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論 文 要 旨

THESIS SUMMARY

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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Methane fermentation is successfully used for the treatment of wastes and additionally production of alternative energy as methane to cope with the increase of sludge production, the energy crisis and climate change all over the world; therefore, an interest in methane fermentation is rapidly increasing. Among diverse factors in methane fermentation, organic loading rate (OLR) is one of important factors because the increase of OLR can induce the large amount of methane production; therefore the high OLR is attractive and important in methane fermentation. However, sometimes methane fermentation deteriorates with increasing OLR. And so far, it has not been understood what happens in methane fermentation by the increase of OLR. In methane fermentation process, it is strongly linked to the methanization performance and microorganism interactions because methane fermentation is a complex microbial ecosystem. In spite of the extensive research to investigate the methane fermentation process with the changes of microbial community accomplished, the detailed understanding on the changes in microbial community associated with the deterioration of methane fermentation by increasing OLR has not been clarified yet. In the present study, it was clarified the deterioration mechanism of methane fermentation by increasing OLR using physico-chemical analyses and biological analyses.

Firstly, a syrup wastewater was treated by methane fermentation in an upflow anaerobic sludge blanket reactor and the deterioration mechanism of methane fermentation with increasing OLR was clarified. The changes in the microbial community, microorganisms in the granules, that of both bacteria and archaea, were analyzed using polymerase chain reaction denaturing gradient gel electrophoresis (PCR-DGGE) and real-time polymerase chain reaction (real-time PCR) during the fermentation process. The OLR of syrup wastewater was increased gradually as fermentation progressed. It was revealed that the high OLR of 30.3 kg COD m^{-3} d^{-1} by short hydraulic retention time (HRT) and high substrate concentration enhanced the bacterial activity to the increases of volatile fatty acids (VFAs) concentration and dissolved oxygen (DO) level which inhibited the archaeal activity, and the iron-reducing bacterium belonging to genus *Geobacter*, which outcompetes methanogens, grew proportionally with the deterioration of methane fermentation.

Secondly, the effects of HRT and substrate concentration on the deterioration of methane fermentation in the laboratory-scale anaerobic sequencing batch reactor were investigated when the OLR of the syrup wastewater into the reactor increased with the progress of fermentation. The OLR, which is calculated by dividing the substrate concentration by HRT, was set at the same level in two experiments; one experiment with high substrate concentration and long HRT, and another experiment with low substrate concentration and short HRT. When methane fermentation operated at the OLR of 20.4 g COD L^{-1} d^{-1}, for the reactor with short HRT of 3.1 days and with the low substrate concentration of 63.5 g COD L^{-1}, the deterioration of methane fermentation was observed immediately after the increase in the OLR, whereas the deterioration of methane fermentation delayed more than 10 days in the reactor with long HRT of 6.2 days and high substrate concentration of 126.7 g COD L^{-1}. It was revealed that the short HRT condition resulted in the increase of the oxygen level that directly inhibited the archaeal activity and also stimulated the VFAs production by the increase of bacterial activity causing the decrease in pH, which consequently affected

adversely to the archaeal activity. In contrast, long HRT condition corresponding to the low level of the oxygen slowed down the increase in the VFAs production, resulting in the delay of the deterioration of methane fermentation. As a result, it can be clarified that short HRT can affect more strongly than high substrate concentration to the deterioration of methane fermentation.

Lastly, peptone wastewater was used as a substrate in a laboratory-scale methane fermentation reactor and the deterioration mechanism of methane fermentation was clarified. Methane fermentation was operated at the HRT of 8 days with the OLR of 2.5 g COD L^{-1} d^{-1} from 0 to 17 d of fermentation, and at the HRT of 4 days and 1 day from 18 to 161 d and from 162 to 197 d of fermentation, respectively with keeping the constant OLR at 5.0 g COD L^{-1} d^{-1}. When methane fermentation operated with the HRT of 1 day, the methane production diminished because the HRT was too short to stably operate the reactor. It was revealed that the short HRT enhanced the bacterial activity, and thus the concentrations of ammonium ion and VFAs increased to relatively high concentrations of 1,400 mg L^{-1} and 3,100 mg L^{-1}, respectively, associated with the rapid degradation of peptone. Although these features were not sufficient to deteriorate methane fermentation individually, together they deteriorated methane fermentation in conjunction with the growth of sulfate-reducing *Desulfoglaeba* bacteria, which competes with methanogens for reducing power. The archaeal activity was inhibited by the accumulation of two unfavorable substances together with the interception of reducing power which is required by the archaea to produce methane.