Optimization of the Operational Parameters of a Mesophilic Two-Phase Anaerobic Digester for Vegetable Waste Degradation

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Key words: anaerobic digestion, vegetable waste, biogas, Organic Loading Rate
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Vegetable wastes which are disposed from centralized food preparation facilities contain high percentage of water and organic fractions. Anaerobic digestion of this kind of waste has been a topic for long time because the anaerobic process convert waste stream into renewable biogas energy. Compared to some of the conventional disposal methods such as landfill, composting and feed production, industrial anaerobic digestion does have many benifits such as bioenergy production, low environmental pollution and almost no odor and leachate emission. However, the engineering applications of vegetable waste digestion were limited by its low organic loading rate (OLR) and long digestion time. Lots of experimental and pilot studies have been conducted to develop a novel process for high rate digestion of vegetable waste. However, most of them used traditional or modified continuous-stirring-tank-reactors (CSTR) with single stage process because of the consideration of initial investment.

In this paper, optimized anaerobic-sludge-bed-reactors (ASBR) were used with a novel two-phase anaerobic process to achieve fast process startup, high OLR and short digestion time. The investment would be under control because this process did not use complicate reactors and unit operations. A series of mesophilic (35℃) batch anaerobic trials were firstly conducted to find the optimal Food/Microorganisms ratio (F/M=3) and initial OLR (OLR=10 gVS L^{-1}) for quick startup of hydrolysis reactor. This experiment suggested that most of the hydrolysis processes could be finished in 4 d. The above key parameters were sucessfully applied in a two-phase anaerobic system to achieve a quick and stable startup of hydrolysis reactor (HR) which was operated as ASBR before the ultimate CSTR application. The effluent from HR was feed into the mathanegenesis reactor (MR) at OLR of 5 gVS L^{-1} for sufficient conversion of organic fractions. The hydrolic retention times (HRT) of HR and MR were 4 d and 20 d, leading to an overall digestion time of 24 d. The effluent from MR was mixed with new feedstock and fed back into the HR to maintain stable alkalinity and pH. The digestion system discussed in this paper worked well for 80 d, achieving biogas yield of 660±20 mL gVS^{-1} and methane content of 60±3%. A higher OLR and shorter HRT would be practicable in further studies.

This study proved that mesophilic two-phase process are applicable for the digestion of vegetable waste at high OLR and short HRT. The optimization of operational parameters and reactors could help the digestion system to be a better choice than traditional single stage system. A pilot system is under construction to get long-term results from the engineering standpoint.