Simultaneous ammonia removal & regeneration air stripping system using high strength regenerant: preliminary system evaluation

Maghfiroh, Miratul*,***, Na-Ri Park*, Hyang-Yeon Chang*, Yeo-Ju Jang*, Hyun-Man Lim**, Kwang-Ho Ahn**, Jin-Hong Jung**, Sang-Hoon Ji**, Weon-Jae Kim**
*University of Science and Technology, KICT School, Republic of Korea
**Korea Institute of Civil Engineering and Building Technology, Republic of Korea
***Research Center for Limnology, Indonesian Institute of Sciences, Indonesia
e-mail: wjkim1@kict.re.kr

고강도 재생액을 이용한 일체형 암모니아 제거·재생 스트리핑 시스템: 예비시스템 평가

미라툴 매크피로*,***, 박나리*, 장향연*, 장여주*, 임현만**, 안광호**, 정진홍**, 지상훈**, 김원재**
*과학기술연합대학원대학교 건설환경공학
**한국건설기술연구원 국토보전연구본부 환경자원재생연구센터
***호수연구센터, 인도네시아과학연구원

요 약

Removal of nitrogen from water resources becomes indispensable since the excessive accumulation of nitrogen is allegedly associated with concerning environmental issues. Treating wastewater or water containing ammonium loads, therefore, is one of the means for securing environmental sustainability. Ion exchange using natural zeolites can be promising alternative to remove ammonium ions from wastewater or polluted water. In ion exchange loop stripping configuration, ion exchange and simultaneous air stripping technique are combined together. Relative cost for operation an investment are comparatively lessened. In this study, we carried out preliminary experiment to evaluate the feasibility of simultaneous ammonia removal & regeneration - air stripping method using high strength regenerant in ion exchange loop stripping configuration. Our findings showed that ammonium removal was 82% after 3 hours. This indicated potential application of simultaneous air stripping system to exhibit better performance for ammonium removal. Simultaneous air stripping can be used with high strength regenerant and our findings agreed with the study done with aeration type for air stripping method. Simultaneous air stripping significantly reduced the amounts of residual ammonium in the zeolites and provided higher rates of ammonia recovery.

1. Introduction

Removal of nitrogen from water resources becomes indispensable since the excessive accumulation of nitrogen is allegedly associated with concerning environmental issues [4],[5] such as eutrophication [1] and algal bloom [9]. The generation of excessive nitrogen can be introduced by various anthropogenic activities including from agricultural, urbanization and industrialization [3],[8].

The reduced form of nitrogen i.e. ammonium is one of the chemical species contributing in nitrogen loads in the environment. Ammonium loads can be supplied into the environment from animal agriculture, fertilizer (hydrolysis of urea), and aquaculture (aquatic excrements and excess fish feeds) [1].

Treating wastewater or water containing ammonium loads, therefore, is one of the means for securing environmental sustainability. Ion exchange using natural zeolites can be promising alternative to remove ammonium ions from wastewater or polluted water. Natural zeolites offer advantages as compared to other techniques for removing ammonium. They are cheap, abundantly available and relatively uncomplicated to maintain operationally [7].

Regeneration of natural zeolites is needed when zeolites get saturated and there is necessity to reuse zeolites for the coming cycles. By reusing zeolites, the operation can be cost effective and more environmentally friendly. There are some methods in regenerating zeolites. It can be (1) chemical and (2) biological regeneration. In chemical regeneration, NaCl or $NaNO_3$ is usually used. Salts are commonly selected as regenerant since they are abundant and relatively cheap. Once the excess sodium solutions pass through the zeolite bed, sodium ions replace the ammonium ions bound at the active sites inside the zeolite structures [6]. After being regenerated, zeolites are ready for another cycle for ammonium adsorption.

In ion exchange loop stripping configuration, ion exchange and simultaneous air stripping technique are combined together. Relative cost for operation and investment are comparatively lessened as compared to conventional air - stripping technique since lower energy and size reduction of stripping column are possible [2].

In this study, we carried out preliminary experiment to evaluate the feasibility of simultaneous regeneration-air stripping method using high strength regenerant in ion exchange loop stripping configuration. Our preliminary data derived from this experiment favors the direction in optimizing the operation of pilot scale for ammonium removal and recovery in wastewater i.e. greywater.

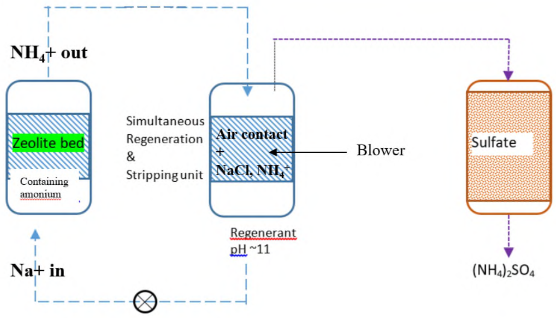
2. Methods

2.1 Ammonium adsorption via batch test

In order to provide zeolites that contain ammonium, batch test was prepared. Approximately 200 mg in 4 liter of ammonium chloride solutions were prepared so that ammonium was, then, loaded into 200 grams of zeolites within 24 hours of batch test. Zeolites were subsequently dried overnight and weighed prior to being transferred into the column.

2.2 Ion exchange loop stripping experiment

Prepared zeolites were packed in column. The schematic set up of ion exchange loop stripping was described in Figure 1 below.



[Fig. 1] Schematic set-up of ion exchange loop stripping configuration

During the run, 200 grams of zeolites containing 200 mg ammonium were regenerated using sodium chloride 4 Molar in 4 Liters and afterwards, ammonium accumulated in the container was simultaneously air stripped using air-blower (100 L/min). 0.5 M of Sulfate was prepared to react with stripped ammonia (gas) so that final reaction produced $(NH_4)_2SO_4$.

The amount of remaining ammonium was measured spectrophotometrically every hour while the experiment lasted in 3 hours. Observations were recorded and feasibility of the system was evaluated.

$$Ammonia\ removal\ (\%) = \frac{(200\ mg - ammonium\ conc.\ in\ 1\ L\ solution)}{200\ mg}\ x\ 100\%$$

3. Results

In our experiment, zeolites containing ammonium were regenerated first using sodium chloride. Ion exchange occurred so that ammonium ions were released in exchange to sodium ions. The exchange of ions was facilitated by high concentration of sodium in the system. Ammonium ions were, then, accumulated in the “simultaneous unit” in which, at the time, ammonia would be stripped simultaneously using air blowing apparatus. Ammonia gas generated was then transferred to “ammonia recovery unit”. In the end of the process, $(NH_4)_2SO_4$ was produced.

The blower was turned on after 15 min run of regeneration to make sure that ammonium started accumulating in regeneration solutions which we noticed that NH_4 concentration was 109.08 mg in 4 L regenerant solution (Table 1). After 3 hours, ammonium detected in regenerant solutions was 30.05 mg/4 L, and the remaining ammonium in 200 g zeolites was 4.96 mg/L. This preliminary test showed that simultaneous regeneration & air stripping was feasible (applicable), however, it still needs more validation and modifications for optimal performance. By using the combination of 4 M 4 L salt + pH 11 + air blower for 3 hours, ammonia removal from zeolites could be achieved c.a ~82%. Since the remaining ammonium in the zeolites was only 4.96 mg in 200 g, this suggested better regeneration performance than that of using 4 M 8 L salts alone which left ammonium in 200 g zeolites around 22.7 mg after 24 hours (data not shown).

Our preliminary data showed that simultaneous air stripping can be used with high strength regenerant and our findings agreed with the study done in simultaneous system with aeration type for air stripping method [2]. Simultaneous air stripping significantly reduced the amounts of residual ammonium in the zeolites and provided higher rates of ammonia recovery [2].

[Table 1] Ammonium concentration during the experiment

Time	Ammonium conc. (mg) in 4 L regenerant
15 min	109.08
1 hour	52.80
2 hour	32.06
3 hour	30.05

In regards to our next experiment, we move forward with different apparatus for air stripping unit. In our different preliminary experiment (detailed data not shown), air stripping using aerocyclone type unit gave higher ammonium removal efficiency (97%) as compared to using air blower unit (70%).

4. Conclusions

We demonstrated preliminary experiment on simultaneous air stripping and evaluated the feasibility using high strength regenerant. Our findings showed that ammonium removal was 82% after 3 hours. This indicated potential application of simultaneous air stripping system to exhibit better performance for ammonium removal.

5. Acknowledgement

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