REMOVAL OF COD AND AMMONIUM FROM LANDFILL LEACHATE BY USING A MODIFIED ECO – BIO – BLOCK MATERIAL IN ANOXIC-OXIC SYSTEM

Hoang Luong*, Trinh Van Tuyen, Tang Thi Chinh, Dang Thanh Tu

Institute of Environmental Technology, VAST, 18 Hoang Quoc Viet Road, Hanoi, Vietnam

Email: independenthanoivn@yahoo.com

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ABSTRACT

The research on removal efficiencies of COD and NH₄⁺ in landfill leachate by an application of the modified Eco - Bio - Block (EBB) material in Anoxic-Oxic (A-O) system was conducted in the laboratory scale. The experimental results showed that the treatment efficiencies of COD and NH₄⁺ were relatively high. Removal efficiencies of COD and NH₄⁺ in two columns (anoxic and oxic) were 35% and 50%, respectively, after 19-hour in the experimental system at the flow rate of 1 liter per hour. The results of this study might suggest technical solutions toward landfill leachate treatment at the low cost. Moreover, this method could be widely applied to other wastewater sources suitable in the condition of Vietnam.

Keywords: Eco - Bio - Block, Modified EBB, Bacillus natto, A-O system.

1. INTRODUCTION

Currently, the leachate from the landfill site is an alarming issue in the big cities in Vietnam. Although many researches and applications were carried out to deal with the landfill leachate most of treatment plants did not met the environmental emission standard of Vietnam (type B for the target COD and ammonium in QCVN 25-2009/BTNMT that are lower 300 mg/L and 25 mg/L, respectively, after discharge).

The main reasons for low treatment efficiency are the high content of persistent organic matter that is slowly biodegradable and the high loading of total nitrogen in the landfill leachate. Consequently, COD and total nitrogen content of the landfill leachate after biological treatment are often from 400 to 500 mg/L (mostly calcitrant COD) and approximately 100 mg/L, respectively [1].

EBB technology developed in Japan is based on the porous stones from volcano lava, with Bacillus natto found inside, capable to support polluted water treatment [2, 3]. The modified EBB material has been investigated and produced from different environmental friendly materials such as carbonized product and bio-charcoal from solid waste, zeolite and kazemzit. The improved material is capable to inhibit harmful bacteria, produce cleaner water and reduce odors significantly. Besides of the ability adsorption and absorption the modified EBB products
also sustain microorganisms capable to actively decompose organic substances and nutrients in domestic wastewater [4]. In this study, we have introduced the modified EBB material that possesses highly active properties to treat landfill leachate in order to improve the treatment efficiencies of COD and NH$_4^+$. 

2. MATERIALS AND METHODS

2.1. Materials

In this study the landfill leachate collected from Da Mai Landfill site in Thai Nguyen province was used. The contents and characteristics of the leachate were shown in Table 1.

| No. | Parameter | Unit | Da Mai Landfill |
|-----|-----------|------|-----------------|
| 1   | Color     | Pt/Co| 2.125 - 2.425   |
| 2   | COD       | mg/l | 2.745 - 2.870   |
| 3   | NH$_4^+$  | mg/l | 150 - 250       |
| 4   | NO$_3^-$  | mg/l | 3.47            |
| 5   | NO$_2^-$  | mg/l | 0.409           |
| 6   | BOD$_5$   | mg/l | 825-870         |
| 7   | SS        | mg/l | 4.000-15.000    |

The modified EBB material with a porosity of 30% was produced to have compressive strength of 2.3 N/mm$^2$ and surface area reached to 180 - 200 m$^2$/gr each EBB unit. In this study, Sagi - Bio preparation, manufactured by the Institute of Environmental Technology, was selected. It contains the Bacillus, Lactobacillus and Saccharomyces, and has density of useful microorganisms over $10^8$ CFU/ml [5].

The increase of efficiency of modified EBB material and saving startup time of the processing system, the modified EBBs were put into inoculated basin of capacity of 50 liters of water. There was a pump for mixing in the basin, in order to increase efficiency and microbial growth and adhesion. To the basin 50 ml liquid Sagi - Bio preparation with microbe density of $10^8$ CFU/ml were added together with supplement foods for microorganisms in the COD : N : P rate of 250 : 5 : 1. Anoxic and aerobic microbial densities reached to $1.6 \times 10^5$ CFU/gr and $3.7 \times 10^7$ CFU/gr after 10 days of inoculation [6].

2.2. Experiments

The concentrations of input COD and NH$_4^+$ were controlled from 700 to 1600 mg/L and from 20 mg/L to 50 mg/L, respectively. The leachate was pumped from storage tank 1 (Fig.1) to Anoxic column 3 by controlled pump 2. In anoxic conditions, anoxic microbial population was grown as described above to remove Nitrogen and Phosphor through nitrification and phosphorylation, respectively. By the high level of water, the leachate was overflowed to oxic column 4 where aerobic microorganisms grew. In oxic column, the oxidation and organic matter decomposition were the synthesis of new cells and endogenous decomposition processes. Oxygen in oxic column was supplied by air pump 5. The modified EBB material, which was installed in the anoxic and oxic columns, acted as habitat for anoxic and aerobic bacteria to adhere, survive, grow and degrade polluted components in the leachate.
Removal of cod and ammonium from landfill leachate by using a modified...

![Diagram of laboratory system](image)

**Figure 1.** Diagram of laboratory system.

The experimental system for the leachate treatment was designed by the basic parameters of the leachate composition as COD and NH$_4^+$.$\text{The anoxic and oxic columns were made from the PVC plastic pipe and the volume of each column was approximately } 9.3 \text{ L, in which the length was } 700 \text{ mm and the diameter of the pipe was } 130 \text{ mm. Air was continuously supplied into aerobic column by the flow rate of } 90 \text{ L/min.} \text{The COD and NH}_4^+ \text{ parameters were daily measured in anoxic and oxic columns. The experiment was conducted in 3 phases with the flow rates of } 0.25 \text{ L/hr, } 0.5 \text{ L/hr and } 1 \text{ L/hr.} \text{NH}_4^+ \text{ was measured by sodium nitroprusiat method used spectrophotometer at } 655 \text{ nm by UV-VIS Spectrophotometer 2450 (Shimazu, Japan). The COD parameter was measured by Bicromate method used } \text{K}_2\text{Cr}_2\text{O}_7 \text{ as oxidation agent } [7].$

3. RESULTS AND DISCUSSION

3.1. COD removal efficiency

The COD concentration in the leachate before and after treatment was monitored in 60 days and the results were described in Figure 2. At the first phase, the flow rate was 0.25 L/hr, hydraulic retention time (HRT) was 74.4 hours and the input COD concentration was from 600 mg/L to 1200 mg/L. The average removal
efficiency of COD was relatively high (about 80 %) with the highest efficiency of 90 %. In the phase 2, the flow rate was 0.5 L/hr, HRT was 37.2 hours and input COD concentration was from 600 mg/L and 1300 mg/L. The COD average removal efficiency in this phase was also about 65 %.

The reduction of retention time and high loading of input COD showed that COD removal efficiency ranged from 55 % to 60 % with a HRT of 18.6 hours as at phase 3. In previous study, Van et al. (2012) used coagulation process to remove COD from landfill leachate and obtained 30 % removal efficiency [8]. Our study suggested more efficient method for the removal of COD from landfill leachate.

### 3.2. Ammonium removal efficiency

Figure 3 shows that the NH$_4^+$ treatment efficiency decreased from phase 1 to phase 3. In phase 1, the concentration of NH$_4^+$ input was from 25 mg/L to 45 mg/L, the average treatment efficiency was about 80 %. At the phases 2 and 3, NH$_4^+$ input sometimes reached to 55 mg/L and NH$_4^+$ treatment efficiencies were about 50 % and 70 %, respectively. The trend of NH$_4^+$ removal efficiency showed an opposite trend with the loading of NH$_4^+$ input.

Tang et al.(2012) reported that microorganism in Bio - Sagi preparation reduced 30 % NH$_3$ from pig manures, suggesting that the Bio - Sagi preparation assimilates the ammonium [9]. In this study, our experiment confirmed the Bio - Sagi microorganism dwelled in the EBB and reduced about 50 – 70 % of ammonium.

### 4. CONCLUSIONS

The ability of the COD and NH$_4^+$ removal from the leachate by the modified EBB has been investigated. The input COD and NH$_4^+$ were in the ranges from 600 mg/L – 1500 mg/L and 25 mg/L – 90 mg/L, respectively, the input flow rates from phase 1 to phase 3 increased from 0.25 L/hr to 1 L/hr and HRT were 74.4 hr, 37.2 hr and 18.6 hr. The experimental results showed that high efficiencies for COD and NH$_4^+$ removal have been achieved (50 % - 90 %) and modified EBB applied in A-O system have shown effectiveness to remove COD and NH$_4^+$ from the leachate. Further experiments should be conducted to reveal deeper mechanism inside the treatment process such as the effect of pH and temperature parameters on the treatment process and the strains dominated in microbial community in the modified EBB.

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