Influence of nitrate loading on solid stabilization of fresh refuse

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Abstract. The effect of nitrate loading on the change of solid index during the stabilization of fresh refuse was studied by controlling the nitrate concentration. The moisture content of each reactor was lower, and the degree of reduction was less than 10%. At the beginning of the experiment, the organic matter of each reactor solid refuse decreased rapidly, and the content of organic matter decreased slowly or did not decrease further in the middle and the end of the experiment. The change of total nitrogen content followed the law of first urgency and then slowed down, which was in accordance with the variation of organic matter content.

1. Introduction
Landfill is a huge, special micro-ecological system. Its stabilization process is a series of biological, chemical and physical interaction of the succession [1]. The bioreactor landfill can accelerate the stabilization of waste compared to conventional landfill methods [2-3]. Price studied the ability of fresh refuse layer and aged refuse layer to remove nitrate nitrogen in leachate through laboratory simulation of landfill column. The results showed that the fresh refuse layer of landfill has strong denitrification ability [4]. Sun Faqian studied the population characteristics of denitrifying bacteria in fresh landfill through the integration of some combination process. The study showed that landfill 7 years after the refuse had a better denitrification performance [5]. The recharging load of leachate is one of the main factors influencing the efficiency of landfill gas production. The existing research results had big discrepancy, the best recharge ratio from 13% to 30% [6-8]. The recharging program should be appropriately adjusted at different stages including the amount of recharge, recharge ratio, temperature in order to improve the rate of stabilization of refuse [9]. In this study, nitrification leachate was simulated by recharging to study the effect of different nitrate loading on solid refuse during the process of stabilization of fresh refuse.

2. Materials and methods

2.1 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.

| Indicator | Water content | Total nitrogen | Organic matter | pH  |
|-----------|---------------|----------------|----------------|-----|
|           | 70%           | 6.13 g/kg      | 30.6%          | 5.89|

2.2 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 and 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.

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

2.3 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 Figure 1.

![Figure 1. Device schematic diagram](image)

1-Water inlet; 2-Gas gathering device; 3-Rubber gasket; 4-Fresh refuse layer; 5-Gravel layer; 6-Water outlet

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.

2.4 Monitoring indicators and methods
Solid samples were taken every month, and the indicators of moisture content, total nitrogen, organic matter and pH were measured. The moisture content was heated to constant weight at 105 °C. The total nitrogen was determined by azotometer. The organic matter was determined by potassium dichromate oxidation method and the pH was determined by glass electrode method.

3. Results and discussion

3.1 The change of moisture content of refuse in each reactor

Table 3. Moisture content of refuse in each stage

| Sampling time (week) | 0  | 8    | 18   |
|---------------------|----|------|------|
| A                   | 70.00% | 66.68% | 63.85% |
| B                   | 70.00% | 60.01% | 62.01% |
| C                   | 70.00% | 64.53% | 65.03% |
| D                   | 70.00% | 68.28% | 67.51% |
| E                   | 70.00% | 66.93% | 65.99% |
| F                   | 70.00% | 62.83% | 63.25% |

Table 3 showed that the moisture content of the refuse in each reactor was reduced to different extents. The moisture content of each reactor decreased from 70.00% to 63.85%, 62.01%, 65.03%, 67.51%, 65.99% and 63.25%. In general, the moisture content of each reactor decreased little, probably because the watermelon rind was filled in the fresh refuse, which resulted in no significant decrease of moisture content.

3.2 The change of pH of refuse in each reactor

Table 4. pH of refuse in each stage

| Sampling time (week) | 0  | 8    | 18   |
|---------------------|----|------|------|
| A                   | 5.89 | 5.80 | 6.02 |
| B                   | 5.89 | 5.33 | 6.39 |
| C                   | 5.89 | 6.07 | 6.59 |
| D                   | 5.89 | 5.67 | 7.03 |
| E                   | 5.89 | 5.92 | 6.98 |
| F                   | 5.89 | 6.31 | 6.78 |

Table 4 showed the variation of the pH of solid samples in each reactor. The pH of the reactors A, B and D decreased gradually from 5.89, 5.33 and 5.67, and then increased to a certain extent. At the end of the experiment, the pH of solid samples increased to 6.02, 6.39 and 7.03. The pH of solid samples in reactors C, E, and F increased by a small margin from the beginning of the experiment. At the end of the experiment, the pH reached 6.59, 6.98 and 6.78 respectively.

3.3 The change of organic matter of refuse in each reactor

Table 5. Organic matter of refuse in each stage

| Sampling time (week) | 0  | 8    | 18   |
|---------------------|----|------|------|
| A                   | 30.60% | 12.98% | 11.36% |
| B                   | 30.60% | 13.00% | 11.96% |
| C                   | 30.60% | 12.06% | 11.24% |
| D                   | 30.60% | 17.24% | 15.24% |
| E                   | 30.60% | 13.63% | 13.62% |
| F                   | 30.60% | 10.02% | 11.25% |
As shown in Table 5, the content of organic matter in the fresh refuse was 30.60%. After a period of operation, the organic matter content of the reactors decreased in different degrees. At the end of the experiment, the organic matter content decreased to 11.36%, 11.96%, 11.24%, 15.24%, 13.62% and 11.25% respectively. At the beginning of the experiment, the organic matter of solid refuse of each reactor decreased rapidly, and the content of organic matter decreased slowly or did not decrease further in the middle and the end of the experiment.

3.4 The change of total nitrogen of refuse in each reactor

| Table 6. Total nitrogen of refuse in each stage |
|-----------------------------------------------|
| Sampling time (week) | 0  | 8  | 18 |
| A (g/kg)            | 6.13 | 5.22 | 3.26 |
| B (g/kg)            | 6.13 | 4.49 | 2.16 |
| C (g/kg)            | 6.13 | 4.62 | 3.03 |
| D (g/kg)            | 6.13 | 5.02 | 3.99 |
| E (g/kg)            | 6.13 | 3.87 | 2.54 |
| F (g/kg)            | 6.13 | 3.40 | 3.04 |

From Table 6, the total nitrogen content of each reactor decreased from 6.13 g/kg to 3.26 g/kg, 2.16 g/kg, 3.03 g/kg, 3.99 g/kg, 2.54 g/kg, 3.04 g/kg at the end of the experiment. The change of total nitrogen content also followed the discipline of anxious and then slow, which was consistent with the content of organic matter in solid refuse of each reactor.

4. Conclusion

The nitrate loading had some effect on the solids in the reactor. The pH of most of the reactor solids were gradually increased, except for the relatively low reactor A, the other groups of the reactors pH were basically stable in the 7.00 or so. The moisture content of each reactor was slightly reduced, not more than 10%. The trends of the total nitrogen content and organic matter content of each reactor were consistent, and all of them followed the law of change before and after.

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