

TREATMENT OF FOODWASTE AND POSPHORUS REMOVAL USING STRUVITE CRYSTALLIZATION IN HYBRID ANAEROBIC REACTOR WITH SAC MEDIA

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I. ABSTRACT

The purpose of this research was to understand possibility of foodwaste treatment by hybrid anaerobic reactor(HAR). The Possibility of methane utility and applicability of hybrid reactor system using foodwaste as substrate was investigated. The maximum loading rate and optimized operational conditions were determined. Hybrid anaerobic reactor was filled with packing material 50% of its total volume between the tube and the outer surface. The packing material used was randomly packed open-pore synthesis activated ceramic(SAC) media as support media for microbial attachment, growth, and chemical stability protected bacteria from effect of organic acid accumulation.

In this research, although foodwaste has high concentrations Cl^- and SO_4^{2-} concentration the possibility of foodwaste anaerobic treatment was when foodwaste is treated by anaerobic digestion, this study focused on the possibility using CH_4 gas made under the anaerobic treatment as an alternative energy source. Other objective of this research is to study struvite formation and crystal forms in anaerobic digester. HAR is used to investigate phosphate crystallization without the addition of chemicals.

II. OPERATION AND METHODS

1. Reactor operation

For anaerobic treatability, namely a hybrid anaerobic reactor made of stainless with a total volume of 59L was used. The diameter of the reactor was 34cm and the height was 65cm. In this reactor, a tube having 24cm diameter and 60cm height with lots of holes of the diameter 3mm on the surface was inserted. Hybrid anaerobic reactor was filled with packing material 50% of its total volume between the tube and the outer surface.

The reactor was continuously operated for 280days, including the start-up periods of 20 days. The hybrid anaerobic reactor started at OLR of 1.43kg COD/m³/day and HRT of 49days. The OLR was increased by increasing COD concentration, or by reducing HRT. The OLR was increased gradually from 1.43kg COD/m³/day to 12.25 kg COD/m³/day while HRT of 24.5days.

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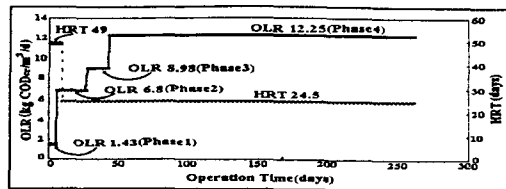
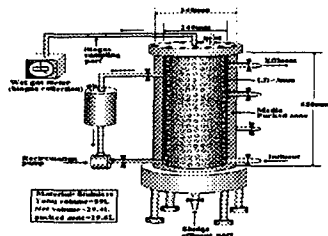


Figure 1 Schematic diagram of reactor Figure 2 changes of Loading Rate and HRT

2. Analytical methods

The pH, volatile suspended solids(VSS), total suspended solids(TSS), COD, Cl^- , NH_3 , SO_4^{2-} and PO_4^{3-} were analyzed according to the standard methods(APHA, 1998). T-N, T-P and alkalinity were analyzed according to Environmental pollution official methods(Korea 1999). The concentration of methane in biogas was analyzed by a gas chromatograph(Shimadzu GC-4C). The volatile fatty acids(VFA) concentration was determined by a gas chromatograph(GC-HP5890). Scanning electron microscope observations were carried out using a JEOL, JSM-5400 instrument. X-ray diffractometer observations were carried out using a RIGAKU, DMAX/1200 instrument. Energy dispersive x-ray spectroscopy observations were carried out using a JEM-2000FXII instrument. P-fractionation for sol-P(soluble P), adsorbed-P(NH_4Cl extractable P), Fe, Al-P($NaOH$ extractable P), Ca, Mg-P(HCl extractable P), and org-P(residual P) was made in accordance with the method used by Hietjes(1980).

III. RESULTS AND DISCUSSION

Under the anaerobic digestion in HAR, the average of T-P and P as PO_4^{3-} removal efficiency were 72.7% and 63.5%, respectively at 35°C. Figure 3 and Figure 4 show phosphate and T-P concentrations in influent and effluent. The P removal in the foodwaste sample was achieved at a pH level of 7.8~8.0.

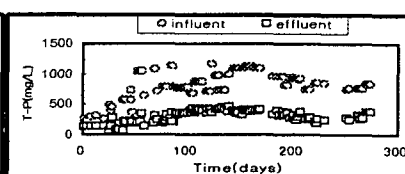
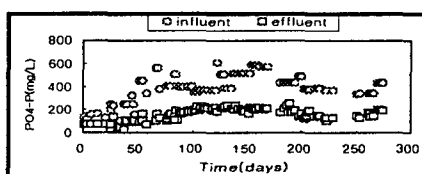


Figure 3 PO_4 -P Changes of HAR

Figure 4 T-P Changes of HAR

Nutrient released from the foodwaste during anaerobic digestion was refixed with Ca^{2+} and Mg^{2+} ions as struvite and Ca-precipitates. Ca^{2+} and Mg^{2+} contents of foodwaste in this study were generally low. Particularly, Mg^{2+} was low, and refixation of NH_4 -N and PO_4 -P as struvite($MgNH_4PO_4 \cdot 6H_2O$) was limited. To make struvite precipitate, Mg^{2+} , NH_4 -N and PO_4 -P contents must be balanced. Fig. 5 and Fig. 6 show Ca^{2+} and Mg^{2+} changes in influent and effluent. The molar loss ratio of magnesium and ammonia with respect to phosphate suggested that the struvite crystallization was not the only mechanism for p removal in this study. Approximately, 52% of phosphate removed was formed as struvite.

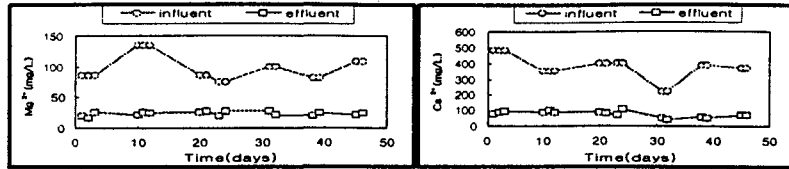


Figure 5 Mg^{2+} changes in HAR

Figure 6 Ca^{2+} changes in HAR

1. XRD and P-fractionation of digested foodwaste

Figure 7 illustrates the X-ray diffraction pattern for precipitant removed from a HAR and the struvite standard X-ray diffraction pattern. Based on the X-ray diffraction results, precipitants were determined to be struvite.

Digested foodwaste withdrawn from HAR was P-fractionated and compared with those foodwaste without digestion. Figure 8 represent the result of foodwaste. Generally organic phosphorus was solubilized as expected. In addition, adsorbed-P and organic-P were reduced during digestion. However, Ca and Mg-P were increased from 4.3 to 23.7%. This would suggest phosphorus could be removed by Ca^{2+} and Mg^{2+} during digestion.

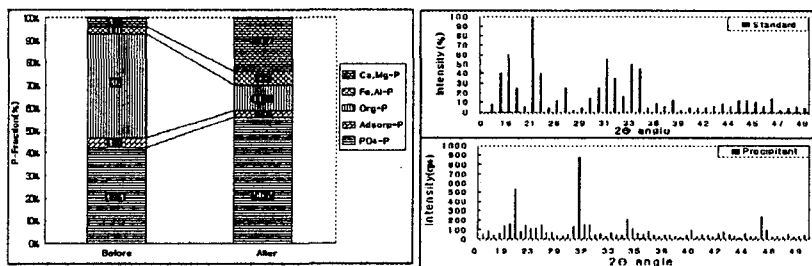


Fig.7 P-fractionation of foodwaste before and after digestion Fig.8 Powder X-ray diffraction pattern of struvite

2. Energy Dispersive X-ray Spectroscopy(EDXS) and SEM

The study indicated that struvite crystallization can be obtained in a hybrid anaerobic reactor. Energy Dispersive X-ray Spectroscopy was used to identify the crystals in the precipitant. SEM was done to adjust the position of the sample and to select the crystals for further EDXS analysis. The selected crystal was then analyzed its composition. The results were presented as a series of curves, each peak indicated the presence of an element. Each test was done on one or more seeds. The SEM and EDXS results confirmed the presence of the other metals in crystals found in precipitant. They are aluminum, calcium, sodium, and potassium. Considering the molar loss ratio(MLR)with respect to phosphorus of each sample, the ratio is not stoichiometrically comparable to struvite($P:Mg:N=1:1:1$). If one considers the percentage of phosphorus to form struvite to be equal to the smallest molar loss value among the three components of struvite, one could say that only about 52% of phosphate was fixed as struvite crystals in foodwaste. The rest of phosphate removal must have been in other forms. It might be reasonable to assume that the struvite crystallization was not the only mechanism for P removal in this study. The SEM and EDXS results confirmed the presence of the other metals in crystals found in precipitant. Figure 9 shows some of the SEM and EDXS results of these crystals. The coexistence of calcium and

magnesium in Figure 9 could indicate the co-precipitate of calcium phosphate and magnesium phosphate, as being published by Battistoni et al.(1997).

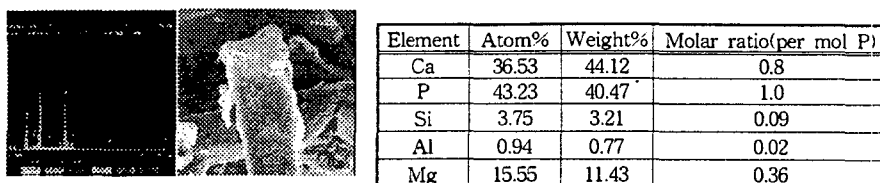


Figure 9 Crystals found in the precipitants

IV. CONCLUSION

Under the anaerobic digestion for treating foodwaste in HAR, average T-P and P as PO_4^{3-} removal efficiency was 72.7% and 63.5%, respectively at 35°C. The P removal can be improved by increasing pH level over pH 8.0 as demonstrated by Momberg and Oellermann(1992). The molar loss ratio of magnesium and ammonia with respect to phosphate suggested that the struvite crystallization was not the only mechanism for P removal in this study. Approximately 52% of phosphate removed was formed as struvite. The SEM and EDXS results confirmed the presence of the other metals in crystal found in precipitant. They are aluminum, calcium, sodium, and potassium. This was phosphate removal by struvite crystallization without addition of chemicals.

P-fractionation for sol-P (soluble P), adsorbed-P (NH_4Cl extractable P), Fe, Al-P (NaOH extractable P), Ca, Mg-P (HCl extractable P), and Org-P(residual P) was made in accordance with the method used by Hietjes(1980). P-fractionation of HAR indicated that the contents of Ca and Mg-P of digested foodwaste increased from 4.3% to 23.7%. From the results of anaerobic digestion of foodwaste with the high NH_4^+ concentration, it was found that soluble phosphate released from polyphosphate made Ca-precipitants and struvite combining with Mg^{2+} in HAR. But Mg^{2+} and Ca^{2+} concentrations decreased to 20mg/L and 90mg/L, respectively, while NH_4^+ and phosphate concentrations were high. The supplement of metals should be considered if the high efficiency is required. Therefore adding Mg^{2+} in anaerobic digester, we could remove them using maximum re-fixation of the NH_4^+ and phosphate. Nutrient released from foodwaste during anaerobic digestion was re-fixed with Ca^{2+} and Mg^{2+} ions as struvite and Ca-precipitates.

V. REFERENCES

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