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COMPARISON OF NITROGEN REMOVAL IN A MEMBRANE SEPARATION BIOREACTOR UNDER AMBIENT AND LOW TEMPERATURES

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INTRODUCTION

Nitrogen removal in a membrane separation bioreactor developed for on-site domestic wastewater treatment was studied. The bioreactor was operated under intermittent aeration of 90 minutes on and off operation to achieve simultaneous nitrification and denitrification for nitrogen removal. In the previous studies, high nitrogen removal could be obtained under ambient temperature of 25-29°C [1] and low temperature of 5°C [2] in this long sludge age system. The probable key factors in the achievement of high nitrogen removal even at low temperature was the operation without sludge wastage resulting in a complete retention of nitrifiers in the system. Moreover, dispersed floc condition of sludge by a long sludge age operation probably allowed sufficient oxygen to penetrate to nitrifiers inside the bioflocs even at high viscosity of mixed liquor. In this paper, a comparative study was carried out to evaluate the nitrogen removal efficiency in both temperatures.

MATERIALS AND METHODS

Membrane separation bioreactor has a volume of 62 l in which a separation unit of 10 l is immersed. Two hollow fiber microporous membrane modules of 0.03 μm of pore size and 0.3 m^2 of surface area each were put in the separation unit. Permeate was extracted under intermittent operation of 5 minutes on and off cycle whereas aeration was intermittently supplied in 90 minutes on and off operation. pH of mixed liquor was kept in the range of 6.8-7.5. Synthetic wastewater composed of sodium acetate as a main carbon source is used. Other components are peptone, yeast extract, nutrients and minerals. $(NH_4)_2SO_4$ is mainly supplied as nitrogen source. Toilet paper was also fed as insoluble waste to the system.

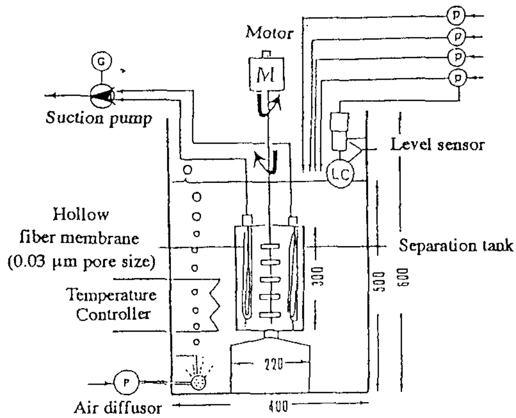

Fig. 1. Schematic of experimental system

RESULTS AND DISCUSSION

Evaluation of nitrogen removal in a constant nitrogen loading experiment The bioreactor was initially operated at 25 and 5°C to achieve stable nitrogen removal. Material balance was then performed after steady effluent quality has been obtained for at least one month of operation. Average organic and nitrogen loadings to the system were 0.356 (SD = 0.145) kgCOD/m^3.d and 0.039 (SD = 0.015) kgN/m^3.d at 25°C and 0.305 (SD = 0.054) kgCOD/m^3.d and 0.031 (SD = 0.003) kgN/m^3.d at 5°C respectively before material balance analysis. MLSS was 4.2 g/l at 25°C and 6.6 g/l at 5°C at the time material balance were performed. Results of material balance under both temperatures are shown in Table 1.

Table 1. Nitrogen balance at 25 and 5°C (9 days duration)

Temperature(°C)	25	5
Maximum DO(mg/l)	4.0-5.0	9.0-10.0
Inflow of liquid waste	42.1	22.7
Inflow of toilet paper	0.09	0.09
Accumulated in reactor	0.74	-0.62
Outflow of TN	3.1	4.9
Outflow of KN	2.0	0.8
Nitrification	39.5	22.6
Denitrification	38.4	18.5
Percentage nitrification	95.3	96.6
Percentage denitrification	92.6	79.1

Note : Mass unit is expressed in gram

Maximum nitrification rate Subsequent experiment was done to compare the maximum nitrification rate at 25 and 5°C. Fig.2 shows time course of increasing nitrogen loading at both temperatures. Organic loading to the system was maintained constant during the increase in nitrogen loading. The average values were 0.249 (SD = 0.031) and 0.279 (SD = 0.039) $kgCOD/m^3.d$ at 25 and 5°C respectively. The nitrogen was increased from 0.015 to 0.156 $kgN/m^3.d$ at 25°C and 0.025 to 0.190 $kgN/m^3.d$ at 5°C. Average MLSS were 2.2 g/l (SD = 0.2 g/l) and 5.7 g/l (SD = 0.7 g/l) at 25 and 5°C.

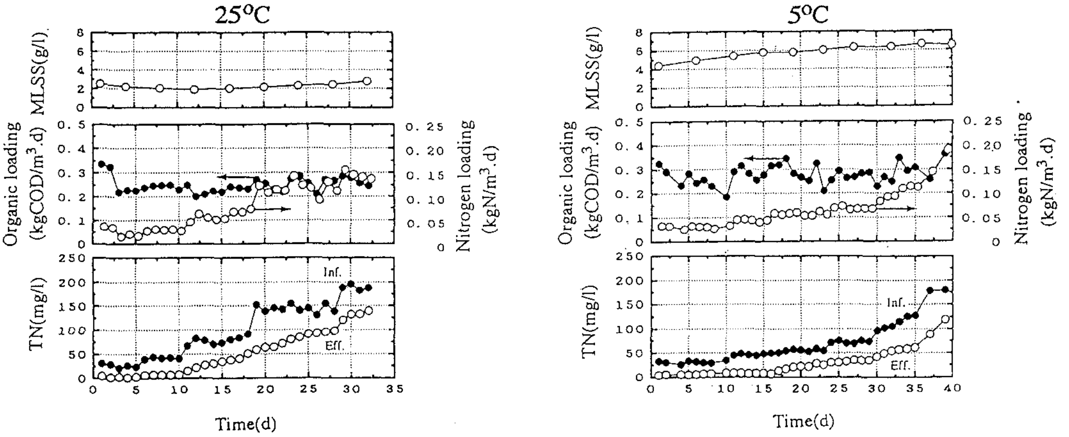

Fig.2. Time course of organic and nitrogen loading at 25 and 5°C

Plots of nitrogen loading with volumetric nitrification rate and specific nitrification rate of sludge at 25 and 5°C are shown in Fig.3. In Fig.3a, almost complete nitrification rate was obtained in the nitrogen loading range of 0.02-0.07 $kgN/m^3.d$. Beyond the loading of 0.07 $kgN/m^3.d$, it deviated from the linear increase and reached a constant maximum value probably because of oxygen transfer limitations. Insignificant difference between maximum volumetric nitrification rate suggests that there was not much difference in oxygen availability for nitrifiers in both temperatures. There exists a possibility that several parameters affecting nitrification like saturation concentration of oxygen, viscosity of mixed liquor, diffusional depth in the biofiocs or activity of heterotrophs might balance each others and result in insignificant difference in oxygen availability for nitrifiers at different temperatures. Maximum nitrification obtained in this study was about 0.09 $kgN/m^3.d$, i.e. 3 fold of normal nitrogen loading. Specific nitrification rate at 25°C was much higher than that of 5°C (Fig.3b). This was due to lower biomass concentration maintained in the system at 25°C. At 5°C lower specific nitrification rate of sludge was probably caused by larger decrease in the activities of nitrifiers than the heterotrophs resulting in less percentages of nitrifiers in sludge or an increase in the storage material of heterotroph cell due to less metabolic activity.

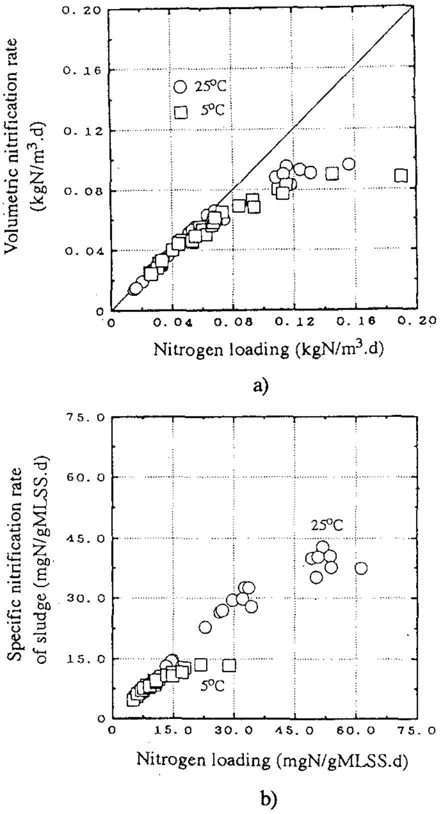

Fig.3 Plot of nitrogen loading and a) volumetric nitrification rate and b) specific nitrification rate of sludge

REFERENCES 1. C.Chiemchaisri et al., Proceeding of 26th Annual Conference of the JSWE.
2. C.Chiemchaisri et al., Proceeding of 27th Annual Conference of the JSWE.