Mitigation of ammonium/salinity inhibition of anaerobic digestion through bioaugmentation with tolerant microbial community

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Abstract

Methane recovery by anaerobic digestion is considerably reduced by various factors present in wastes and wastewater to be treated, and especially high concentrations of ammonium and salt are recognized as important inhibitors. In this research, the microbial reactions that can be inhibited by high concentrations of ammonium and salt in anaerobic digestion were elucidated, and anaerobic microbial communities that are tolerant to high concentrations of ammonium and salt were introduced into the anaerobic digestion process (bioaugmentation) to mitigate the ammonium/salt inhibition. The bioaugmentation significantly mitigated the inhibitory effects, and enabled efficient methane production with equivalent efficiencies to those in the systems without the inhibitory factors.

Background & Results

The bioaugmentation strategy established in this research is expected to expand the range of waste/wastewater which can be treated by anaerobic digestion to recover methane as the carbon-neutral energy, thereby making a significant contribution to the environmental conservation and a recycling-oriented and decarbonized society. In the subsequent researches, we have also found the possibility of alleviating the inhibition of anaerobic digestion for inhibitors other than ammonium and salt by the bioaugmentaion strategy. We are currently conducting scale-up studies to apply this strategy to full-scale facilities.

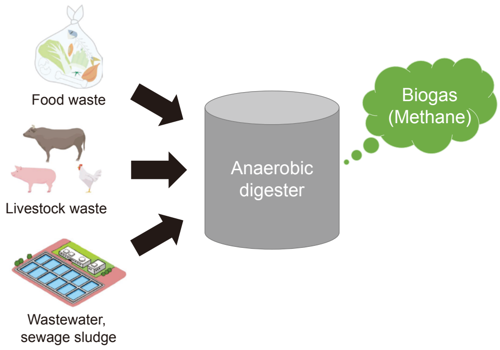
Significance of the research and Future perspective

Inhibition of anaerobic digestion by high concentrations of ammonium and salt is an important problem to be solved in methane recovery from organic wastes and wastewater. This study aimed to clarify the mechanism of ammonium and salt inhibition in anaerobic digestion, which takes place through the interactions of diverse microbial populations, and to establish effective inhibition mitigation techniques.

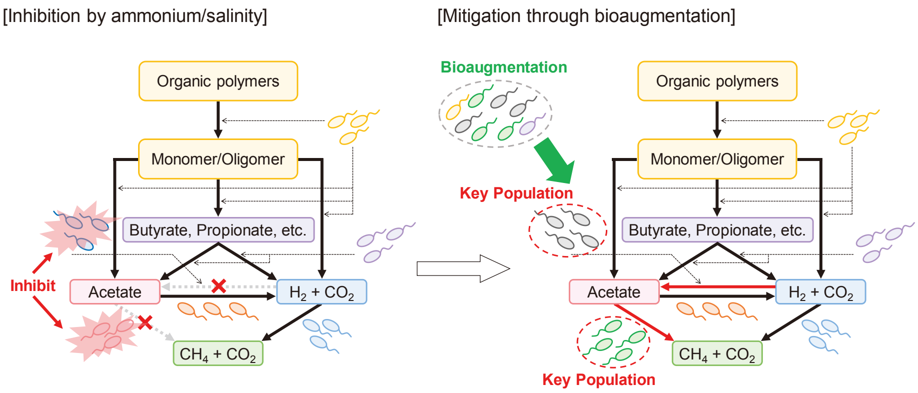
Inhibition of anaerobic digestion by high concentrations of ammonium (>3 g-NH_4-N/L) or salt (>10 g-NaCl/L) was found to be commonly caused by inhibition of microbial populations involved in hydrolysis of complex organic compounds, symbiotic propionate oxidation, and aceticlastic methanogenesis, indicating that it is important to strengthen these microbial reactions to mitigate the inhibition.

Therefore, we acclimated marine sediments to high concentrations of ammonium (5 g-NH_4-N/L) and salt (30 g-NaCl/L) under anaerobic conditions to construct tolerant microbial communities, and the established microbial communities were introduced into anaerobic digestion systems (bioaugmentation). Bioaugmentation significantly reduced the inhibition of methanogenesis even in the presence of high concentrations of ammonium or salt, and the final methane production was found to be almost equivalent to that of the control system without each inhibitory factor. The results of microbial community analysis strongly suggested that hydrogenotrophic methanogens derived from the introduced tolerant microbial communities contributed to the mitigation of the inhibition on the methane production.

Optimizing the size and timing of the inoculation of tolerant microbial communities into the anaerobic digestion system should maximize the effectiveness of the bioaugmentation to mitigate the ammonium and salt inhibition.



Biogas (methane) production from organic waste/wastewater by anaerobic digestion



Ammonium/salinity inhibition of metabolic pathways in anaerobic digestion and its mitigation through bioaugmentation with tolerant microbial community

Patent

Treatise

Luong Van Duc et al. Identidfication of key steps and associated microbial populations for efficient anaerobic digestion under high ammonium or salinity conditions. Bioresource Technology. 2022, 360, 127571. doi:10.1016/j.biortech.2022.127571

Luong Van Duc et al. Bioaugmentation with marine sediment-derived microbial consortia in mesophilic anaerobic digestion for enhancing methane production under ammonium or salinity stress. Bioresource Technology. 2023, 360, 128853. doi:10.1016/j.biortech.2023.128853

URL

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