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Studies on factors affecting a unique autothermal thermophilic aerobic digestion

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Title : **Studies on factors affecting a unique autothermal thermophilic aerobic digestion**
(ユニークな自家熱型高温好気消化に影響を及ぼす諸因子に関する研究)

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Thesis Summary

Autothermal thermophilic aerobic digestion (ATAD) has been applied for stabilizing organic waste since the 1960s and has been considered a sustainable technology. ATAD has several absolute advantages, including high biodegradation efficiency, inactivation of pathogens, and ease of operation. However, the high-energy consumption characteristic of the aerator and foam cutter makes the process less economical. We previously reported a unique three-phases full-scale ATAD, showing distinctive bacterial community transitions and producing high-nitrogen-content liquid fertilizer within ten days. Therefore, this study focused on elucidating the uniqueness of the full-scale ATAD and establishing a more efficient ATAD for stabilizing human excreta sludge and utilizing the end product as liquid fertilizer.

In chapter I, the most recent advances in ATAD was reviewed and discussed, comparing with characteristics of other biological processes such as composting, activated sludge, and anaerobic digestion, and discussing the physicochemical properties and factors, the digestion system and operation mode, and the transition of the microbial community during the ATAD. In chapter II, shear stress and oxygen supply system were investigated to elucidate the uniqueness of the full-scale ATAD. ATAD equipped with a gas-inducing agitator (GI) under high shear stress (1000 rpm, GI1000) could model the uniqueness of the full-scale ATAD. GI1000 achieved higher ammoniacal nitrogen concentration, total carbon removal efficiency than low shear stress (490 rpm) and disk-turbine agitator runs. Shear stress and oxygen supply system would change the bacterial community structure, thus affecting ATAD performances. In chapter III, to further understand the uniqueness of the three-phases full-scale ATAD, the thermal effect (temperature rising strategy) on ATAD was performed. The temperature behavior greatly affected physicochemical properties, pathogen inactivation, and bacterial community structure. These three phases have different effects on organic degradation, nitrogen reservation, and bacterial proliferation. Higher temperature would be favorable for organic degradation, nitrogen reservation, and pathogen inactivation, whereas unfavorable for bacterial proliferation. In chapter IV, the effect of the overall oxygen transfer coefficient (K_La) on ATAD was carried out to optimize ATAD for liquid fertilizer production. The K_La value greatly affected physicochemical properties and bacterial community structure. The low K_La value groups (10 to 25 h^{-1}) achieved ammoniacal nitrogen preservation rates higher than 70% due to the low ammonia stripping effect and few nitrifying bacteria, much higher than that in high K_La value groups (50 to 90 h^{-1}). Meanwhile, the low K_La value groups (10 to 25 h^{-1}) had a chemical oxygen demand (COD) removal rate higher than 64%, resulting from the higher copies number and community

richness and diversity.

In chapter V as general conclusion. ATAD is a considerably efficient process that can stabilize human excreta sludge with short processing time and simple facilities. Our results indicated that ATAD equipped with a gas-inducing agitator under high shear stress (1000 rpm) and low K_La value (10 to 25 h^{-1}) produce high-nitrogen-containing liquid fertilizer and achieve a minimum electric power consumption. ATAD-treated sludge is an eco-friendly product, which can be used legally as high-nitrogen-content liquid fertilizer in farms. Thus, the application of ATAD for human excreta sludge treatment would help several nations meet their sustainable development goals.