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Editorial: Anaerobic digestion: towards a more sustainable future

Huseyin Guven [a,*], Jules van Lier [b], Aijie Wang [c], Mustafa Evren Ersahin [a,d] and Hale Ozgun [a,d]

[a] Istanbul Technical University, Civil Engineering Faculty, Environmental Engineering Department, Ayazaga Campus, Maslak, 34469, Istanbul, Türkiye
[b] Delft University of Technology, Faculty of Civil Engineering and Geosciences, Stevinweg 1, 2628, CN, Delft, The Netherlands
[c] School of Civil and Environmental Engineering, Harbin Institute of Technology (Shenzhen), Shenzhen 518055, China
[d] National Research Center on Membrane Technologies, Istanbul Technical University, Ayazaga Campus, Maslak, 34469, Istanbul, Türkiye
*Corresponding author. E-mail: guvenhu@itu.edu.tr

HG, 0000-0001-6754-0106

Anaerobic technologies have gained increasing importance in recent decades due to the growing emphasis on the circular economy and sustainability, as they offer low-cost treatment while enabling waste-to-resource recovery and biorefinery approaches. In this context, the IWA Anaerobic Digestion conference series is one of the most important international platforms for discussing the latest developments and innovations in the field. The 18th IWA World Conference on Anaerobic Digestion (IWA AD18) was held in Istanbul, Türkiye, from 2 to 6 June 2024. The conference theme, 'Bridging waste to value through anaerobic digestion', emphasized the ongoing focus on waste valorization and resource recovery.

The IWA AD18 Conference brought together approximately 700 participants from 43 countries, representing universities, institutes, research centres, and companies, who delivered around 480 oral and poster presentations. The major themes of the event were as follows:

- Novel and hybrid/integrated anaerobic process configurations and emerging technologies
- Microbial diversity in anaerobic processes
- Anaerobic treatment of industrial, municipal, and agricultural waste(water)
- Anaerobic digestion coupled with algal biomass: Algae-microbiome interactions
- Bio-based fertilizers from digestate in green biorefinery
- Valorization of anaerobic digestate from biowaste to high-value-added products
- Advanced processes and technologies for enhancing waste degradation and biogas production
- Anaerobic co-digestion for maximizing biogas production
- Pre- and post-treatment strategies for anaerobic digestion
- Modelling, optimization, instrumentation, and control of anaerobic processes
- Circular bioeconomy concept: Nutrient, energy, and product management through anaerobic digestion
- Presence and fate of micropollutants during anaerobic digestion
- Biogas upgrading and use areas
- Economic and environmental sustainability analysis of anaerobic processes
- Water, sanitation, and hygiene concerns in resource-constrained communities
- Policy issues related to anaerobic digestion
- Utilization of direct electron transfer materials in anaerobic digestion

In this special issue of *Water Science and Technology*, seven peer-reviewed papers addressing various aspects of anaerobic digestion were selected from those presented at the IWA AD18 Conference. The selected papers cover a wide range of topics, including co-digestion, pre-treatment, microbial ecology, emerging contaminants, and operational conditions.

Co-digestion of different waste streams is a promising option to enhance energy recovery from wastes and to support the circular economy approach (Marami *et al.* 2022). Nammana *et al.* (2025) investigated the co-digestion of primary sludge (PS) and secondary sludge (SS) at various mixing ratios to enhance methane production and found that a PS:SS ratio of 1:3 yielded the highest methane yield of approximately 920 mL CH_4 per g volatile solids (VS) fed and the shortest lag phase of 1.59 days. Pre-treatment is another approach to enhance methane yield from substrates. Cardova *et al.* (2025) studied thermal hydrolysis (THP), a pre-treatment method involving high temperature and pressure followed by depressurization, applied both to waste

activated sludge (WAS) and as a post-treatment on digestate. The results showed that THP as a pre-treatment was unfavourable due to its adverse effects on process stability, whereas THP as a post-treatment increased biogas yield by 10% and raised the methane content of biogas to 73.2%. Coupling co-digestion with pre-treatment is also a promising strategy to further optimize process conditions (Yang *et al.* 2024). Accordingly, Islam & Ranade (2025) suggested applying vortex-based hydrodynamic cavitation (HC) pre-treatment to brown sludge and dissolved air flotation (DAF) sludge, followed by co-digestion of these wastes. The soluble chemical oxygen demand (sCOD) increased by up to 42 and 12.4% after HC pre-treatment of brown and DAF sludges, respectively. Moreover, co-digestion of these pre-treated wastes in equal VS amounts provided the highest methane conversion of 85.2%.

In this special issue, the organic fraction of municipal solid waste (OFMSW) has been the focus of two studies. The first, conducted by Musluoğlu *et al.* (2025), evaluated the mono-digestion of OFMSW and its co-digestion with chicken manure and excess sludge at full-scale under dry digestion conditions, based on four years of operational data. Secondly, Jojoa-Unigarro *et al.* (2025) investigated the fermentation of OFMSW at pH values of 4, 5, and 6, with an analysis of the volatile fatty acid (VFA) composition under each condition. They also examined changes in microbial diversity and found that diversity increased with increasing pH. Similarly, Vázquez-López *et al.* (2025) investigated the fermentation process to evaluate biohydrogen and VFA production from corn industry wastewater. A comparison of different hydraulic retention times (HRTs) showed that maximum biohydrogen production was achieved at an HRT of 1 day, primarily accompanied by acetic and butyric acids, which are the main by-products of biohydrogen production. Another emerging concern in anaerobic digestion is the presence of antibiotic residues in treated wastes, which may promote the persistence and proliferation of antibiotic-resistant bacteria (Zeng *et al.* 2022). Within this context, Budatala *et al.* (2025) compared different operating temperature (37, 55, and 65 °C) and found that higher temperatures achieved greater reduction of antibiotic resistance genes.

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