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Email: tapchikhoahoc@hcmue.edu.vn; Website: http://tckh.hcmue.edu.vn

DETERMINATION THE AMMONIUM SEPARATING IN GROUND WATER BY USING POLYURETHANE-DERIVED CARRIER WITH MICROBIAL FILM TECHNIQUE

Tran Thi Kim Hoa, Huu Thi Ngan*, Dao Duy Khanh, Pham Vy Anh

Institue of Chemistry,Vietnam Academy of Science and Technology

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ABSTRACT

In order to determine the ammonium treating efficiency, several factors were investigated, including: carrier size and dimension, the volume of carrier, ammonium concentration… which impact on nitrification rate by two (02) techniques: moving and fixed bed microbial film. The results indicated that with moving bed microbial film technique, the best size and dimension of carrier is a cube with 1x1x1 cm, the content of carrier is of 20% in volume. However, fixed bed microbial film technique is favored by the cube of 2x2x2 cm carrier, the content of 50% in volume.

Keywords: ground water, ammonium, microbial film, moving bed, fixed bed, efficiency of carrier.

TÓM TẮT

Đánh giá khả năng tách loại amoni trong nước ngầm sử dụng vật liệu mang polyurethan bằng kĩ thuật màng vi sinh

Để đánh giá hiệu quả xử lí amoni chúng tôi nghiên cứu ảnh hưởng của một số thông số như: Kích thước vật liệu mang, phần trăm vật liệu mang, nồng độ amoni… lên tốc độ nitrat hóa theo hai phương pháp màng vi sinh tầng chuyển động và tầng tĩnh. Kết quả cho thấy với phương pháp màng vi sinh tầng chuyển động thì kích thước vật liệu mang tối ưu là hình lập phương 1x1x1 cm, phần trăm là 20% vật liệu mang theo thể tích. Nhưng với phương pháp tầng tĩnh thì ưu tiên kích thước lập phương 2x2x2 cm, phần trăm vật liệu mang theo thể tích là 50%.

Từ khóa: nước ngầm, amoni, màng sinh học, tầng chuyển động, tầng cố định, hiệu quả của chất mang.

1. Introduction

Ammonium pollution in Red River Delta is relatively popular, with intensity varying widely. Particularly in southern area of Hanoi, Ha Nam and Nam Dinh area, pollution level of ammonium in groundwater is relatively high, from trace level to 30 mgN/L [1]. Most of these areas is polluted by ammonium, in which some areas such as Phap Van, Dinh Cong, Ha Dinh, Tuong Mai… are intensively-polluted area. Areas with low-level pollution are Luong Yen, Yen Phu, Ngo Si Lien, Don Thuy. Intensively-polluted areas are located in

* Email: *huuthingan69@gmail.com*

southern of Hanoi, with the highest ammonium concentration of about 20 mgN/L are Phap Van Dinh, followed by Ha Dinh area (12 mgN/L), Tuong Mai (about 10 ngN/L) [2].

In present, 04 ammonium treatment methods are often chosen: Air stripping, chlorinating at break point, mircro-organism treating and ion exchange. In which, micro-organism is the most interesting [1]. Using a specific technical method is decided by considering the initial concentration of ammonium, available of technical aspect, cost of treatment operating (both of investing and maintance), as well as quality controllable of effluent.

In this paper, moving-bed and fixed-bed biofilm technique using microorganism carrier are investigated.

2. Methods, Materials and Experiments

2.1. Experiment set-up

The initial ammonium concentrations are diluted with ammonium-free tap water to achieve the desired concentrations. The requirement compositions such as, phosphorus, alkaline are added in order to remain the activity of microorganism. The phosporous in form of KH_2PO_4 is added to achieve concentration ratio of P : N = 0.2; the alkaline, which is in form of $NaHCO_3$, has the concentration of 100 + 7.14 x S_{N-NH4} ($mgCaCO_3/L$) [6]. All experiments are implemented in ambient temperature of about 28 – 30 ^oC; pH of 7.5 – 8.5; DO concentration of 2.5-3.5 mg/L; effluent alkalinity of about 100 $mgCaCO_3/L$.

Carrier used is polyurethane (PU) with density of 28 kg/m^3, cubic dimension with commercial name as MBC. In these experiments, cubic dimensional size of carrier is 1; 1.5 and 2 cm, respectively. Figure 1 illustrates the carrier with different sizes.

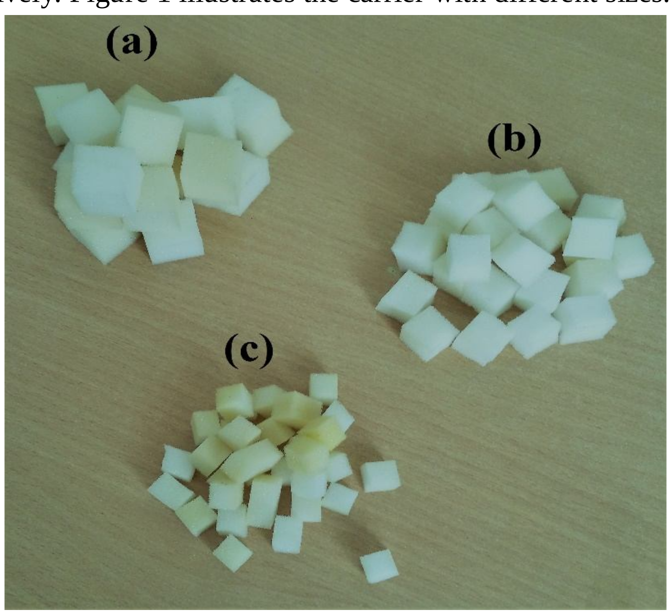

Figure 1. *The microbial carrier with difference size: (a) 2 cm; (b) 1.5 cm; (c) 1 cm*

Moving-bed biofilm reactor (MBBR), as illustrated in Figure 2a, includes 02 plastic tanks with loading volume of 6 L for each. Fix-bed biofilm reactor (FBBR), as illustrated in Fig. 2b, is a column with dimension of: diameter x height = 160 x 1000 mm. The microbial carrier fill up the reactor with different ratio. In fixed-bed reactor, the carrier is packed in a layer of 800 mm, creating a fixed media of carrier.

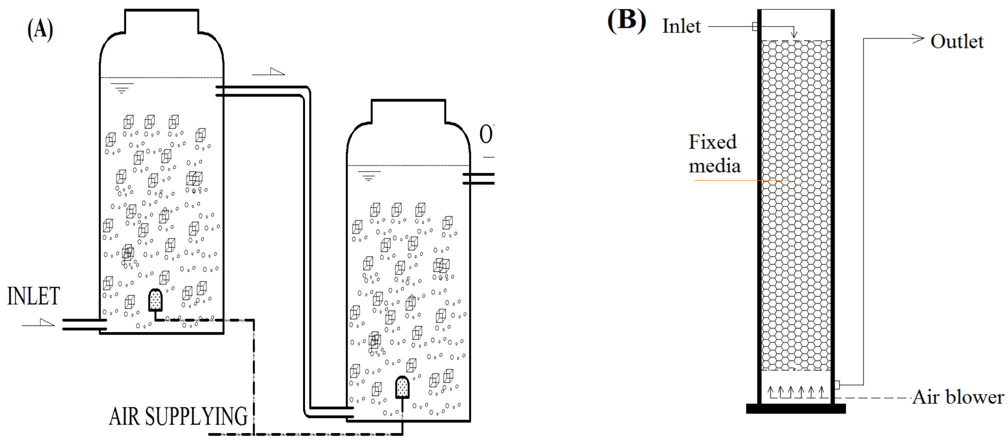

Figure 2. *The diagram of (a) moving-bed biofilm reactor and (b) fixed-bed biofilm reactor*

Airflow is supplied from the bottom of tanks in order to not only supply sufficient oxygen for microorganism activity but also mobilize the carrier (for moving-bed technique). The influent flowrate of both reactors is adjusted by dosing pump system. The samples are collected at the outlet of reactors and analyzed some factors such as: NH_4^+-N, NO_2^--N, NO_3^--N, alkalinity, pH… The analysis methods are implemented according to the reference [3]. The experiments condition implemented are described in Table 1. The experiment investigating the effect of carrier ratio, influent ammonium concentration and carrier size, namely TN1, TN2 and TN3, respectively, have implementing conditions described in Table 1.

Table 1. *The condition of different experiments*

	Carrier ratio (%)	**Carrier cube size (cm)**	**Initial ammonium concentration (mgN/L)**
MBBR			
TN1	10-30	2	20
TN2	20	2	5-30
TN3	20	1-2	20
FBBR			
TN1	30 - 60	1	20
TN2	50	1	5-30
TN3	50	1-2	20

3. Results and discussions

3.1. Effect of carrier ratio

Increasing the ratio of carrier is equivalent to the increasing of biomass content in the reactor. Assuming that carrier size is relatively even, if the volume increases, the biomass will proportionally turn up. Therefore, reacting rate will be intensified theoretically. However, the practical reaction is different.

The results showed in Table 2 indicated that, in case of increasing of carrier ratio, nitrification rate also turns up, but inproportionally. Ammonium oxidizing rate depends on not only biomass density in the reactor (carrier density in this case), but also substrate supplying capability from outer environment. When the density of carrier is relatively low, the moving ability is higher, which leads to transport the substrate easier, and vice versa. Moreover, increasing of carrier density causes the raising of substrate demand. However, the actual supplying capability is insufficient, leading to the decreasing of micro-organism activity [5]. The inproportionally increasing of nitrification rate should be explained by the aforementioned reasons.

The nitrification rate at carrier ratio of 50 % is used as standard for comparing the results in the fixed-bed technique. It is showed that the increase of carrier ratio results the raise of nitrification rate, but nonlinearly. The highest nitrification rate at carrier ratio of 60 % is practically 1.15 times higher than one at the ratio of 50 %. At the ratio of 30 % and 40 %, the nitrification rate is higher than one at the ratio of 50 %, however, the carrier is able to mobilize in the reactor, which relates to the moving-bed technique. Therefore, the most favorable carrier ratio is 50 %.

Table 2*. Effect of carrier ratio to ammonium treatment*

The ratio of carrier (%)	Relative ammonium treatment rate (%)
MBBR	
10	62
15	81
20	100
30	127
FBBR	
30	70
40	85
50	100
60	115

3.2. Effect of ammonium concentration

The results showed in Table 3 illustrate the effect of ammonium treatment with various concentrations of ammonium. In order to achieve the discharge standard for ammonium (concentration of $N\text{-}NH_4 < 3$ mgN/L) in accordance with QCVN 01:2009 BYT, the fixed-bed technique has more advantage than the moving-bed technique at the same initial concentration of ammonium in terms of efficiency. However, the increasing amount of carrier results in the more expensive in terms of economy. Therefore, it should be taken in consideration of choosing the type of reactor for different initial ammonium concentrations. For low-level polluted groundwater, the moving-bed technique is more favorable and the fixed-bed technique is the best choice for high-level polluted sources (concentration of ammonium is higher than 20 mgN/L).

Table 3. *Ammonium treatment efficiency at the different initial concentrations*

Initial concentration of ammonium (mgN/L)	Effluent concentration of ammonium (mgN/L)	Efficiency (%)
MBBR		
5.9	2.2	65
10.2	2.1	79
20.7	2.5	88
25.5	2.7	89
30.4	2.8	91
FBBR		
5.2	2.0	62
9.8	1.6	84
20.6	2.6	87
25.7	2.8	89
30.6	2.8	91

3.3. Effect of carrier size

Carrier dimensional size relates to mass transferring process of nutrient, oxygen from ambient media to the inside of carrier, which causes different biochemical conditions inside a certain volume of carrier. These conditions include oxic condition at the outside of the film, followed by the anoxic and the last is anaerobic condition. Because of various conditions within a volume of carrier, there are many processes implementing. Denitrification is able to happen even in oxic condition, relatively significant in case of using porous carrier, because oxygen-lacking and nitrate-abundant condition dominates in the inner space of carrier or film. This is the result of diffusion efficiency of oxygen is about 5 times less than one of nitrate in aqua environment. Therefore, the deeper into the inside of the carrier or film, the more favorable the denitrification is. The experiments are implemented with the following conditions: pH of about 8.1 – 8.3; DO of 3.5 – 4.0 mg/L; NH4 – N of 20 mg/L, carrier ratio of 20 % and 50 % for moving-bed and fixed bed technique, respectively.

The results showed in Table 3 indicate the change of nitrification and denitrification efficiency in case of the increase of carrier dimensional size. In general, the efficiency of the nitrification increases while one of the denitrification decrease when the dimensional size of carrier raises for both of moving-bed and fixed-bed technique [4]. For example, in moving-bed reactor, the highest efficiency of the nitrification of about 95 % is achieved at the cubic dimensional size of 1cm, while the lowest of about 82 % occurs at the size of 2 cm. However, for the denitrification, the highest efficiency of about 17% comes up at the size of 2 cm and the lowest of about 14 % arises at the size of 1 cm. This could be explained that the increase of dimensional size produces the rise of proportional of anoxic condition volume compared to the oxic condition volume while the total volume of both conditions is stable. This promotes the denitrification while inhibits the nitrification. This should be notified that the efficiency of the denitrification reaches 45 % at size of 2cm when using fixed-bed reactor. This could be the prove for the effective of the fix-bed technique for the denitrification.

Table 3. *Effect of the size of the carrier to the efficiency of nitrification and denitrification with retention time of 2h*

Cubic dimensional size (cm)	Nitrification efficiency (%)	Denitrification efficiency (%)
MBBR		
1	95	14
1.5	87	15
2	82	17
FBBR		
1	97	39
1.5	91	41
2	87	45

4. Conclusions

The effect of carrier ratio and size, initial ammonium concentration to treating efficiency of ammonium in groundwater using fixed-bed and moving-bed biofilm techniques is investigated. The following results are highlighted:

- Increasing of carrier ratio causes the raising of nitrification rate inproportionally. The results indicated that the acceptance of lower efficiency for each carrier unit when increase the ratio.

- The larger size of carrier is, the lower nitrification efficiency is but the higher denitrification efficiency is.
- Fixed-bed technique is more advantage about ammonium treatment than the moving-bed one, particularly in the case of initial ammonium concentration reaching more than 20 mgN/L .
- In both techniques, the denitrification efficiency reaches the highest when using the carrier with a dimensional size of 2 cm cube; while the highest of nitrification efficiency are achieved with the carrier size of 1 cm cube.

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