Influence of Nitrate Loading on Leachate During the Stabilization of Fresh Refuse

Jing-Han GUO$^{1,2,a}$, Xiao-Jie SUN$^{1,2,b,*}$, Hong-Xia ZHANG$^{1,2,c}$, Pan-Fei XIAO$^{1,2,d}$ and Xiao-Xiao HU$^{1,2,e}$

$^1$Guangxi Key Laboratory of Environmental Pollution Control Theory and Technology, Guilin University of Technology, Guilin 541004, China
$^2$Guangxi Collaborative Innovation Center for Water Pollution Control and Water Safety in Karst Area, Guilin University of Technology, Guilin 541004, China
$^a$ysulirengjh@163.com, $^b$sunxiaojie@glut.edu.cn, $^c$1287328680@qq.com, $^d$1192178777@qq.com, $^e$2077963114@qq.com

*Corresponding author

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Abstract. In this experiment, the change of nitrate loading on the leachate quality during the stabilization of fresh refuse was studied by controlling the nitrate concentration. The results showed that the nitrate loading in leachate had a certain influence on the quality of leachate in the stabilization of fresh refuse. At the end of the experiment, the pH value of the leachate in each reactor reached or nearly 7.00. The ORP of each reactor was very low and similar.

Introduction

The research of bioreactor landfill technology, which aims to maximize the use of limited landfill capacity, the implementation of the source of leachate pollution control, and the active control from the previous passive management, etc. [1,2]. Anaerobic bioreactor landfill technology, is based on the original sanitary landfill addition to a set of leachate recharge system to accelerate refuse degradation. Previous studies have shown that the stabilization of fresh refuse is greatly influenced by the recharge method, pH, VFA concentration, aeration frequency and pressure of recharge leachate. In the 1970s, Pohland simulated the leachate situ recharging into the refuse heap under laboratory conditions and the experiments showed that the leachate recirculation greatly promoted the stabilization of the refuse [3,4]. Shao Liming’s research showed that the leachate pH and VFA concentration affected the initial methane production process of landfill [5]. Jiang Juan studied the effect of alkalinity on the stabilization of fresh refuse, that was, adding alkalinity to the leachate. The results showed that the addition of alkalinity to the leachate in the landfill bioreactor could not only buffer the pH, decreased the COD, BOD$_3$ and VFA of the leachate, but also could make the landfill system to accelerated the process of methanation to improved gas production, landfill system tended to stabilize the state [6]. Li Qibin and Liu Dan adjusted the pH of leachate through the addition of some chemical substances. The results showed that kept the pH of leachate above 8.0, and improved the frequency of recharge could make refuse layer acidification stage with shorter time [7]. In this study, nitrification leachate was simulated by recharging to study the effect of different nitrate loading on the quality of leachate during the stabilization of fresh refuse.

Materials and Methods

Composition and Source of Refuse

The fresh refuse used in the experiment was man-made. The composition of fresh refuse was as follows: plastics, 10%; leftovers, 15%; leaves and branches, 15%; waste paper, 10%; watermelon rind, 30%; soil, 20%. Refuse was manually crushed before filling in order to maintain its particle
size of about 1 cm. The physical and chemical properties of the manually disposed fresh refuse are shown in Table 1.

Table 1. Fresh refuse basic physical and chemical properties.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Water content</th>
<th>Total nitrogen</th>
<th>Organic matter</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>70%</td>
<td>6.13 g/kg</td>
<td>30.6%</td>
<td>5.89</td>
</tr>
</tbody>
</table>

Composition and Source of Nitrified Leachate in Recharge

The nitrified leachate was simulated by artificial simulation. The concentration of nitrate in each reactor was controlled using sodium nitrate, the concentration of COD in each reactor was controlled using glucose. The basic physical and chemical properties of nitrified leachate in recharge were shown in Table 2.

Table 2. Nitrified leachate in recharge control indicators.

<table>
<thead>
<tr>
<th>Reactor</th>
<th>Nitrate concentration (mg/L)</th>
<th>Nitrate loading (mg/kg·d)</th>
<th>COD concentration (mg/L)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0</td>
<td>0</td>
<td>1060-1065</td>
<td>6.8-7.2</td>
</tr>
<tr>
<td>B</td>
<td>100</td>
<td>5</td>
<td>1060-1071</td>
<td>6.8-7.2</td>
</tr>
<tr>
<td>C</td>
<td>300</td>
<td>15</td>
<td>1060-1068</td>
<td>6.8-7.2</td>
</tr>
<tr>
<td>D</td>
<td>500</td>
<td>25</td>
<td>1060-1078</td>
<td>6.8-7.2</td>
</tr>
<tr>
<td>E</td>
<td>700</td>
<td>35</td>
<td>1060-1075</td>
<td>6.8-7.2</td>
</tr>
<tr>
<td>F</td>
<td>1000</td>
<td>50</td>
<td>1060-1072</td>
<td>6.8-7.2</td>
</tr>
</tbody>
</table>

Experimental Device and Operation

The main experimental device in this study was six sets of the same size of PVC cylindrical fresh refuse reactor, respectively named reactor A, reactor B, reactor C, reactor D, reactor E and reactor F. The structure and size of the reactor were as follows: the height of the column was 60 cm, and the column diameter was 6 cm. The top of the column was provided with a water inlet and a gas gathering device, and the bottom was provided with a water outlet. The water inlet was sealed with rubber gasket, and the diameter of the outlet is 0.3 cm. The top of the water outlet was filled with 15 cm high gravel. The gravel had a grain size of about 2 cm. The gravel played a major role in supporting and retaining water. The upper part of the gravel layer was fresh refuse landfill layer. The loading height of all six reactors was 35 cm and the filling quality was about 0.5 kg. Schematic diagram of the device was shown in Fig. 1.

![Figure 1. Device schematic diagram.](image-url)
After the six sets of reactors were charged with fresh refuse, the reactor was placed in a constant temperature incubator at an incubator temperature of 30°C. In this experiment, water inlet and outlet were used by syringes. The influent water of the reactor was 0.05 L/(kg d), and the reactor was drained before recharging.

**Monitoring Indicators and Methods**

During the operation of the reactor, the water samples were taken every five days and monitored for water quality, including VFA, TP, pH, ORP and EC. Among them, VFA measured according with acid hexanediol spectrophotometry (principle and application of anaerobic biological technology (Ren Nanqi)), the TP was performed in accordance with GB 11893-1989, the pH test was done in accordance with CJ/T 428-2013, the ORP was determined in accordance with CJ/T 428-2013 and the EC was determined in accordance with conductivity meter (water and wastewater detection and analysis methods (4th edition)).

**Results and Discussion**

**Effect of Nitrate Loading on VFA in Leachate**

As shown in Fig. 2, the concentration of VFA in reactors A, B, C, D and E increased from 14.73 mg/L, 14.50 mg/L, 14.26 mg/L, 15.11 mg/L to 15.08 mg/L, 18.43 mg/L, 18.09 mg/L, 17.43 mg/L and 18.37 mg/L, respectively. After a sharp decline, in the process of the 15th day of the experiment fell to a certain value and then gradually increased. Reactors A, B, D and E increased to 12.29 mg/L, 17.49 mg/L, 12.61 mg/L, 14.71 mg/L on the 25th day of the experiment. After that there had been several fluctuations but the overall was downward trend. The VFA concentration in the reactor C began a sharp decline in the process after rising. The VFA concentration of reactor C increased slowly from day 30 of the experiment to 8.63 mg/L on the 50th day of the experiment, and then entered a phase of continuous reduction. The VFA concentration of the reactor F reached a high level at the beginning of the experiment. The next rule was similar to the VFA concentration in the reactor D.

![Figure 2. The change trend of each reactor VFA concentration.](image-url)
Effect of Nitrate Loading on TP in Leachate

As shown in Fig. 3, the concentrations of TP in the six reactors were similar. They first experienced a sharp increase in the experiment, followed by a sharp decline, and then after entered the relatively gentle changes. Comparison of TP concentration of six reactors can be found that the concentration of TP in reactor C was the highest and the concentration of TP in reactor A was the lowest during most of the experiment. The following general rule was exhibited: reactor C > reactor B > reactor D > reactor E > reactor F > reactor A.

Effect of Nitrate Loading on PH in Leachate

As shown in Fig. 4, comparing the change of the pH in leachate of each reactor could be found that the pH of reactor A was always lower than the pH of the other reactors except for a few points above 7.00. The pH of each reactor showed the following regularity: reactor E > reactor F > reactor D > reactor C > reactor B > reactor A.
Effect of Nitrate Loading on ORP in Leachate

ORP is oxidation-reduction potential, mainly used to characterize the relative degree of oxidative reduction of the medium, but also reflects the composition of the compound in the medium, dissolved oxygen and other differences [8]. As shown in Fig. 5, the change of ORP on six reactors were basically the same, first to a certain extent, then to a steep decrease. At the end of the experiment, the ORP were stable at -300, -329, 310, -310, -320, and -300. The dissolved oxygen in nitrified leachate in recharge was at a low level, the reactor was operated with anaerobic loading and the ORP of each reactor was similar. Therefore, the composition of the compounds contained there should also be relatively close.

Effect of Nitrate Loading on EC in Leachate

As shown in Fig. 6, the change of EC of the six reactors was similar. After initial fluctuation, they reached a certain value, the EC of the six reactors rised sharply, and finally became stable in the fluctuation. At the end of the experiment, the EC of each reactor was maintained at 90.00 us/cm, 300.00 us/cm, 550.00 us/cm, 600.00 us/cm, 850.00 us/cm and 1100.00 us/cm.

The change law of the EC of the reactors in each group can be found that reactor F> reactor E> reactor D> reactor C> reactor B> reactor A. Since the EC reflected the extent of the charge transfer in the effluent of the effluent from each of the reactors, there was a direct correlation with the nitrate concentration in the nitrified leachate. The higher nitrate concentration in the nitrified leachate, the higher the EC of the leachate.
**Conclusion**

The nitrate loading had a certain influence on the water quality of leachate. The leachate pH of each reactor was in an ascending phase from the beginning of the experiment to the end of the experiment. At the end of the experiment, the pH of the reactors in each group reached or nearly reached 7.00. The leachate ORP of each reactor was very low and similar, indicated that each reactor was in an extremely anaerobic environment and the leachate composition was similar.

**References**


