Effect of loading rate on treatment of higher-load graywater

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Submerged MBR with ultrafilter hollowfiber membrane was used to treat higher-load graywater. Appropriate loading rate to be supplied to the system was determined by monitoring the organic matter removal, N and P, and flux. The COD of permeate and reactor exhibited stable conditions at OLR$\leq$3 kg_{COD}/m^3-d (HRT$\geq$8hr). However, the values were higher in the system treating a mixture of KSWW and WMWW than KSWW only (from previous experiment), even though operated at the same condition. This indicated that washing machine wastewater has component that is hard to biodegrade. Moreover, nitrates and phosphates were detected at reactors and permeates with longer HRT (12 and 24 hours). UF membrane results in low flux. Therefore, further investigation using a microfilter membrane will be considered using HRT$\geq$8hr or OLR$\leq$3kg_{COD}/m^3-d.

１．Introduction

Treatment of higher-load graywater, kitchen sink wastewater (KSWW) and washing machine wastewater (WMWW) is one of the aspects of OWDTS concept. Appropriate technology that can be used for necessary treatment is needed. Submerged MBR (subMBR) has become popular in treatment of domestic wastewater especially for wastewater recycling where stringent criteria is needed. In this regard, subMBR is a promising technology for treatment of higher-load graywater. However, operating parameters are needed to be established for proper operation. This paper aims to determine appropriate loading rate that can be supplied to the system treating higher-load graywater (mixture of KSWW and WMWW). The following parameters are monitored: a) removal of organic matter; b) N and P.

２．Materials and Methods

Four subMBRs with ultrafilter hollowfiber (UF HF) membrane were operated continuously at different HRT (4, 8, 12 and 24 hours). The activated sludge that was used for the operation was obtained from Shinkawa Wastewater Treatment Plant in Sapporo, Japan. The kitchen sink wastewater was obtained at the cafeteria of the Faculty of Engineering, Hokkaido University while the washing machine wastewater (1st discharge only) was obtained from four students. The mixture (1:1) was continuously supplied to the system. The sludge was maintained at 9-11 g/L in all the reactors. The airflow rate was 2.5 L/min (DO$\geq$4mg/L)and permeate was withdrawn at constant TMP of 5 kPa. Samples from the influent, reactor and permeate were obtained for subsequent analyses. Samples were analyzed for total COD, dissolved COD, N and P components.

３．Results and Discussion

The reactors were operated for 72 days. But R1 was stopped after 25 days because of foaming problem and permeate flowrate is hard to maintain. The average COD of the influent is 890 mg/L (range: 540-1200 mg/L). This range is higher than the domestic raw wastewater (250-800 mg/L)[1] and total graywater discharge (495-682 mg/L)[2].

Table 1. OLR and F/M ratio at four reactors

Reactor	**HRT** h	**OLR** kg_{COD}/m^3-d	**MLSS** g/L	**F/M** kg_{COD}/kg_{MLSS}-d
R1	4	6.0	9 – 11	0.6
R2	8	3.0	9 – 11	0.3
R3	12	2.0	9 – 11	0.2
R4	24	1.0	6 – 7	0.15

Keywords: higher-load graywater, subMBR, organic matter, nitrogen, phosphorus

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Table 1 shows the organic loading rate (OLR), MLSS concentration, and F/M ratio in the four reactors. The F/M ratio in R1 is high compared to existing MBRs treating domestic wastewater which has F/M ratio which sometimes approaches 0.

The permeates' COD at different loading rates is shown in Fig. 1. The fluctuations observed are due to changes in the COD of the influent. It was shown that HRT≥8 hr or OLR≤3 kg_{COD}/m^3-d will give a stable COD at permeate, and the lowest value is at longest HRT (COD=12-51 mg/L). Furthermore, COD inside the reactor was also measured to determine the effect of biological reaction only and to determine if significant accumulation of un-decomposed organic matter happened. For OLR≤3 kg_{COD}/m^3-d, the COD value also fluctuates as the influent COD fluctuates but there is no significant accumulation of un-decomposed organic matter (figure not shown). In terms of organic matter removal, this indicates that relatively stable operation will be observed at this OLR, but at around OLR=6 kg_{COD}/m^3-d stable operation will not be observed. The same was observed when only KSWW was treated at almost the same operating conditions as in this experiment. That is, stable operation is observed at HRT of 8hr and longer. However, the COD of both the permeate and reactor is relatively higher at mixture of KSWW and WMWW rather than KSWW alone. For example, COD of permeate in HRT=24 hours are: a) KSWW only=10-20 mg/L; b) KSWW+WMWW=10-50 mg/L. This indicates that there is a component in WMWW that is hard to biodegrade.

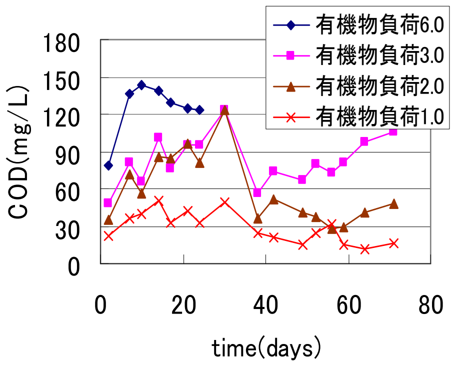

Fig. 1. COD (mg/L) of permeate

Nitrates (Fig. 2) and phosphates (figure not shown) are observed only at longer HRT (12 and 24 hours) in samples of both the reactor and permeate. These are related to frequency of sludge withdrawal. High sludge wasting enables the release of these substances out of the MBR system.

Flux is small because UF membrane was used. To determine the practicality of this operation, other types of membrane like MF membrane will be further investigated.

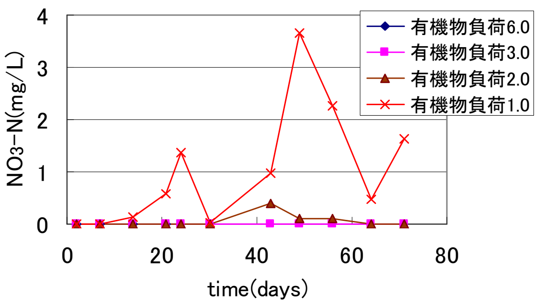

Fig. 2. NO_3-N (mg/L) of permeate

４． Conclusions

Submerged MBR with UF HF membrane was used to treat higher-load graywater. Appropriate loading rate to be supplied to the system to give stable conditions in terms of organic matter removal is at OLR≤3 kg_{COD}/m^3-d (HRT≥8hr). However the values were higher in the system treating a mixture of KSWW and WMWW than KSWW only, even though operated at the same condition. This indicated that washing machine wastewater has component that is hard to biodegrade. Moreover, nitrates and phosphates were detected at reactors and permeates with longer HRT (12 and 24 hours). UF membrane results in low flux. Therefore, further investigation using a microfilter membrane will be considered using HRT≥8hr or OLR≤3kg_{COD}/m^3-d.

References:

1) Tchobanoglous,G., Burton, F.L., Stensel, H.D. (2003) Wastewater Engineering Treatment and Reuse. 4th Ed (Int. Ed.). Metcalf and Eddy, McGraw-Hill, New York, p. 186, 857 [1819pp].

2) Palmquist, H., Hanæus, J. (2005) Hazardous substances in separately collected grey- and blackwater from ordinary Swedish households. Science of the Total Environment 348, 151-163.