Treatment of Starch Wastewater by Anaerobic Digestion Combined with Hollow Fiber UF

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ABSTRACT

Anaerobic digester coupled with hollow fiber membrane unit. Treatment of starch waste with anaerobic digester-membrane system was studied. 0.17 m^2 area of hollow fiber membrane unit of known pore size was immersed into laboratory-scale anaerobic digestion system. The gas production was about 0.74 m^3/kg COD treated. The COD removal efficient was about 80-95% depending on the hydraulic retention time. Crossflow ultrafiltration as post treatment to anaerobic filter. The study conducted with different membrane pore size indicated that membrane with 1,000,000 molecular weight cut-off size gave a higher COD removal efficiency in the range of 83-87% while giving a study flux of 120-130 L/m^2 · h. A study was conducted to see the long term clogging effect of membrane also.

INTRODUCTION

Wastewater from the tapioca starch factories released directly into the surrounding areas before proper treatment has been a source of pollution and has caused environmental problems to the nearby population. Anaerobic digestion was popular in the years immediately following World War II and there has been a resurgence of interest in this application of the process in recent years. However, this form of the once-through completely-mixed anaerobic digester, in which the solids retention time(SRT) equals the hydraulic retention time(HRT), is of limited value in the treatment of liquid industrial effluent. In a digester with SRT/HRT ratio of 1.0, "wash out" of anaerobic microorganisms will pose a serious problem if high loading rates are applied and short hydraulic retention time results. Hence, developments in anaerobic biological processes for industrial waste treatment have concentrated on ways of achieving higher SRT/HRT ratios, thus allowing high loading rates to be applied to small digester volumes.

The membrane anaerobic digester system is one of the processes which adopts a suspended growth digester in conjunction with an external ultra/micro filtration membrane unit for solid/liquid separation[1]. Laboratory-scale anaerobic digester coupled with hollow fiber ultrafiltration experiments were conducted using different operating parameters such as membrane pore size, organic loading rate, and detention time to study the role of ultrafiltration in the improvement of treatment efficiency and biogas production. The study also looked into the possibility of using membrane as post treatment for the effluent of tapioca starch wastewater from an anaerobic filter(AF).

MATERIALS AND METHODS

The volume of the digester is 1L and the synthetic tapioca starch wastewater was fed by using peristaltic pump twice per day or at every 12 hrs. Feeding time for each digester was about 30 minutes. During this 30 minutes, filtrate was withdrawn at a constant rate. After each feed, synthetic starch wastewater was kept in 5℃ room temperature. The digesters were installed in a room where the temperature was maintained at 30℃. Composition of synthetic starch wastewater[2] is shown in Table 1. The experimental runs conducted with the anaerobic digester coupled with the hollow fiber module are shown in Table 2. In this study, the treated effluent of tapioca wastewater by anaerobic filter was

Table 1. Composition of Synthetic Starch Wastewater

Items	Concentration (mg/L)
Starch	20,000
$(NH_4)_2SO_4$	250
$MgSO_4$ $7H_2O$	50
$FeCl_3$ $6H_2O$	0.25
$CaCl_2$	3.75
KH_2PO_4	263.5
K_2HPO_4	535
$MnSO_4H_2O$	5
$NaHCO_3$	2,000

Table 2. Experimental Runs with the Arrangement of Anaerobic Digester Coulped with Hollow Fiber UF Module

Membrane Pore Size(㎛)	Detention Time(days)	Organic Loading Rate (kg COD/m³ · d)
0.03	10	1.76
0.03	2	8.83
0.05	10	1.76
0.05	3	5.88
0.10	10	1.76
0.10	5	3.53
0.15	10	1.76
0.15	7	2.51
0.15	1.5	11.77

treated by using the laboratory-scale crossflow ultrafiltration module. The ultrafiltration in this case (flat geometry), was used as post-treatment after anaerobic filter. The effluent from anaerobic filter was pumped from the base of the stock tank and fed into the membrane filter. The temperature, crossflow velocity, and applied pressure were fixed at 30℃, 3 m/s and 138 kPa respectively.

RESULTS AND DISCUSSION

Anaerobic digester coupled with hollow fiber membrane unit

COD removal efficiency increased with an increase in HRT and decreased with an increased in the organic loading rate. Fig. 1 shows the average COD removal efficiency at the steady-state which was about 92.2% at HRT of 10 days (organic loading rate of 1.76 kg COD/m³ · d) and reduced with a decrease in HRT. Fig. 2 also shows the plot of biogas and methane gas production at different organic loading rates.

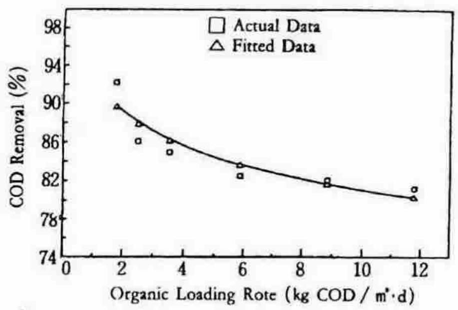

Fig.1. Average COD removal efficiency at steady-state with organic loading rate (Influent COD=20,150 mg/L).

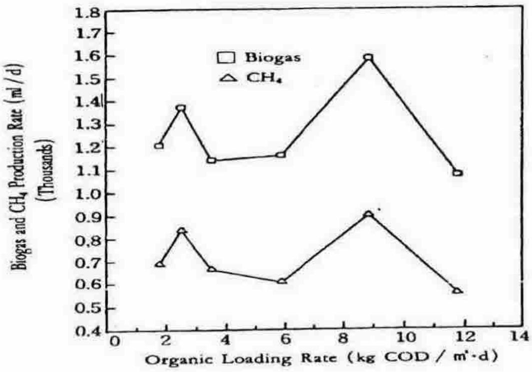

Fig. 2. Biogas and methane gas production with organic loading rate.

Crossflow ultrafiltration as post treatment to anaerobic filter

The effluent from anaerobic filter, which had a total COD in the range of 4,500-5,200 mg/L was treated by crossflow ultrafiltration units. Fig. 3 shows that an increase in membrane pore sizes results in a higher filtrate rate. COD removal at the steady state is also high, about 85% at a steady state flux of 120-130 L/m² · h. Fig. 4 shows the performance of membrane filtration in terms of filtrate rate recovery and COD removal. After each steady state, the membrane was backwashed by using a crucible apparatus and distilled water.

The recovery filtrate rate is about 80% of the pervious one. This may have been due to the gel formation and standard blocking mechanism that occurred on the surface of the membrane.

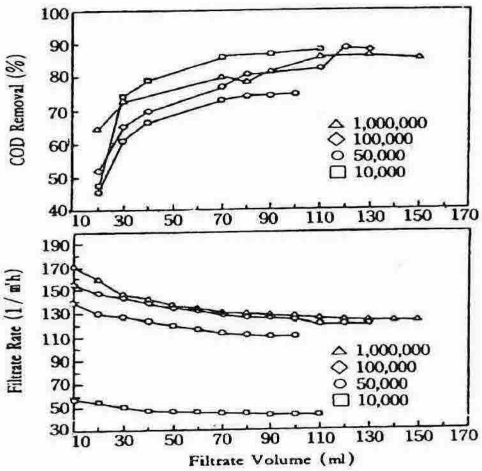

Fig.3. Effect of pore size of membrane: velocity=3 m/s, pressure=138 kPa, temperature =30℃.

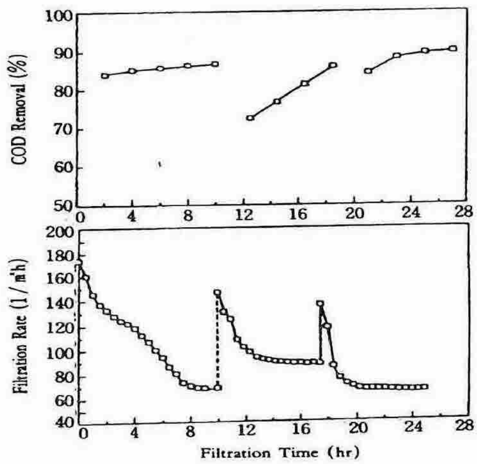

Fig.4. Long term filtration study: molecular weight cut-off size=1,000,000, velocity=3 m/s, pressure=138 kPa, temperature=30℃. Note* after backwash, let the membrane submerged in distilled water overnight.

CONCLUSION

The study clearly showed satisfactory performance of the four digesters indicating that the treatment of tapioca starch wastewater using an anaerobic digester coupled with hollow fiber UF membrane is possible. The performance of the digester at the organic loading rate of 1.76 kg COD/m³ · d was the best among the four digesters in terms of daily gas production. Post-treatment of the effluent of tapioca starch wastewater from an anaerobic filter by UF membrane filtration was possible. The COD removal was about 85%.

REFERENCES

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2. T. Manickam and A. F. Gaudy, "Qualitative-Quantitative Shock of Activated Sludge"(1979), J. WPCF, 51, 2033-2042.