Heavy metals decreased by water elution method on bottom ash from municipal solid waste incineration plant

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Abstract: By incineration treatment became the most important disposal method. The bottom ash, which accounting for 20% to 30% of the original municipal solid waste has been a large content source of municipal solid waste in China. The heavy metal will be released to the environment by the eluent produced from the bottom ash. It has a negative influence on bottom ash treatment and reuse. This study analyzed the changing of heavy metals of Cu, Ni and Zn during the elution process by the column simulation experiment. The study revealed the regulation of heavy metals migration under the condition of slow speed elution. These results can help environmental release risk assessment of heavy metal in bottom ash from municipal solid waste incineration plant.

1. Introduction

Bottom ash and incineration fly ash are two final solid wastes which produced in municipal solid waste incineration plant. In the two sorts of waste, the incineration bottom ash occupies a large proportion. In China, there has no commercial way to reuse of waste incineration bottom ash except landfill disposal. In other countries, the use of incineration bottom ash mainly focuses on the production of concrete ingredients [1] and subgrade fillings [2]. In whole bottom weight, there are more than 70% particles diameter less than 8mm and more than 52% particles diameters less than 4mm [3]. The heavy metals and soluble chlorine was mainly concentrated on particles less than 0.6 mm diameter reported by Linyiming et al. [4, 5]. These studies have theoretical and practical meanings for the removal of soluble chlorine and heavy metals in waste incineration bottom ash to improve the commercial use of this waste.

2 Materials and methods

2.1 Chemical analyzing equipment

1mL pipette, 10mL pipetting tube, 50mL capacity bottle, 1/10000 sensitive electronic balance, conical bottle, 50mL titrator, colorimeter, ultraviolet spectrophotometer, refrigerator, beaker, 50mL centrifugal tube, platform balance (weighing soil), X Ray fluorescence analyzer (Produced by Panalytical Company, Netherlands, ZETIUM model, processing software Super Q), EXCEL office software, SPSS
statistical analysis software.

2.2 Testing device
The testing device is one organic glass column has 10 mm thickness wall about 500 mm height, and 200 mm diameter outside. One stainless steel water tank and a spray pump are connected with the PVC plastic pipe fittings. The column equipped a water distributor on the top and connected the base with flange. A 30 mm thickness gauze cushion was laid at the bottom of the column. To prevent fine-grained bottom slag particles flowing out of the column, a layer of non-woven fabric was placed on the cushion. The drain valve was equipped at the bottom of each column.

2.3 Sample pretreatment
The samples were collected from one large municipal solid waste incineration plant in Beijing and air-dried for half a year. The moisture content of the samples was measured by oven drying methods. Then samples were sifted through 8mm screen and removed impurities such as glass, metal, tile, broken porcelain and stone can be removed by manual operation. After screening, the samples was divided into two parts. The coarse particle size which larger than 4mm and the fine particle size which smaller than 4mm.

2.4 Experimental procedure
In order to keep sealing of the device, rubber gaskets were installed at each interface of the simulated column and water leakage test was carried out. After empty and dry the column again, different particle size bottom ashes were putted into two different columns, until the filling volume was 2.67 L. During the experiment, the temperature in the laboratory was stable at 21 °C. The water added to different sizes bottom ash filling columns were 120 mL per day. The liquid naturally seeped through the filling material layer and through the geotextile and plastic partition of the column. The eluent was collected at the bottom of the column. When there was no evident eluent flowing out from the column, the drainage valve was open to collect eluent, and the time of each eluent collection was about 5 to 10 minutes. Soluble chloride ion content was determined by silver nitrate titration method GB 11896-89[6], The heavy metals of Cu, Ni and Zn in the elution liquid was detected by ICP-MASS method. The experiment data were analyzed by SPSS 22 software.

3. Results and analysis

3.1 Chloride ion changing in elution
During 935 hours experiment, the soluble chloride of the fine particle treatment was decreased by 125.03 mg/L from the initial 166.76 mg/L. And in coarse particle treatment, it was decreased by 60.53 mg/L from 88.48 mg/L. The final concentration of soluble chloride in the fine particle treatment and coarse particle treatment was 41.73 mg/L and 27.95 mg/L respectively. And the concentration of

![Figure 1 structure of simulated column](image)
soluble chlorine in the eluent of the two treatments decreased by 68.4% and 75.0% respectively.

3.2 Heavy metals changing in elution
The concentration of heavy metal in solution that washed out by distilled water was detected. The order of heavy metal concentration is Cu, Zn and Ni. The heavy metals of Cu, Ni and Zn in incineration bottom ash have dissolved quickly during first week and these concentrations have similar variation in eluent. All the heavy metal concentration in eluent went down to the bottom of the curve after three weeks. It is revealed the dissolution of heavy metals is a faster process compared to dechlorination. The heavy metals dissolution process only need three weeks in the experiment.

There has significant correlation of Cu and Ni in the eluent of coarse particle treatment. And the correlation coefficient is 0.922(two tails test). To the fine particle treatment, there also has correlation between Cu and Ni (correlation coefficient is 0.917, two tails test). And there has correlation between Cu and Zn (correlation coefficient is 0.833, two tails test).

But, there have no correlation between chloride ion and heavy metal by statistical analysis. The peak value of chloride ion concentration appeared on the third week, just meet the heavy metals concentration went down to the bottom of the curve. It is revealing the highest concentration of chloride ion can mark the end of the dissolution process of soluble heavy metals in water elution pretreatment process.

The highest ion dissolution concentration appeared at 72 hours in both of fine particle and coarse particle treatment. The Cu, Zn, Ni concentration in fine particle treatment was 1.84 mg/L, 0.45 mg/L and 0.12 mg/L respectively. The Cu, Zn, Ni concentration in coarse particle treatment was 0.68 mg/L, 0.21 mg/L and 0.06 mg/L respectively. All the concentrations are below the limitation of China standard of Identification standards for hazardous wastes-identification of extraction toxicity (GB5085.3-2007).

Compared to the highest value in eluent, the 3 heavy metals reduced obviously during the six-week experiment. The Cu, Zn, Ni concentration in the eluent of fine particle treatment was decreased by 90.2%, 71.1% and 58.3% respectively. Cu, Zn, Ni concentration in the eluent of coarse particle treatment was decreased 75.0%, 81.0% and 50.0% respectively. It is generally considered safe to incineration bottom ash. But the removability and cumulative effect of the heavy metals may have negative affection to environment in long period.
4 Conclusions

4.1 Heavy metals can be dissolved by distilled water
The order of heavy metal concentration in eluent is Cu, Zn and Ni. The highest value of heavy metal appeared at 72 hours. Compared to the highest value the 3 heavy metals reduced obviously during the six-week experiment. The Cu, Zn, Ni concentration in the eluent of fine particle treatment was decreased by 90.2%, 71.1% and 58.3% respectively. Cu, Zn, Ni concentration in the eluent of coarse particle treatment was decreased 75.0%, 81.0% and 50.0% respectively.

4.2 Soluble chlorine remove procedure is slowly than heavy metal dissolve
The highest concentration of chloride ion can mark the end of the dissolution process of soluble heavy metals in water elution pretreatment process.

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