

High-rate Nitrification of Groundwater Contaminated with Ammonium Using a Novel Acryl-Resin Fiber for Biomass Attachment

○ Nguyen Hai Duong¹⁾, Leu Tho Bach¹⁾, Kenji Furukawa²⁾, Toichiro Koyama³⁾, and Tran Hieu Nhue⁴⁾

¹⁾ Graduate school of Science and Technology, Kumamoto University

²⁾ Department of Architecture and Civil engineering, Kumamoto University

³⁾ Networking of Engineering and Textile processing Co. Ltd., Japan

⁴⁾ Center for Environmental Engineering of Town and Industrial Areas, Vietnam

INTRODUCTION

Groundwater is used as the source for the public water supply system of Hanoi. However, in recent years ammonium contamination in the groundwater of Hanoi has become an increasing problem for water quality (Anderson *et al.*, 1998; HWBC, 2000; Takizawa *et al.*, 2001)

In this study, we focus on biological treatment of groundwater contaminated with ammonium and present the results of high-rate nitrification assays using a novel acryl-resin fiber material called Biofill (BL) as a biomass carrier

MATERIALS AND METHODS

Reactor description and operations

Fig. 1 shows the schematic diagram of the experimental system. Two strips of the BL material each with a one-sided surface area of 300×450 mm and a weight of 32.7 g were used as biomass carriers in this study. With a width of 15 mm, the BL strips had a total effective volume of $4.05 \times 10^{-3} \text{ m}^3$ and a bulk density of 16,000 g/m^3 . The BL strips were folded in to 4 layers and set symmetrically on two sides of the reactor using aluminum frames. The synthetic groundwater used in this study was prepared with the similar composition as the polluted groundwater of Hanoi and its' composition was as show in Table 1.

To determine the maximum acceptable ammonium loading capacity, the reactor was initially inoculated with 15 g of nitrifying activated sludge. This seed sludge completely attached to the BL materials within 2 hours of gentle aeration. The influent $\text{NH}_4\text{-N}$ concentration was maintained at 30 mg/L and the hydraulic retention time (HRT) was varied from 24h to 0.5 h by adjusting the influent flow rate. The reactor was operated in the dark at room temperature. Influent alkalinity and the pH of the reactor contents were regulated by addition of a NaHCO_3 solution. The flow rate of the air supply was 0.5~1.5 L air/ min.

Analyses

Flow rate, pH, DO and alkalinity were monitored every 2 days and SS, $\text{NH}_4\text{-N}$, $\text{NO}_3\text{-N}$ and $\text{NO}_2\text{-N}$ levels were determined in the effluent. The pH and DO were measured by using a Mettler Toledo-320 pH meter (Switzerland) and UC-12 Digital DO/ O_2 / Temp. Meter (TOA, Ltd., Japan), respectively. Analyses of $\text{NH}_4\text{-N}$, $\text{NO}_3\text{-N}$, $\text{NO}_2\text{-N}$, MLSS, SS and alkalinity were performed according to Japanese Industrial Standards (JIS, 1986).

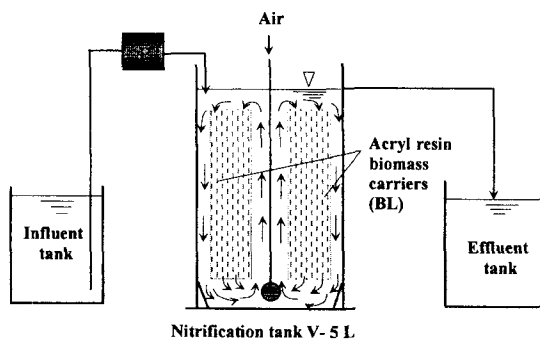


Figure 1. Schematic diagram of the experimental system.

Table1. Composition of the synthetic groundwater.

Composition	Concentration (mg/L)	Source
$\text{NH}_4\text{-N}$	30	NH_4Cl
$\text{NO}_3\text{-N}$	3.2	NaNO_3
TOC	3.2	$\text{C}_6\text{H}_{12}\text{O}_6$
SO_4^{2-}	2.8	tap water
SiO_2	30.9	tap water
Fe(II)	0~18	FeCl_2
Ca	25	$\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$
Mg	13	$\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$
Na	35	tap water
K	5.7	tap water
Alkalinity	100~250 (as CaCO_3)	NaHCO_3

RESULTS AND DISCUSSION

After attachment of sludge on the BL material, operation was started with an influent $\text{NH}_4\text{-N}$ concentration of 30 mg/L, iron of 18 mg/L, and alkalinity of 100 mg/L at a HRT of 24 hours. As shown in Fig. 2(c and d), the effluent $\text{NH}_4\text{-N}$ concentration was high with only 30% of influent $\text{NH}_4\text{-N}$ nitrified to $\text{NO}_3\text{-N}$ and the pH dropped to 4.7. This may have been because of the low influent alkalinity (100 mg/L, see Fig. 2(a)). The effluent iron concentration was close to 0 mg/L (data not shown) and the reactor was colored due to the precipitation of oxidized iron on the BL material. Subsequently, iron was eliminated from the influent and the alkalinity was increased to buffer the pH. After about 2 weeks more than 99% nitrification to $\text{NO}_3\text{-N}$ was obtained and effluent $\text{NO}_2\text{-N}$ concentrations were close to 0 mg/L (Fig. 2(c)). Thereafter, the nitrogen volumetric loading rate (VLR) was increased stepwise by decreasing the HRT to 0.5 hour. The alkalinity of the influent was also increased stepwise and then maintained at approximately 230 mg/L to achieve a pH of 7 ± 0.2 . As shown in Fig. 2(a, c and d), more than 95% nitrification efficiency occurred at each HRT. $\text{NO}_2\text{-N}$ concentrations of about 5–8 mg/L were observed in the effluent at a HRT of 1 hour, which may have been due to the high loading rate associated with the short HRTs.

To support the activity of nitrifying bacteria attached on BL material, the reactor was aerated at an air flow rate of 0.5 L air/min, by which stable nitrification was maintained until the HRT was lowered to 3 hours corresponding to a nitrogenous VLR of 0.25 g-N/L.d. As shown in Fig. 2 (b), further increases in VLR were associated with a decrease in DO, which caused the nitrifying activity to become unstable. At a HRT of 1 hour (VLR of 0.75 g-N/L.d), the DO concentration was decreased to 0.5 mg/L and the nitrification efficiency dropped to 88%. At this point, the airflow rate was increased to 1.5 L air/min (on day 234), after which the DO concentration and nitrification efficiency recovered to 1 mg/L and 95%, respectively.

Fig. 3 summarized the relationship between the nitrogen VLR and nitrification efficiency. As shown with use of acryl-resin fiber BL material, the reactor can maintain a high nitrification efficiency of more than 95% even when a short HRT of 1 hour corresponding to a VLR of 0.75 g-N/L.d.

CONCLUSIONS

Use of acryl-resin fiber BL material for nitrification treatment of $\text{NH}_4\text{-N}$ polluted groundwater was demonstrated. With an influent alkalinity of about 230 mg/L, at a HRT of 1 hour, the reactor was able to nitrify over 97.5% of 30 mg-N/L applied ammonium. Thus the use of BL material as a biomass attachment medium has demonstrated potential for nitrification treatment. Considering the ammonium contaminated groundwater of Hanoi, such a system can play an effective role in providing safe drinking water.

ACKNOWLEDGEMENTS

This study was supported by grants from the Environmental Science and Technology in the Core University Program between Japan Society for the Promotion of Science (JSPS) and National Center for Natural Science and Technology, Vietnam (NCST).

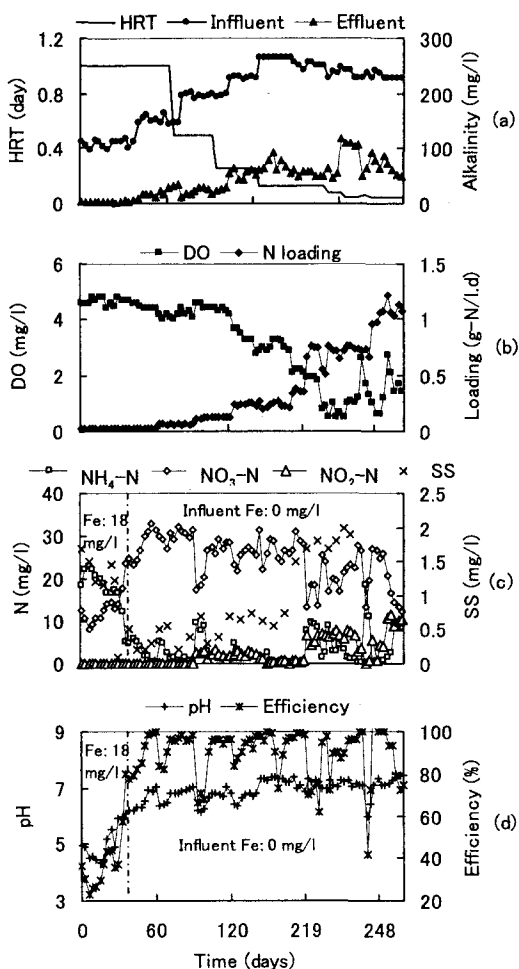


Figure 2. Time courses of
(a) HRT, influent, effluent alkalinity;
(b) DO, nitrogen loading rate;
(c) Effluent $\text{NH}_4\text{-N}$, $\text{NO}_2\text{-N}$, $\text{NO}_3\text{-N}$, SS;
(d) pH and nitrification efficiency.

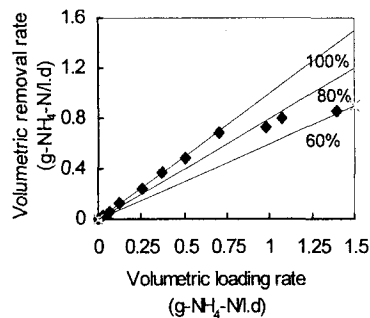


Figure 3. Relationships between ammonium loading and removal rates