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Nitrification Behavior in Downflow Hanging Sponge-cubes (DHS) Reactor
下降流スポンジ・キューブ懸垂型反応器（DHS）の硝化特性

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INTRODUCTION

A novel sewage treatment system was proposed, which consists of a UASB anaerobic pre-treatment unit and the following DHS (downflow hanging sponge-cubes) aerobic post-treatment unit, as a low-cost and easy maintenance process. Although the DHS post-treatment unit requires no external aeration input, the process was capable of performing very high organic removal and simultaneously high nitrification (Machdar *et.al.*, 1997). This article focused on nitrification behaviors of the DHS reactor, giving the experimental results with respect to ammonia oxidation rates and nitrite oxidation rates determined from reactor height nitrogen profiles and determined from separate batch tests using biomass harvested from sponge-cubes.

MATERIALS AND METHODS

The schematic of the UASB and the DHS units are shown in Figure 1. The proposed system was installed at a municipal sewage treatment plant site in Nagaoka City. The UASB pre-treatment unit was operated by feeding an actual municipal sewage at a HRT of 7 hr. The DHS aerobic post-treatment unit received the effluent from the UASB pre-treatment unit. Three DHS units were in parallel operated at different modes, R-1 (one-through), R-2 (recirculation), and R-3 (anoxic and recirculation). Each DHS reactor was 2 m in vertical length, composed 90 sponge-cubes (each 1.5 x 1.5 x 1.5 cm) connected diagonally in series with each other. The nominal HRT of the DHS unit was kept at 1.3 hr. Both UASB and DHS units were operated at 25°C.

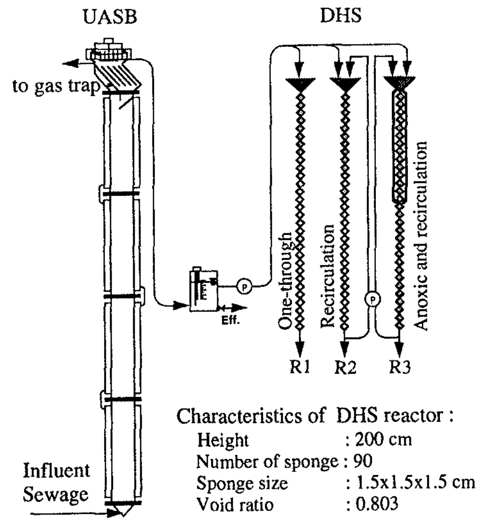

Fig. 1. Schematic diagram of whole system UASB and DHS reactor

RESULT AND DISCUSSION

Reactor performance of the UASB unit and the DHS units for a period of six months was summarized in Table 1. The whole system (UASB plus DHS units) showed excellent organic removal performance: achieving 94% of total-COD removal, 81% of soluble COD removal, and nearly perfect SS and total-BOD removals at the overall HRT of 8.3 hr (7 hr in UASB and 1.3 hr in DHS unit). Moreover, the DHS post-treatment units functioned satisfactorily not only for removals of residual organics from a UASB pre-treatment unit, but also for nitrification. Three DHS units performed a similar extent of nitrification, showing 73 - 78% ammonia oxidation in respective of operational mode, and also some extent of denitrification.

Fig. 2 shows in situ ammonia oxidation rates (expressed on the basis of unit volume of sponge-cubes), which were determined from ammonia-nitrogen profiles at different DHS height-locations when a defined synthetic wastewater was imposed onto the DHS units.

Table 1. Reactor performance of UASB, DHS, and whole system

Parameter	UASB Reactor		Effluent from DHS units			Total System
	Influent	Effluent	R-1	R-2	R-3	
CODt (mg/l)	672 (163)	144 (54)	40 (18)	42 (17)	42 (17)	
CODs (mg/l)	201 (22)	67 (18)	36 (16)	39 (16)	39 (16)	
BODt (mg/l)	259 (110)	68 (33)	2 (1)	2 (1)	2 (1)	
BODs (mg/l)	95 (60)	23 (15)				
T-Kjeldahl (mgN/l)	52 (10)	56 (19)	6 (2)	8 (2)	8 (2)	
S-Kjeldahl (mgN/l)	40 (8)	42 (9)				
NH4-N (mgN/l)	31 (8)	32 (15)	6 (5)	8 (5)	8 (5)	
NO2-N (mgN/l)	N D	N D	0.64 (*)	0.77 (*)	0.77 (*)	
NO3-N (mgN/l)	N D	N D	30 (8)	34 (8)	34 (8)	
SS (mg/l)	235 (116)	75 (39)	N D	N D	N D	
VSS (mg/l)	201 (95)	43 (27)	N D	N D	N D	
DO (mg/l)	0.7 (0.6)	0	7.18 (0.6)	7.49 (0.6)	7.49 (0.6)	
pH	6.3-8.5	6.4-7.4	3.8	3.8	3.8	
CODt removal (%)	80 (10)		71(12)	70(14)	70(12)	94
CODs removal (%)	65 (10)		44(15)	46(17)	46(15)	81
BODt removal (%)	74		97	97	97	99
BODs removal (%)	76		~100	~100	~100	~100
NH4-N removal (%)			78(18)	73(17)	74(13)	75
SS removal (%)	60		~100	~100	~100	~100

( ) *standard deviation*
(*) *detected only until one week after start up*
ND = *not detectable*

Separate batch experiments were conducted to determine sludge nitrogen conversion activity with respect to ammonia oxidation, nitrite oxidation and denitrification rate. The batch tests were made by using sludge suspension obtained by squeezing out from sponge-cubes of DHS R-2 unit. The results of sludge activity presented in Fig. 3 were given as per unit sponge volume so as to facilitate comparison with Fig.2.

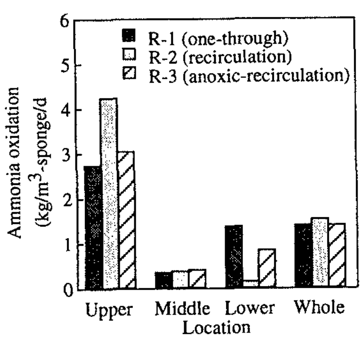

Fig. 2. Ammonia oxidation rates determined from nitrogen profiles using a synthetic wastewater

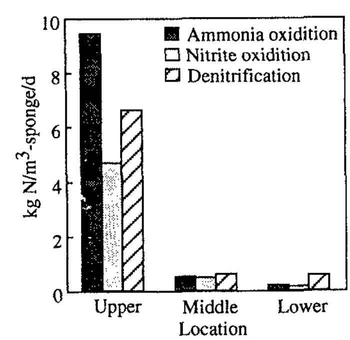

Fig. 3. Specific nitrogen conversion activity of the DHS R-2 sludge, determined from batch-tests

Fig. 4 shows DO profiles along the upper 50 cm distance from the inlet of the DHS reactor at two different flow rates. Although no forced aeration was provided to the DHS reactor, dissolved oxygen level increased from zero at the inlet (the UASB effluent) to 5 mg DO/l at 50 cm below from the inlet. Furthermore, it is noteworthy that the effluents from the three DHS reactors were all time kept at 7.2 - 7.5 mg DO/l (SD±0.6 mg DO/l) (Table 1).

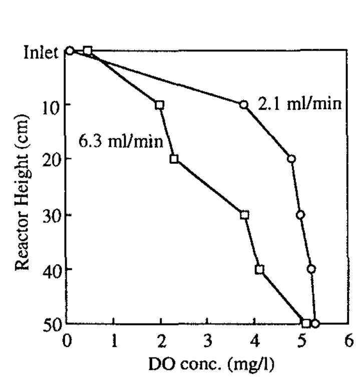

Fig. 4. DO profiles from the inlet down to 50 cm of DHS unit

Ref. Izarul Machdar et.al., (1997). Post Treatment of UASB Effluent by Downflow Hanging Sponge-cubes (DHS) Reactor. Proc.: *Japan Society on Water Environment*, Hokkaido, 1997. p9.