

JSWE-IDEA Water Environment International Exchange Award

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I am truly honored and excited to be invited to the 59th Annual Conference of Japan Society on Water Environment (JSWE) as a recipient of the JSWE-IDEA Water Environment International Exchange Award. I deeply appreciate the time and effort of the Committee on Overseas Member Invitation Program and would like to take this opportunity to express my sincere gratitude. This is my fourth visit to Sapporo, including a summer family trip. With this award and the conference, the city has become even more special to me.

I define myself as a researcher working at the intersection of environmental microbiology and bioprocess engineering. I earned my B.S. in Biological Sciences from Korea Advanced Institute of Science and Technology (KAIST) in 2000 and my Ph.D. in Environmental Engineering from Pohang University of Science and Technology (POSTECH) in 2005. Following postdoctoral studies at POSTECH and at National University of Ireland, Galway as Marie Curie Fellow, I began my faculty career in 2010 as an assistant professor at the School of Civil and Environmental Engineering at Nanyang Technological University, Singapore. Two years later, I returned to my home country and joined Ulsan National Institute of Science and Technology (UNIST), where I now serve as a full professor of Environmental Engineering.

I lead the Applied Biotechnology Lab for Environment (ABLE) at UNIST, committed to developing and advancing sustainable biotechnologies for environmental applications. Our research focuses on bio (electro) chemical conversion of waste streams and CO₂ into valuable products, such as biogas, hydrogen, and organic acids, by harnessing microorganisms, with recent efforts expanding into biodegradable plastics and microbial protein. Additionally, we investigate the diversity, functions, and interactions of microbial players driving these waste-to-value bioprocesses

through ecophysiological studies, aiming to gain deeper mechanistic insights.

My presentation at this JSWE conference introduces a new approach to high-rate anaerobic treatment of domestic sewage. While anaerobic treatment offers several benefits over aerobic treatment, such as lower energy requirements, reduced sludge generation, and biogas production, its application to domestic sewage remains limited by high volumetric loading and low organic concentration. This issue worsens under mainstream conditions subject to temperature fluctuations, especially low temperatures that adversely impact microbial activity. In my talk, I will discuss the development of magnetite-embedded granular sludge (MEG) through self-embedding of submicron magnetite (Fe²⁺Fe³⁺₂O₄) particles into methanogenic granules, and its application in expanded granular sludge bed (EGSB) reactors for high-rate anaerobic treatment of domestic sewage under ambient to low-temperature conditions. MEG enhanced methanogenic organic matter degradation by boosting electric syntrophy and improving granule settling and stability. MEG-EGSB reactors achieved ≥ 90% COD removal (initial COD: 250 mg L⁻¹) at 8–12-h HRTs at 25 °C, sustaining ≥ 80% removal at 15 °C and ≥ 75% even at 10 °C at 8-h HRT. Correspondingly, enrichment of electro-syntrophic microbes within MEGs was observed. These findings highlight the promising potential of the MEG-EGSB process for advancing mainstream anaerobic treatment of low-strength wastewater, with HRTs comparable to the aerobic activated sludge process.

I look forward to this conference as a valuable opportunity to connect with colleagues from Japan and other countries for academic exchange and research collaboration. I am sincerely grateful to JSWE for organizing this wonderful event and for inviting me to be a part of it.