or process combination with bioelectrochemical systems (BESs), and other topics relevant to enhancing strategies for AD, were introduced in this RT.

Pretreatments for enhancing AF/AD toward bioresource/bionenergy harvest

Shi et al. revealed the effects of thermal hydrolysis pretreatment (THPT) on anaerobic digestion (AD) of protein-rich substrates, which proposed that THPT helped overcome the acidification inhibition present in batch AD of tofu at such a high TS content of 3.6%, with obtaining a maximum methane yield rate of 589.39 ml·$(gVS)^{-1}$. Continuous AD of protein-rich tofu heavily depended on ammonia-tolerant hydrogenotrophic methanogens and bacteria.

Wang et al. found that the hydrothermal pretreatment (HT) was conducted for erythromycin removal before erythromycin fermentation dregs (EFD) AD with the temperature ranging from 80 to 180°C. The results showed that under the optimal hydrothermal temperature of 160°C, more than 85% of erythromycin was eliminated. In addition, HT significantly reduced the ARGs in the EFD AD process and *erm*T and *mef* A relative abundance decreased by one order of magnitude. The maximum methane production of 428.3 ml g^{-1} VS. was obtained in the AD system of EFD with hydrothermal treatment at 160°C. It is attributed to the cooperation of hydrolysis and acidogenesis bacteria (e.g., *Aminicenantales* and *Sedimentibacter*) and methylotrophic methanogens (*Candidatus_Methanofastidiosum* and *Methanosarcina*), and they presented the highest relative abundance.

Besides, the biochar played important roles in electron transfer during AF/AD process. Wang et al. summarized the progress of preparing and using invasive plant biochar (IPB), which included the production, modification, merit and demerit of IPB, its application in improving soil quality, the adsorption of pollutants, application in energy storage, and climate change mitigation potential. It provides a basis for further study of IPB based on the currently existing problems and proposes a direction for future development.

Process combination/modification for prompting AF/AD with higher bioresource/bionenergy production toward Toxicity Elimination and Carbon Neutralization

In terms of process modification/combination for boosting organic wastes biodegradation or contaminants removal, Shu et al. investigated that the performance of a two-stage anaerobic co-digestion (TS-AD) of spent mushroom substrate and chicken manure was evaluated in terms of methane and biogas production and process stability with respect to single stage anaerobic digestion (SS-AD). TS-AD exhibited better performance and enhanced methane generation over SS-AD. The optimal temperatures were determined as 35 and 50°C for the first and the second stage of TS-AD, respectively. C/N ratio of 10 was the most suitable for biogas and methane production; Yu et al. proposed a novel bioelectrochemical reactor assembled with cooperative cathodes of chemical cathode and bio-cathode (BERCC) and with excess sludge as the anodic substrate obtained continuous and effective of Cr(VI) reduction. Cooperative cathodes in BERCC stimulated the growth of electrochemically active microorganisms such as Geobacter sp. And Shewanella sp. In the anodic biofilm and produced 8. 21 ± 0.64 mg C/(Lh) more electrons than dual chemical cathodes in the bioelectrochemical reactor with dual chemical cathodes, which enhanced the electrons for electricity generation and Cr(VI) reduction by approximately 58.3% and 56.1 ± 5.6%, respectively.

Some novel organic waste/wastewater treatment method were developed simultaneously. Sun et al. focused on important factors including light intensity, light/dark cycles, and the biomass of algae/bacteria to explore the relationship between algae and bacteria, aiming to obtain the optimal performance in the algae-sludge membrane bioreactor (AS-MBR). It was found that 3,000 lux was considered to be the appropriate light intensity that could improve algal biomass and nitrogen removal among the chosen light intensities. A higher or lower light intensity could not simultaneously promote algal energy absorption and nitrifying bacterial activity. Moreover, the highest average growth rate of algae (0.16 mg/L d^{-1}) and the removal efficiency of NH_4^+-N (96.4 ± 1.5%) were both observed during the 12-h light/12-h dark cycle, respectively. Meantime, the appropriate algal proportion would mitigate membrane fouling compared with the conventional MBR.

Finally, Chen et al. proposed "biexponential disposition" model to exhibit promising feasibility of wide-ranged applications to biotic and abiotic degradation of pollutant(s), which extended to provide the key performance indicator (KPI)- the area under time course (AUC) of pollutant concentrations from time zero to end-point (i.e., AUC

(0~tf)), quantitatively revealing the most promising strategy for pollutant (bio)degradation.

Overall, the studies in this RT proposed some efficient ways for realizing "waste -to-energy/resource" toward toxicity elimination and carbon neutralization. Our hope is that this RT will inspire researchers to design and conduct new intervention studies aiming at improving AF/AD performance associated mechanism revealing for organic wastes treatment and resource/energy recovery.

Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

Barber, W. P. F. (2016). Thermal hydrolysis for sewage treatment: A critical review. *Water Res.* 104, 53–71. doi:10.1016/j.watres.2016.07.069

Beegle, J. R., and Borole, A. P. (2017). An integrated microbial electrolysis-anaerobic digestion process combined with pretreatment of wastewater solids to improve hydrogen production. *Environ. Sci. Water Res. Technol.* 3, 1073–1085. doi:10.1039/c7ew00189d

Chandrasekhar, K., and Ahn, Y. H. (2017). Effectiveness of piggery waste treatment using microbial fuel cells coupled with elutriated-phased acid fermentation. *Bioresour. Technol.* 244, 650–657. doi:10.1016/j.biortech.2017.08.021

Guo, D. S., Ji, X. J., Ren, L. J., Yin, F. W., Sun, X. M., Huang, H., et al. (2018). Development of a multi-stage continuous fermentation strategy for docosahexaenoic acid production by Schizochytrium sp. *Bioresour. Technol.* 269, 32–39. doi:10.1016/j.biortech.2018.08.066

Jin, H. Y., He, Z. W., Ren, Y. X., Tang, C. C., Zhou, A. J., Liu, W. Z., et al. (2022). Current advances and challenges for direct interspecies electron transfer in anaerobic digestion of waste activated sludge. *Chem. Eng. J.* 450, 137973. doi:10.1016/j.cej.2022.137973

Kavitha, S., Banu, J. R., Kumar, J. V., and Rajkumar, M. (2016). Improving the biogas production performance of municipal waste activated sludge via disperser induced microwave disintegration. *Bioresour. Technol.* 217, 21–27. doi:10.1016/j.biortech.2016.02.034

Pan, X. H., Zhang, Y., He, C., Li, G., Ma, X. R., Zhang, Q. G., et al. (2022). Enhancement of anaerobic fermentation with corn straw by pig bone-derived biochar. *Sci. Total Environ.* 829, 154326. doi:10.1016/j.scitotenv.2022.154326

Xin, X. D., Pang, H. L., She, Y. C., and Hong, J. M. (2020). Insights into redox mediators-resource harvest/application with power production from waste activated sludge through freezing/thawing-assisted anaerobic acidogenesis coupling microbial fuel cells. *Bioresour. Technol.* 311, 123469. doi:10.1016/j.biortech.2020.123469

Yan, Y. Y., Feng, L. Y., Zhang, C. J., Wisniewski, C., and Zhou, Q. (2010). Ultrasonic enhancement of waste activated sludge hydrolysis and volatile fatty acids accumulation at pH 10.0. *Water Res.* 44, 3329–3336. doi:10.1016/j.watres.2010.03.015

Yin, Y., Liu, Y. J., Meng, S. J., Kirran, E. U., and Liu, Y. (2016). Enzymatic pretreatment of activated sludge, food waste and their mixture for enhanced bioenergy recovery and waste volume reduction via anaerobic digestion. *Appl. Energy* 179, 1131–1137. doi:10.1016/j.apenergy.2016.07.083

Zhao, J. W., Gui, L., Wang, Q. L., Liu, Y. W., Wang, D. B., Ni, B. J., et al. (2017). Aged refuse enhances anaerobic digestion of waste activated sludge. *Water Res.* 123, 724–733. doi:10.1016/j.watres.2017.07.026