Feasibility analysis of waste humus soil for Urban Greening

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Abstract: From the landfill site which was closed for 15 years, 10mm sieved humus soil was extracted as test material, to build the wild plant simulation leaching system. The regularity of pollutant release and the migration of heavy metals were studied in the system, in order to explore the feasibility of using humus soil for urban greening. The test results showed that the pH value of the leaching solution is between 6.8 and 7.7; the COD value is basically stable between 40 mg / L and 75 mg / L; the concentration of NH3-N is less than 1 mg / L; Between 200mg / L, it mainly exists in the form of nitrate nitrogen. Total and Morphology Analysis of four heavy metals (Cu, Zn, Pb, Ni) showed that all the metals were able to achieve the soil environmental quality risk of soil pollution control standard for GB36600-2018 in the nature of the land of green space and square, and the proportion of exchangeable and carbonate binding states in the four heavy metal were small, meanwhile the dissolution and mobility were small. In conclusion, humus soil has the feasibility to use for urban greening.

1. Introduction

There were about 27,000 old and informal landfills in China, covered an area of about 550 million m² [1], stored about 8 billion tons of garbage, which containing about 3.5 billion tons of stale organic matter, 1.5 billion tons 1 billion tons of plastic, fabric, 500 million tons of inorganic inert material. It was a huge potential resource, and the pollution was very serious, too. Use “urban mining engineering” for safety mining, pretreatment, second pollution control innocuity and separation recycling use of the stock garbage had important strategic significance.

The stock of garbage aged about 15 years has basically reached a stable level [2][3], and the proportion of humus in the stock of garbage has reached 40~50% (hereinafter referred to as “humus soil”), and there were also risks of complex components, incomplete degradation of organic matter and accumulation of heavy metals [4][5]. This means that there is still uncertainty about the use of humus waste as a substitute for urban greening, such as rainfall leaching, secondary pollution of natural environment such as pollutant and heavy metal transport and transformation should be highly valued.

In this study, a simulated leaching system of humus plants in the field was constructed, the pollutants release and the migration of heavy metals were systematically studied, and the feasibility of humus soil as urban greening soil was analyzed, to provide references for the utilization of bulk resources of stored garbage humus soil.
2. Test Design

2.1 Test materials

2.1.1 The humus soils
The test material was taken from a 15 years old landfill unit. The humus soil was manually sorted, sieved over 10mm sample sieve, and stirred on the HDPE membrane. The control group filler was taken from the nearby clay.

2.1.2 Plant plants
The plants are bought at the flower market, including Tall fescue, Chinese rose, French Holly and Gardenia.

2.2 Test equipment
Eight new brick leaching ponds were built in the field, divided into two groups. One group filled with humus as experimental group, one group filled with clay as a control group. The length and width of each pool were 1m, and the height increased according to the thickness of the filled filler. The wall and bottom are covered by waterproof, prevent leakage of the leaching solution. The slope of the bottom of the pool is 0.1, and a 20 cm gravel layer is laid, and then a 15 cm thick clay layer is laid on the gravel layer. PVC leaching pipes and collection wells (DN200×1.0m) were provided in each leaching tank. Test diagram is shown in figure 1.

![Diagram](image1)

Figure1(a) Design drawing of the leaching device -- floor plan

![Diagram](image2)

Figure 1(b) Design drawing of the leaching device -- A-A profile

2.3 Experiment design

2.3.1 Leaching tank filling and vegetation planting
According to the filler thickness, experimental group with a thickness of 0.3m, 0.5m, 0.8m and 1.2m were numbered 1#, 2#, 3# and 4#. In the control group, the leached tank with clay thickness of 0.3m, 0.5m, 0.8m and 1.2m were numbered 5#, 6#, 7# and 8#, respectively. The leached tank with thickness ranging from small to large were planted with Tall fescue, Chinese rose, French Holly and Gardenia to simulate the nutrient soil of different types of plants.
The planting time was at the end of March 2018. In the early stage of growth, if there was no rain, water every three days with 10l water per tank.

### 2.3.2 Sampling method
Starting from April 2018, after each watering, a small portable pump driven by a battery will be used to extract the leaching solution from each leaching tank, record the volume of the leaching solution, and collect the water sample of the leaching solution.

### 2.3.3 Research indicators.
Study the leaching characteristics of pollutants in humus soil, as well as the total amount and morphology of heavy metals under a certain amount of leaching.

### 3. Analysis of Test Results

#### 3.1 Leaching characteristics of pollutants in humus soil

**3.1.1 Change of pH value of leaching solution**

![Figure 2](image_url)

**Figure 2 Changes of pH in leaching solution with accumulated rainfall**

During the test (2018/4~2018/9), cumulative leaching water volume was about 750 mm, rain pH between 6.5~7.8, and there was no obvious phenomenon of acid rain. As you can see from figure2, pH values of humus soil leaching solution were between 6.8~7.7, lower than pH values of the clay control groups, equivalent to the pH of rainwater. pH value of clay control groups was higher than pH value of humus soil leaching, because of the pH of clay itself is about 8.9, which is higher than that of humus soil.

It can also be seen from the data in figure2 that humus soil has been in a basic degree of stability, and its leaching solution pH will not have a negative impact on the environment.
3.1.2 Change of COD in leaching solution

![COD concentration graph](image1)

Figure 3 Changes of COD concentration in leaching solution with accumulated rainfall

Figure 3 showed that in the early stage of the test (cumulative leaching water volume was less than 300 mm), due to the instability of the device, data fluctuate. Along with the increase of the accumulated leaching water, COD in leaching solution showed a slow downward trend, and COD of humus soil leaching solution were higher than that of control group and rainwater. It meant that under rainfall conditions, organic matter of humus soil will be leached and precipitated.

During the whole test, except for individual data, the COD value of humus soil leaching solution is basically stable between 40 mg/L~75 mg/L, which indicates that the leaching stability is good, meet the class a of integrated wastewater discharge standard (GB8978-1996) level of emission standards (100 mg/L). Even if the leaching solution with rainfall runoff to the class III water of "Surface Water Environmental Quality Standard"(GB3838-2002), it won’t cause pollution to the water.

3.1.3 Nitrogenous pollutants in leaching solution

![TN concentration graph](image2)

Figure 4 Changes of TN concentration in leaching solution with accumulated rainfall
Figure 5 Changes of NO$_3^-$-N concentration in leaching solution with accumulated rainfall

As can be seen from figure 4, the total nitrogen concentration in the humus soil leaching solution was relatively high and the fluctuation range was relatively large, ranging from 100mg/L to 600mg/L. As the accumulated leaching water increases, the leachable substances gradually decrease, and the total nitrogen concentration decreases obviously. When the precipitation reached 650 mm, TN was basically between 100 mg/L~200 mg/L.

It can be seen from figure 4 that the nitrate content in leaching solution was relatively high and showed a similar change trend with total nitrogen, while the content of ammonia nitrogen was very low. The correlation analysis of nitrate nitrogen and total nitrogen showed that except the 5th leaching tank, all tanks leaching of nitrate nitrogen and total nitrogen in the leaching solution had a very good correlation between, correlation coefficients of above 0.85.

Figure 6 Changes of NH$_3$-N concentration in leaching solution with accumulated rainfall

Known from the figure 6, the ammonia nitrogen humus of soil leaching solution was relatively low, less than 1 mg/L, except for individual points. The ammonia nitrogen concentration reached quality standard GB3838-2002 III water quality standards and groundwater quality standard (GB/T14848-2017 IV class standard, won't cause pollution to the general industrial and agricultural water.

3.2 Analysis of the total amount and morphology of heavy metals in humus soil

The experimental data of four heavy metals (Cu, Zn, Pb, Ni) in humus soil were shown in table 1. It
can be seen from table 1 that the Cu, Zn, Pb, Ni in humus soil fully meet the nature requirements of the second type of land use in the construction land (GB36600-2018) (Except Zn), which meant there was no heavy metal potential pollution in humus soil.

Table 1 Heavy Metal Content and Morphology Analysis of Humus Soil

| Heavy metal | The sample | The total T/(mg kg⁻¹) | Construction land standard limit */(mg•kg⁻¹) |
|-------------|------------|-----------------------|------------------------------------------|
| Cu          | Humus soil | 321.99                | Category I land                           |
|             |            |                       | 2000                                     |
| Control soil|            | 17.75                 | Category ii land                          |
|             |            |                       | 18000                                    |
| Zn          | Humus soil | 759.14                | --                                       |
|             | Control soil| 103.64                | --                                       |
| Pb          | Humus soil | 541.12                | 400                                      |
|             | Control soil| 77.23                 | 800                                      |
| Ni          | Humus soil | 65.18                 | 150                                      |
|             | Control soil| 51.74                 | 900                                      |

Note: * the limit value of construction land shall be subject to the standard for control of soil pollution risk of soil environmental quality construction land GB36600-2018

The morphology of humus soil was analyzed by Tessier five-step continuous extraction method, which divided heavy metals into exchangeable state, carbonate bound state, Fe-Mn oxide bound state, organic bound state and residue state, and their environmental harmlessness was reduced successively. The morphological analysis results were shown in figure7.

![Figure 7 Distribution of Heavy Metal Morphology in Humus Soil](image)

Known from the figure7, Cu mainly exist in the organic combination state, accounts for 74.03% of the total, followed by the residual state, accounting for 22.23% of the total and mobility was very low. For Zn, the exchange state content was relatively small and the mobility was relatively low, the other four forms were more evenly distributed, with the highest Fe-Mn oxide bound state, accounting for 36.35% of the total, followed by the residue state. Most of the Pb was in the residue state and Fe-Mn oxide bound state, accounting for 42.52% and 28.30% of the total amount, respectively, and the mobility was low. Ni mainly exist in residue and carbonate bound states, accounting for 34.16% and 27.99 respectively, the exchangeable state content was the highest among the four heavy metals, accounting for 16.77% of the total.

4. Conclusion

By constructing a humus leaching device to simulate the leaching characteristics of humus soil pollutants under rainfall leaching conditions, the total amount and morphology of heavy metals were analyzed, the feasibility of utilizing humus soil as a resource for urban greening was comprehensively evaluated.

When using humus soil with basic stability as greening soil, the pH in the leaching solution was between 6.8 and 7.7, and the COD value was basically stable between 40 mg/L and 75 mg/L, water quality meets the first class effluent discharge standard (GB8978-1996)(100 mg/L), even if the leaching solution with rainfall runoff to the surface water environmental quality standard GB3838-2002 class III waters. NH₃-N concentration was less than 1mg/L, reached the surface water
environment quality standard GB3838-2002 class III water quality standards and groundwater quality standard GB/T14848-2017 classIV standard. TN content was higher, basically from 100 mg/L to 200mg/L, and mainly existed in the form of nitrate nitrogen. Humus soil leaching solution will not cause secondary pollution of surface water environment.

Analysis of total amount and morphology of four heavy metals (Cu, Zn, Pb, Ni) in humus soil shown that the proportion of exchangeable state and carbonate bound state were small, mainly as the Fe-Mn oxide bound state, organic c state and residue state, mobility was low. The risk of heavy metal dissolution of contaminated surface water and groundwater is relatively small in the use of soil for urban greening.

To sum up, humus soil was feasible for urban greening.

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