B−1 The effect of temperature decrease on the process performance of an anaerobic EGSB reactor

○Wilasinee YOOCHATCHAVAL[1,3]*・大橋 晶良[1]・原田 秀樹[2]・珠坪 一晃[3]

[1]長岡技術科学大学　環境システム工学（〒940-2188 新潟県長岡市上富岡町 1603-1）
[2]東北大学工学部　土木工学科（〒980-8579 仙台市青葉区荒巻字青葉 6-6）
[3]独立行政法人 国立環境研究所（〒305-8506 茨城県つくば市小野川 16-2）

* E-mail: *wilasinee.y @nies.go.jp*

1. Introduction

The great advantages of anaerobic treatment over aerobic treatment are lower sludge production, lower energy requirement and biogas production. In anaerobic biofilm processes such as upflow anaerobic sludge blanket (UASB), fluidized bed and fixed bed, were usually applied to high strength wastewater under mesophilic and thermophilic condition. However, most of wastewater discharged at ambient temperature and low organic concentration as the unsuitable condition for methane fermentation. To expand the anaerobic treatment technology, we investigated the process reliability of expanded granular sludge bed (EGSB) reactor for the treatment of low strength wastewater (0.6-0.8 gCOD/L) in our previous study (Kawasaki et al., 2005). At that time, we got the successful process performance (i.e., COD loading of 12 kgCOD/m^3/day) from the EGSB reactor at 20℃. In this study we investigate the effect of temperature decrease on the process performance of the EGSB reactor and changes of physical property of the retained sludge.

2. Material and Method

The continuous flow experiment was conducted by 2 L EGSB reactor (Column: 1.3 L, Gas-Solid separator: 0.7 L) over 400 days. Reactor was inoculated with 20℃ grown granular sludge. Recirculation of the effluent made the upflow velocity of wastewater reach 5 m/h. Reactor was fed with low strength synthetic wastewater 0.6-0.8 gCOD/l and 0.04 gSO_4^{2-}/l. The organic loading rate was controlled by HRT. Reactor temperature was controlled by cooler and water jacket. The composition of synthetic wastewater is shown in table 1. Hydraulic Rention Time (HRT) was varied from 3 to 6 hours. The start-up temperature was set to 15℃. When the reactor became stable state and achieved sufficient COD removal efficiency, temperature was decreased step-wise from 15℃ to 5℃ (refer to table 2).

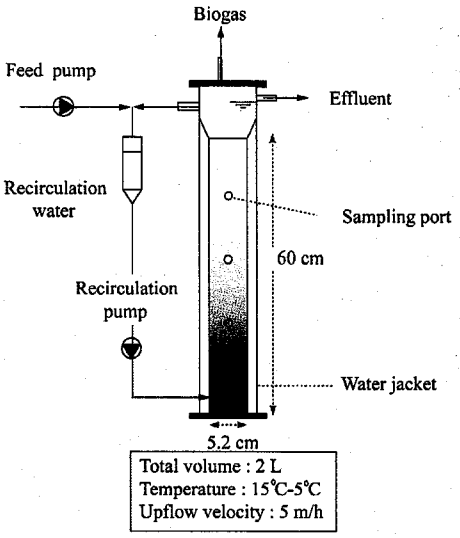

Fig. 1 Schematic diagram of an EGSB reactor

Table 1 Medium composition of feed solution

Substrate	mgCOD/L	Mineral	mg/L
Sucrose	180	NH_4Cl	37
CH_3COONa	90	KH_2PO_4	33
CH_3CH_2COOH	90	$MgCl_2 \cdot 6H_2O$	13
Yeast Extract	40	$CaCl_2 \cdot 2H_2O$	33
		$NaHCO_3$	800

Process performance of the EGSB reactor and methanogen activities of the retained sludge were investigated. The methane producing

activities of the retained sludge were determined on the day 0, 42,132 and 196. Analysis procedures followed to Syutsubo et al., (1997). Physical characteristics of the retained sluge such as MLVSS and Sludge Volume Index (SVI) were analyzed occasionally followed by APHA standard method.

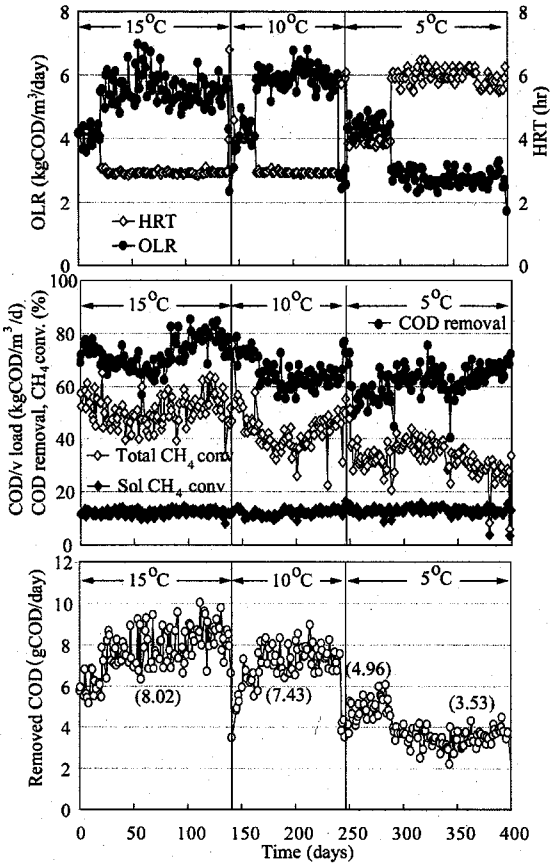

Fig. 2 Process performance of EGSB reactor with the effect of temperature decrease (15℃ - 5℃)

3 Result and Discussion

The performance of the EGSB reactor is shown in Figure 2. In this study we started with organic loading rate (OLR) of 4 kgCOD/m^3/day and hydraulic retention time (HRT) of 4 hours. Then, the OLR was increased by the reduction of HRT. As a result, COD removal efficiency tended to decrease. However, after 90 days operation at 15℃, the reactor achieved the sufficient process performance, 80 % of COD removal efficiency and 60 % of methane conversion efficiency at OLR of 6 kgCOD/m^3/day. After that, temperature was decreased to 10 ℃. In order to avoid the serious deterioration of process performance by the temperature decrease, OLR was backed to the same as the start-up period and gradually increased to 6 kgCOD/m^3/day (same loading as phase 1). The COD removal efficiency and methane gas conversion efficiency decreased after temperature changed to 10℃ (63 % and 40 % respectively). However, two months later, we found the good recovery of methane gas (50 %-60 % from removed COD) and possible to get sufficient COD removal efficiency. During phase 1 and 2, sludge settleability (SVI) was maintained sufficiently (Figure 3).

Table 2 Operational condition

	Phase 1		Phase 2			Phase 3		
Temp	15℃		10℃			5℃		
OLR(kgCOD/m^3/day)	4	6	3	4	6	3	4.4	3
HRT(hours)	4	3	6	4	3	6	7	6
Day	0-20	21-139	140-145	146-165	166-242	243-250	251-291	292-453

In the final phase, temperature reduced to 5℃, the decreasing of COD removal efficiency and serious deterioration of settleability (SVI) of the retained sludge occurred (Figure 3). In this phase we can not maintain HRT as the same as previous phase. HRT must be kept at 6 hours to achieve the sufficient removal efficiency. As a result, the average removed COD reduced only 3.53 gCOD/day (44 % compared with the phase 1 [15 ℃]).

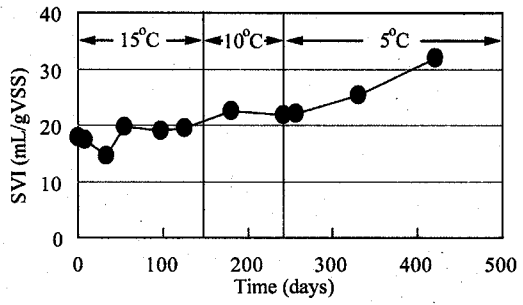

Fig. 3 Physical property of retained sludge

Acetate, H_2CO_2 and Propionate were used as test substrates to investigate the methanogen activity of the retained sludge. Testing temperature was varied from 10℃ to 45℃, the result as shown in figure 4.

From the figure 4, it is illustrated that continuous fed experiment lead the increasing of retained sludge activity. The optimum temperature of retained sludge from day 0 to day 196 is not so much change due to the operation under low temperature. We found optimum temperature for acteate utilizing methanogen and H_2/CO_2 utilizing methanogen is 35 ℃ and 45 ℃ respectively.

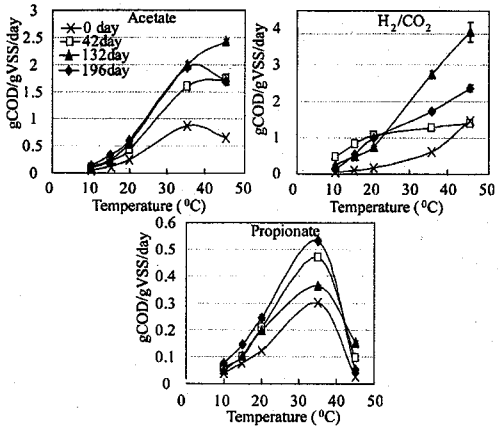

Fig. 4 Change in methanogenic activity of retained sludge

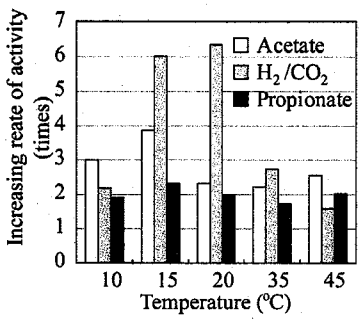

Fig. 5 Increment of activity on day 196 as compared with activity on day 0

Figure 5 shows the increment of methanogenic activity on day 196 (phase 2, 10℃) as compared with activities of seed sludge (day 0). For acetate and H_2/CO_2 substrate, the activities increased drastically under10 ℃-15 ℃ and under 15 ℃-20 ℃, respectively. These are the evidence of growth of psychrotolerant mesophilic methanogen. On the other hand, the increment of activity for propionate substrate (Acetogenic bacteria) was uniformed in all test temperatures. In phase 3, methanogenic activity of the retained sludge decreased drastically (data not shown).

From these observations, we conclude that the EGSB reactor is possible to achieve the high COD removal and good recovery of methane gas at only 10 ℃ due to the good maintenance of granular sludge with sufficient level of methanogenic activity.

Reference

1. Kawasaki T., Ohashi A., Harada H., and Syutsubo K., (2005). High reate treatment of low strength wastewater by an EGSB reactor. *Environmental Engineering Research*, Vol. 42,39-49(in Japanese).

2. APHA, AWWA, and WPCE, editors. (1992) Standard methods for the examination of water and wastewater, 18 edition. American Public Health Organization, Washington DC, USA

3. Syutsubo K., Harada H. Ohashi A. and Suzuki H. (1997). An effective start-up of thermophilic UASB reactor by seeding mesophilically-grown granular sludge. *Wat. Sci. Tech.*,36(6-7), 391-398.

Acknowledgement

A part of this study was supported by New Energy and Industrial Technology Development Organization (NEDO).