Analysis of physical composition and heavy metals pollution of municipal solid waste (MSW) in Beijing

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Abstract. By using on-site sampling and physical-chemical analysis, the physical composition and the contents of heavy metals in Beijing MSW were researched. The result showed that the main components of MSW in Beijing are mainly kitchen waste, the average content of kitchen waste are more than 60% and 50% in summer and in winter, respectively. The pollution of Cu, Hg and Cr are all more serious for MSW in Haidian and Dongcheng district. The heavy metal pollution of MSW in summer is higher than that in winter in Beijing. Seasonal impacts should be taken into consideration when dealing with MSW. The content of heavy metals in MSW exceeded the background value of soil in Haidian and Dongcheng districts. In order to reduce heavy metal pollution, the MSW should be separated collection and treated.

1. Introduction

Generally, MSW contains a certain amount of heavy metals. There are potential environmental risks in the treatment and disposal of municipal solid waste, and the disposal way of MSW is also very much restricted to a great extent because of the existence of heavy metals. Such as landfill, a large amount of heavy metal ions in leachate can easily cause pollution of soil and groundwater when the landfill is improperly carry out［1-2］. Such as incineration treatment, slag and fly ash also contains a high concentration of heavy metals tend to cause heavy metal concentrations in the soil and atmosphere ［3-4］. For composting, if the heavy metal content of compost products is higher, the heavy metal pollution and heavy metal accumulation in crops will be further caused by the application of farmland ［5-6］.

At present, the content of heavy metals in MSW is regarded as a very important indicator in during the MSW disposal. Currently, there are few reports on the assessment of heavy metal pollution of MSW in China [7-8], and the dynamic monitoring of heavy metal content in MSW in different seasons has not yet been carried out.

In this study, the contents of typical heavy metals in municipal solid waste in Haidian and Dongcheng districts were investigated and analyzed. The changes of heavy metal content in different

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seasons were also compared. This study can provide the technical data for the reduction, harmless and resource recovery of MSW in Beijing.

2. Materials and methods

In Beijing, a typical residential area with similar population and economic level was selected as the sampling point of MSW in Haidian and Dongcheng district, respectively. The MSW were collected from the MSW sealed cleaning stations which belong to the selected residential area as the research object. Sampling and sample preparation were conducted according to urban construction standard method, domestic waste sampling and physical analysis (CJ/T313-2009). The MSW dumped in plastic film on the ground and mixed them thoroughly. One fourth MSW is used for laboratory test analysis. The MSW samples were divided into fresh samples and air-dried samples that could pass through a 1-mm sieve. The MSW were collected in summer (June) and winter (November) respectively, each collection lasted 3 days.

3. Analysis method

In this study, the MSW samples were classified manually as kitchen waste, plastic, paper, wood, metal, ash, fabrics, glass, mixture. The moisture content was determined by drying the samples at 105℃ until the weight was constant. The waste dry sample was digested with nitric acid hydrochloric acid perchloric acid. The residue of the digestion tube was washed into 50mL volumetric flask with 1% nitric acid, after fixed volume, shaken and filtered, and the filtrate was stored in the plastic bottle. The concentration of Pb, Cd, Cr, Cu, Zn, Mn and Ni was determined by flame atomic absorption spectrophotometer [9]. As and Hg in the sample digestion with aqua regia in boiling water bath for 2h, after cooling with 5% hydrochloric acid transfer to a 50mL volumetric flask, the concentration of As, Hg and Se was determined by atomic fluorescence spectrometer [10].

4. Results and discussion

4.1 Physical composition of MSW. The physical composition and moisture content of MSW for two districts were shown in Table 1. It was clear to see that the percentage of kitchen waste was obviously higher than other components, and the average content of kitchen waste is higher in summer than in winter. In summer, the average content of kitchen waste is 68.83% and 60.32% in Haidian and Dongcheng district, respectively. In the winter the average content of kitchen waste is about 50% for two districts. In addition, the other two main components of MSW are plastic and paper, the two components accounted for 17-30% of the quality of MSW. The content of other components in MSW is relatively small, which average contents were below 7%.

Table 1 MSW physical composition of Haidian and Dongcheng districts （%）

District	Season	Kitchen waste	Paper	Plastic	Fabric	Wood	Ash	Metal	Glass	Mixture
Haidian	Summer	68.83	10.02	13.92	1.43	0.43	1.26	0.87	0.25	3.00
	Winter	50.08	17.40	7.10	6.82	0.80	0.00	10.97	0.88	5.95
Dongcheng	Summer	60.32	18.60	10.96	2.69	0.13	0.22	2.10	4.07	4.24
	Winter	46.75	9.31	8.01	1.08	0.99	0.00	4.19	0.59	2.41

4.2 The content of heavy metals. The heavy metals contents of MSW for two districts were shown in Table 2. The influence of sampling time and geographical difference on heavy metal content in MSW samples is great. In order to better characterize the pollution degree of heavy metals in municipal solid waste from 2 districts, the background value of soil in Beijing and soil environmental quality standards of the two were used as a reference. It was found by contrast the pollution of Cu, Hg, Cr were all more serious for MSW in Haidian and Dongcheng district. The highest value is about 5, 3 and 6 times of background value of soil in Beijing. It exceeded the two grade standard of soil environmental quality in China, but it was lower than the standard of urban refuse agricultural control. In summer, Zn and

arsenic exceed the local soil background value, which may cause soil pollution to a certain extent. In the two seasons of winter and summer, Pb and Ni in MSW were all lower than the soil background value in Haidian and Dongcheng district, and do not directly cause soil pollution.

Table 2 Heavy metal concentrations of MSW in Haidian and Dongcheng districts（mg/kg）

District	Season	Pb	Cd	Cr	As	Hg	Cu	Zn	Mn	Ni
Haidian	Summer	15.00	0.55	56.80	2.11	0.016	37.00	392.00	47.50	16.00
	Winter	<5.00	0.32	80.80	1.52	0.092	16.00	98.00	119.00	13.00
Dongcheng	Summer	20.00	0.64	27.70	13.10	0.196	101.00	127.00	49.10	15.00
	Winter	7.00	0.41	133.0	1.40	0.105	13.00	74.20	76.50	22.00
Soil background value in Beijing[11]		24.6	0.119	29.8	7.09	0.08	18.7	57.5		26.8
Soil environmental quality standard		80	0.5	300	25	0.5	100	250		90
Agricultural control standard for MSW		≤100	≤3	≤300	≤30	≤5				

4.3 Quantitative analysis. In order to quantitative description of heavy metal pollution in MSW and determine the main heavy metal pollutants in Haidian and Dongcheng district. Based on the background value of soil heavy metals in Beijing City, single factor index method was used to calculate the single pollution coefficient (Pi) of 9 heavy metals except Pb, Ni and Mn in MSW.

$$p_i = C_i / S_i$$

C_i represents the measured value of heavy metal element i in MSW;

S_i indicates the background value of pollutant I in soil of Beijing City.

When a Pi element values greater than 1, showed that the concentration of the element is greater than the soil background value, will cause direct contamination of the soil in the area is to be considered as the main pollutants.

It can be seen from table 3 that the pollution degree of heavy metal in summer obviously higher than that in winter of MSW in Haidian and Dongcheng districts. It also can be seen that the pollution of Cd is the most serious among the MSW in 2 districts. In summer, the single factor index is 4.6 and 5.4 times of the soil background value in Haidian and Dongcheng district, respectively. The pollution of Cr and Zn is next. In addition, the degree of pollution of other heavy metal pollutants in the 2 districts of MSW is different. Compared with Dongcheng district, the pollution degree of heavy metals in MSW is more serious than that in Haidian district.

Table 3 Comparison of heavy metal pollutants of MSW in Haidian and Dongcheng districts

Heavy metals	Haidian—summer	Haidian—winter	Dongcheng—summer	Dongcheng—winter
Cd	4.6	2.7	5.4	3.4
Cr	1.9	2.7	0.9	4.5
As	0.3	0.2	1.8	0.2
Hg	0.2	1.2	2.5	1.3
Cu	2.0	0.9	5.4	0.7
Zn	6.8	1.7	2.2	1.3

The physical composition of MSW will affect the types and contents of heavy metals in MSW. For example, the contents of Cd and Pb in plastic, Cd, Cr and Cu in printed matter, Cu, Zn and Pb in dry battery, Ni and Cd in storage battery are obviously higher than those in other waste components [12-13]. Yin et al. (2006) found that Cd is mainly from kitchen waste，dust and plastic; Se may come from electronic wastes; Cu and Zn come from dust and packing paper in urban，suburban and rural domestic waste of Chengdu; Pb in urban domestic wastes is mainly from dust，plastic and packing paper; Cr and Se in suburban domestic wastes are mainly from dust and Hg is mainly from kitchen waste and dust [14]. To determine the sources of heavy metals in MSW is helpful to guide the classification, transportation and disposal of MSW. Previous studies have shown that 76.3% of Zn and

82.3% of Cu in MSW are mainly from kitchen waste, dust, plastic and paper 4 components [15]. In summer, since the total amount of kitchen waste, dust, plastic and paper is higher than 90%, therefore, the content of Cu and Zn in MSW is higher in summer. The contents of Cd and Pb in MSW are relatively high due to the relatively high content of plastic in MSW in Haidian and Dongcheng districts.

5. Conclusions

(1) The main components of MSW in Beijing are mainly kitchen waste, the average content of kitchen waste are more than 60% and 50% in summer and in winter, respectively. The other two main components of MSW are plastic and paper, the two components accounted for 17-30% of the quality of MSW.

(2) The heavy metal pollution of MSW in summer is higher than that in winter in Beijing. Seasonal impacts should be taken into consideration when dealing with MSW.

(3) The content of heavy metals in MSW exceeded the background value of soil in Haidian and Dongcheng districts. In order to reduce heavy metal pollution, the MSW should be separated collection and treated.

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