



Functional microbiota reconstruction using acclimatized consortium and trace metal supplementation facilitates process recovery in organic-overloaded anaerobic digesters[☆]

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ABSTRACT

Increasing the organic loading in anaerobic digesters enhances energy production from anaerobic digestion (AD). However, this often results in accumulation of volatile fatty acids (VFAs) and ammonia, which disrupts the intricate syntrophy within the AD microbial communities, leading to process instability and undermining the advantages of increased substrate input. Here, efficacy of microbiota reconstruction through a combined bioaugmentation and biostimulation strategy using an acclimatized consortium and trace metal supplementation to recover digesters destabilized by high organic loading and VFA accumulation was investigated. Overloading the digesters with substrate caused process instability, shown by VFA accumulation (6.07 g L^{-1}) and a pH drop (5.45), causing a significant 67.4 % decline in the average daily methane yield compared to the stable process. Microbiota reconstruction in the digesters resulted in a rapid recovery of methane production, with a 242.1 % increase in methane yield and VFA degradation to below detection levels after 15 d, accompanied by a pH restoration to 7.62. This increased the abundance of syntrophic bacteria, including *Sedimentibacter*, *Fermentimonas*, *Clostridium*, *Petrimonas*, *Proteiniphilum*, and *Syntrophomonas*, along with methanogens, such as *Methanosarcina* and *Methanosaeta*. Predictive metabolic pathway profiling via PICRUSt2 indicated enhanced abundance and activity of pathways linked to carbohydrate metabolism, β -oxidation, and acetoclastic methanogenesis in microbiota reconstructed digesters. Microbiota reconstruction through bioaugmentation and biostimulation could be a feasible strategy for recovering digesters that experience process disturbances due to organic overloading. Preliminary considerations suggest that microbiota reconstruction, while demonstrating promising results for rapid digester recovery, requires further analysis for cost-effectiveness and sustainability to enable full-scale implementation.

1. Introduction

Generation of food waste and challenges in its management to reduce the associated environmental impacts, such as water pollution,

greenhouse gas emissions, and soil degradation, represent significant global issues [1,2]. In South Korea, more than 90 % of food waste is repurposed as animal feed or compost. However, this process generates approximately 3.4 million tons of food wastewater annually, known as

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