

Effect of amendments addition on adsorption of landfill leachate

X J Bai¹, H Y Zhang², G Q Wang³, J Gu², J H Wang¹, G P Duan⁴

¹College of Resource and Environment Science, Jilin Agricultural University, Jilin 130102, China

²Beijing Building Materials Academy of Science Research/State Key Laboratory of Solid Waste Reuse for Building Materials, Beijing 100041, China

³Beijing Environmental ³Sanitation Engineering Research Institute/Beijing Key Laboratory of Municipal Solid Wastes Testing Analysis and Evaluation, Beijing 100028, China

⁴Beijing Haidian District Circular Economy Industrial Park Management Center, Beijing 100080, China

672190740@qq.com

Abstract. The disposal of leachate has become one of the most pressing problems for landfills. This study taking three kinds of amendments, corn straw, mushroom residue and garden waste as adsorbent materials, evaluates the different amendments on the leachate adsorption effect through analyzing indicators as the saturation adsorption ratio, sulfur containing odor emission, heat value. The results showed that all three kinds of amendments can effectively adsorb leachate, with saturation adsorption ratio between 1: 2 and 1: 4. Adding amendment could significantly reduce the sulfur containing odor emission of leachate. Compared the three kinds of amendments, mushroom residue could adsorb leachate at a maximize degree with a low concentration of sulfur containing odor emission. The industrial analysis showed that the heat values of the amendments after absorbing leachate are more than 14MJ/kg, and it can be utilized as a biomass fuel.

1. Introduction

Landfill is the main way to deal with municipal solid waste (MSW) in China. As indicated in relevant data, China's MSW will reach to 409 million tons in 2030 and 528 million tons in 2050 [1]. According to Li's study, when the water content of MSW is 47%, it can produce 0.0722t of leachate per ton of MSW [2]. Landfill leachate is a kind of organic wastewater mixed with water and rainwater produced by the fermentation and degradation of garbage landfill. It contains a large amount of compounds such as benzene, phenol and alcohols and carries a large amount of odors, which heavily contaminated the surrounding residents living environment.

At present, the leachate processing technology mainly includes: physical treatment, chemical treatment and physico-chemical treatment, *etal*. However, these treatment methods have the problems of high treatment cost, difficulty of recycle and possible secondary pollutants. The physico-chemical treatment methods such as adsorption and sedimentation and membrane separation merely transfer the pollutants and the pollutants finally return to the form of materialize sludge landfill, causing the



circulation of pollutants [3-5]. Deng had used corn straw composting process piggery wastewater treatment experiments and proved feasible, but the heavy metals might excessive [6]. Chen's research shows that activated sludge and corn straw have good effect on the removal of alkanes, but the removal of organic matter with high toxicity was not obvious [7]. Yin explored the process of landfill leachate and alkali pretreatment corn straw mixed anaerobic digestion process, the experiment proved that the anaerobic digestion process gas production rate and gas production significantly improved, but a slight acidification occurred in the late digestion period, leading to poor test results [3].

The objective of this work was to explore the influence of amendments addition on adsorption of landfill leachate and sulfur containing odor emission in the adsorption process. Corn straw, mushroom residue and garden waste, which are common waste materials in most areas of China, were chosen as the amendments materials.

2. Materials and Methods

2.1. Raw Materials

Landfill leachate was taken from landfill A, landfill B and landfill C in Beijing, the concentrated liquid produced by leachate treatment comes from landfill A, named An. The withered corn straw were collected from farmland in Beijing, and cut to lengths of 1-5 cm. Dry mushroom residue, which had been discarded and stockpiled for a few days, was provided by a mushroom farm in Beijing. The garden wastes were collected from public garden in Beijing, and cut to lengths of 1-3 cm. The related indexes of the three amendments and leachate are shown in Table 1 and Table 2.

Table 1 Properties of Three kinds of Amendments (%)

| Item | Moisture | Ash | Volatile | Fixed carbon |
|------------------|----------|------|----------|--------------|
| corn straw | 2.83 | 6.47 | 74.00 | 16.70 |
| mushroom residue | 4.07 | 8.38 | 70.59 | 16.96 |
| garden waste | 2.86 | 2.24 | 76.86 | 18.04 |

Table2 Leachate water quality determination

| Item | H ₂ S(ppm) | CS ₂ (ppm) | COD _{cr} (mg/L) | BOD(mg/L) | NH ₃ -N(mg/L) | TN(mg/L) | TP(mg/L) | TDS(g/L) |
|------|-----------------------|-----------------------|--------------------------|-----------|--------------------------|----------|----------|----------|
| A | 593.99 | 0.00 | 1820.00 | 191.00 | 1040.00 | 1100.00 | 23.80 | 14.53 |
| An | 0.00 | 0.00 | 1990.00 | 154.00 | 1.00 | 180.00 | 22.80 | 31.82 |
| B | 104.40 | 0.03 | 18250.00 | 6776.00 | 3160.00 | 3400.00 | 98.00 | 26.46 |
| C | 2.47 | 0.07 | 9240.00 | 3541.00 | 3160.00 | 3600.00 | 58.00 | 19.35 |

2.2. Treatments Design

In this study, we investigated twelve treatments. In the first 4 treatments, corn straw was used as the amendments to adsorb the leachate and concentrated liquid from 3 landfills, and we call these the X1, X2, X3, X4. In the second 4 treatments, mushroom residue was used as the amendments to adsorb the leachate and concentrated liquid from 3 landfills, and we call these the Y1, Y2, Y3, Y4. In the last 4 treatments, garden waste was used as the amendments to adsorb the leachate and concentrated liquid from 3 landfills, and we call these the Z1, Z2, Z3, Z4.

Quantitatively mixed until the amendment is saturated with leachate and loaded into a 500 ml test tank, the amendment is saturated with leachate during mixing. The specific grouping and quality are shown in Table 3. To simulate outdoor environmental conditions, the saturating amendment that put into the test tank is to be still-fermented for 30 minutes under ventilation and then sealed. The test ran from September 27, 2017 until October 12, 2017, for a total of 15 days. Periodically collected gas samples from the top vent of the test tank and measured the concentration of sulfur containing odors.

2.3. Test indicators and methods

Saturation adsorption ratio: obtained according to the different amendments adsorption leachate mass ratio. Sulfur containing odors emission test: The material was measured by GC7890B Agilent Gas

Chromatograph on the 1st, 2nd, 4th, 8th and 14th day of mixing. The material is dried to a constant mass at 105 °C and the moisture content of the material is calculated based on the mass of the waste before and after drying. Moisture, ash, volatiles were measured by TRGF-8000 industrial analyzer. The heat value of the sample was measured by 5E-KCIII Rapid Calorimeter.

3. Results and discussion

3.1. Saturation absorptive ratio

Table 3 shows the results for the three kinds of amendments saturation adsorption capacity for different leachate. In the three amendments (X, Y, Z), treatment X had the largest absorption capacity with saturation absorptive ratio at 1: 4. Treatment Z had the smallest absorption capacity with saturation absorptive ratio between 1: 2 and 1: 2.25, and treatment Y was moderate. It is mainly due to the fact that cellulose in garden wastes is usually linked with hemicellulose and lignin, the cell wall is protected by lignin and results in poor leachate absorption. While the surface structure of corn straw and mushroom residue is rough and anomaly, the porosity and specific surface area are larger, which results in its ability to absorb water [8]. Overall, the leachate absorption capacity of corn straw and mushroom residue is far more than the garden waste, while corn straw has the maximum absorption ratio.

Table 3 The saturated absorption ratio of amendments

| Item | amendment (g) | leachate (g) | saturation absorptive ratio |
|---------------------------|---------------|--------------|-----------------------------|
| A+ corn straw (X1) | 30 | 120 | 1:4 |
| An+ corn straw (X2) | 20 | 80 | 1:4 |
| B+ corn straw (X3) | 30 | 120 | 1:4 |
| C+ corn straw (X4) | 30 | 120 | 1:4 |
| A+ mushroom residue (Y1) | 40 | 120 | 1:3 |
| An+ mushroom residue (Y2) | 40 | 160 | 1:4 |
| B+ mushroom residue (Y3) | 40 | 160 | 1:4 |
| C+ mushroom residue (Y4) | 40 | 160 | 1:4 |
| A+ garden waste (Z1) | 40 | 80 | 1:2 |
| An+ garden waste (Z2) | 40 | 80 | 1:2 |
| B+ garden waste | 40 | 90 | 1:2.25 |
| C+ garden waste (Z4) | 40 | 90 | 1:2.25 |

3.2. Properties of saturated amendments

Industrial analysis is valuable for studying the properties of materials and determining the rational use of materials. The industrial analysis of the treated materials is shown in table 4, with little different moisture content of each group between 2% and 5%. The ash content of treatment Y was 6.4% to 14.4% larger than that of treatment Z. Compared with the ash content in Table 1, it is found that the corn straw and the mushroom residue increased by 5% and 5.3% , respectively, while the growth of garden waste by 1.7%.

Volatile and fixed carbon can approximately represent the organic matter in the material [9]. The content of volatile and fixed carbon of treatment Z was 93%~96%, and the content of treatment X and treatment Y was 77%~88.5%. This is because corn straw and mushroom residue with the strong absorption capability of leachate. Leachate is the media in the metabolic response of microorganisms, the organic matter in the experiment decreased after the decomposition of microorganisms. While, the leachate absorption of garden waste is relatively poor and its microbial metabolic capacity is weak, which result in high organic matter.

From the moisture content, the best result can be achieved when the saturation absorptive ratio of treatment X decreased by 46%~59% compared with the treated moisture content, it is 16% higher than

treatment Y, and treatment Z with the least changes of moisture content. And in the adsorption process, the materials both in treatment of X and Y were moldy.

Table 4 Industrial analysis and Moisture content changes of saturated amendments after treated (%)

| Item | Moisture | Ash | Volatile | Fixed carbon | Moisture content |
|------|----------|-------|----------|--------------|------------------|
| (X1) | 3.49 | 11.88 | 66.15 | 18.48 | 16.42 |
| (X2) | 2.44 | 14.89 | 66.18 | 16.49 | 29.07 |
| (X3) | 2.02 | 9.56 | 69.99 | 18.43 | 15.93 |
| (X4) | 2.74 | 10.33 | 68.54 | 18.39 | 21.71 |
| (Y1) | 4.02 | 12.73 | 66.32 | 16.93 | 37.15 |
| (Y2) | 4.53 | 17.9 | 62.23 | 15.34 | 42.88 |
| (Y3) | 4.23 | 12.09 | 65.23 | 18.45 | 43.56 |
| (Y4) | 3.85 | 12.02 | 65.76 | 18.37 | 39.75 |
| (Z1) | 2.41 | 3.62 | 75.03 | 18.94 | 24.53 |
| (Z2) | 2.37 | 3.57 | 73.15 | 20.91 | 23.20 |
| (Z3) | 2.42 | 5.62 | 73.07 | 18.89 | 23.43 |
| (Z4) | 2.61 | 3.68 | 74.49 | 19.22 | 23.20 |

3.3. Emission of sulfur containing odors

Table 5 shows the emissions of sulfur containing odors in the process of experiment. The adsorption effect of sulfur containing odor on leachate was obvious by adding amendment. The high concentration of H_2S disappeared in the early stage of the experiment, and gradually turned into C_2H_6S and COS. At the end of the experiment, C_2H_6S and COS gradually became close to zero. Experiment showed that the adsorption effect of treatment Y was the best, and no sulfur containing odors were found in the adsorption process. The emission peak of sulfur containing odors for treatment X occurred earlier, which concentrated in the first 2-4d. The concentration of X2 and X3 in the adsorption process were large with the maximum as 42.95ppm. X4 produced C_2H_6S and COS in the first 4d. The sulfur containing odor emission peak of treatment Y concentrated in the first 4-8d with small emission concentration.

Table 5 Emission of sulfide in the adsorption process (ppm)

| Item | 1d | 2d | 4d | 8d | 14d |
|---------|---------|-----------|-----------|------|-----------|
| sulfide | sulfide | C_2H_6S | C_2H_6S | COS | C_2H_6S |
| X1 | - | 0.48 | - | - | - |
| X2 | - | 43.00 | 0.98 | - | - |
| X3 | - | 0.45 | 9.89 | - | - |
| X4 | - | - | 0.29 | 1.34 | - |
| Y1 | - | - | - | - | - |
| Y2 | - | 0.13 | - | - | - |
| Y3 | - | - | - | 1.22 | - |
| Y4 | - | - | - | 0.62 | - |
| Z1 | - | - | - | - | - |
| Z2 | - | - | - | - | - |
| Z3 | - | - | - | - | - |
| Z4 | - | - | - | - | - |

3.4. Heat value of materials

Heat value is an important indicator of fuel quality. Table 6 shows the heat value of the amendments after absorbing leachate. The heat value after absorbing leachate tends decrease compared with amendments itself, but not much. The treatment Z had the maximum heat value, average in 18MJ/kg

or more. According to calorie classification (GB / T15224.3-2004), its heating value was equivalent to high calorific value lignite. The difference between the heat value of treatment X and treatment Y were not obvious, as between 14.5MJ/kg to 16.7 MJ/kg, their heat value were equivalent to the moderate heat value lignite. Using the amendments after absorbing leachate as a fuel can achieve the co-processing of waste and recycling of resources.

Table 6 Heat value of materials (MJ/kg)

| Item | Corn straw | Mushroom residue | Garden waste | X1 | X2 | X3 | X4 | Y1 | Y2 | Y3 | Y4 | Z1 | Z2 | Z3 | Z4 |
|------------|------------|------------------|--------------|------|------|------|------|------|------|------|------|------|------|------|------|
| Heat value | 17.5 | 16.6 | 19.3 | 16.4 | 15.6 | 16.7 | 16.6 | 16.0 | 14.5 | 15.5 | 15.7 | 19.1 | 19.1 | 18.4 | 19.1 |

4. Conclusion

(1) It can be found that the corn straw has the largest leachate treatment capacity, according to changes of saturation absorptive ratio and moisture content.

(2) According to the emissions of sulfur containing odors, garden waste achieves the zero discharge of sulfide. The concentration of mushroom residue is low, but with a long adsorption time. The concentrations of X2 and X3 were high with short adsorption time.

(3) According to heat value of amendments after absorbing leachate, the heating value of garden waste is equivalent to the high heat value lignite. The heating value of corn straw and mushroom residue is equivalent to moderate calorie lignite.

(4) Based on the results above, mushroom residue is considered to be the first choice for the treatment of leachate.

Acknowledgements

This study was financially supported by the key projects of BBMG (B8003), Founded by the Beijing Municipal Management Committee project "investigation and prediction analysis of municipal solid waste generation in Beijing".

References

- [1] Li Y Q, 2004 Shaanxi Normal Univ:Nat Sci Edition. 32(2):112-116.
- [2] Li J, Wang S Y, Wang B Z, 2002 China Water & Wastewater, 18(3): 1-6.
- [3] Yin S J, 2014 Southwest Jiaotong Univ.
- [4] Li C, 2014 JiLin Univ.China.
- [5] Yu X, Zhang J Y, 2002 Environ. Sci. & Techno., 25(5): 43-45.
- [6] Deng L W, Tan X Q, Li J, 2004 Transactions of the CSAE, 20(6): 255-259.
- [7] Chen Y L, Li B T, 2014 Environ. Pollution & Ctrl, 36(2): 67-70.
- [8] Xu Y K, Sun X Y, Luan Y N, 2014 Chin J. of Soil Sci. (5): 1071-1076.
- [9] Nie X F, Wang F, 2012 Energy Techno and Manage. (1): 125-127.