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Urban household solid waste generation and collection in Beijing, China



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ABSTRACT

The household solid waste generated in Beijing is increasing quickly due to rapid population growth and lifestyle changes. However, there are no rigorous data on the generation and collection of recyclable household solid waste. The Beijing city government needs this information to establish policies and make plans for waste management. To address this need for information, we undertook the first comprehensive study of recyclable household solid waste for Beijing. We surveyed 500 families across sixteen districts in Beijing. We also analyzed the quantities, spatial distribution and categories of collected waste handled by permanent recycling centers and curbside recyclers for 340 of the 9797 city-defined residential areas of Beijing. From our results, we estimate that the total quantity of recyclable household solid waste was 1.805 million tons in 2013, and 72% of that was collected. The main generation categories were waste paper (24.4%), waste glass bottles (23.7%) and waste furniture (14.3%). In addition, we estimate there were 5.7 thousand permanent recycling centers and 22.8 thousand curbside recyclers in Beijing. The recycling rate of solid waste generated by urban households in Beijing was not low but varied significantly among different types of solid waste. The collecting capability of permanent recycling centers was inadequate. Urban residents had low awareness of some categories of solid waste recycling. The statistical system for waste management needed to be improved. Based on the problems mentioned above, the implications for solid waste management were discussed. We suggest accelerating the construction of permanent recycling centers and innovating the recycling modes. Meanwhile, it is also necessary to strengthen education on solid waste recycling and improve the recycling information statistics.

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1. Introduction

With the increase in urbanization, continuous growth in the population and a changing consumption structure, solid waste is growing rapidly in Beijing (Liu et al., 2009). In particular, the increase in solid waste generated by urban households is prominent (Gu et al., 2015). Large amounts of solid waste can be recycled (Cheng, 2006; Wang et al., 2014). With the prominence of resource shortage and environmental pollution, the Chinese government is paying greater attention to the recycling of solid waste (Wang, 2006; Feng and Zhang, 2009). Recycling solid waste helps to both conserve resources and reduce pollution (Li, 2000; Yu and Wang, 2001). To recycle solid waste successfully, one must have knowledge on generation and collection, including the categories, quantities, participants and channels for disposal. The success of waste management planning lies in the related knowledge and data

on waste generation and collection profiles (Chen and Chang, 2000; Zaman and Lehmann, 2013; Oribe-Garcia et al., 2015).

Several studies have been carried out to estimate waste generation in different countries and areas around the world. Most previous studies use statistical models such as factor models or regression models to identify the interrelationships between different socio-economic factors and urban waste generation (Afon and Okewole, 2007; Ojeda-Benítez et al., 2008; Lebersorger and Beigl, 2011). However, these models have two main drawbacks, data collection and identifying relevant explanatory variables within a heterogeneous group (Oribe-Garcia et al., 2015). Although many studies have been undertaken, due to the widespread distribution and diverse categories of urban household solid waste it is still difficult to obtain detailed information on waste generation and collection. In particular, information on participants, disposal methods, collection channels, and collecting proportions of different types of waste is still lacking. In China, some scholars have employed models to explore waste generation by different households or organizations in some provinces or cities of China (Li et al., 2011; Fu et al., 2015). However, there are no detailed data on

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Fig. 1. A map of our study area.

recyclable household solid waste collection in Beijing. The Beijing city government needs this information to make appropriate policies and plans for waste management. To address this need for information, we undertook the first comprehensive study of recyclable household solid waste for Beijing. Due to our research goal, we did not use conventional household audits as our research method. Our method provides a new convenient and feasible way for the city government, which has no historical data or sufficient information on waste generation and collection, to gain data on waste management. The results of our research will be able to support decision-making processes for the Beijing government's short-term planning for urban recyclable waste management.

2. Materials and methods

2.1. Study area

The investigation was carried out in 16 districts and counties, as shown in Fig. 1. These districts were divided according to the administrative divisions and functional areas of Beijing, China.

2.2. Investigation method

A random sampling survey was carried out. We investigated 500 urban households and 989 recycling sites in 340 residential areas through an internet questionnaire and face-to-face surveys. "Urban households" is defined as families with one or more urban residents. They were counted according to the non-agricultural household registration information. According to the Beijing Statistical Yearbook, in 2013, there were 3.962 million urban households in Beijing. We determined that the minimum sample size that would allow results with a 95% confidence interval was 385 (Song et al., 2012). Five hundred urban households were investigated, ensuring that there was a sufficient number of valid questionnaires to satisfy the sample size requirement. Recycling sites refer to organizations or individuals participating in solid waste recycling, including permanent recycling centers and curbside peddlers. Permanent recycling centers refer to organizations or individuals who have a recycling operation license and fixed location. Curbside peddlers refer to individuals who collect recyclable waste without recycling qualifications. According to data from the Beijing Municipal Commission of Commerce, there were 5979 registered permanent recycling sites in early 2014. However, the number of

Table 1
Survey sample distribution of Beijing urban households.

Area	Urban households of 2013 (10,000)	Percent (%)	Sample size
Beijing	396.2	100	500
1. Central functional area	81.7	20.6	103
Dongcheng district	34.5	8.7	44
Xicheng district	47.3	11.9	60
2. Urban function extended area	188.8	47.7	238
Chaoyang district	69.8	17.6	88
Fengtai district	39.6	10.0	50
Shijingshan district	14.0	3.5	18
Haidian district	65.3	16.5	82
3. New urban development area	85.9	21.7	108
Fangshan district	21.0	5.3	27
Tongzhou district	18.9	4.8	24
Shunyi district	15.5	3.9	20
Changping district	15.7	4.0	20
Daxing district	14.9	3.8	19
4. Ecological conservation development area	39.8	10.0	50
Mentougou district	8.9	2.2	11
Huairou district	6.1	1.5	8
Pinggu district	9.2	2.3	12
Miyun county	9.1	2.3	11
Yanqing county	6.5	1.6	8

Data source: The number of urban households in 2013 is from <http://www.bjstats.gov.cn/nj/main/2013-tjnj/content/mV48.0310.htm>.

curbside peddlers could not be confirmed and the minimum sample size of the recycling sites could not be calculated either. Thus, we ultimately investigated the recycling sites in 340 residential areas in Beijing based on the actual situation.

The sample size and distribution of households in each district and county was determined by the quantitative proportion of urban households, as shown in Table 1. The sample size and distribution of recycling sites were determined by the quantitative proportion of residential areas in the 16 districts and counties, as shown in Table 2.

2.3. Questionnaire design

Two questionnaires were designed, namely, Questionnaire 1 "Survey on the Generation and Disposal of Urban Household Solid Waste in Beijing" and Questionnaire 2 "Survey on Beijing Solid Waste Recyclers." The structure of and questions in the questionnaires were designed based on previously published papers (Chen et al., 2013; Kang and Wang, 2009) and the experiences of previous projects. After we prepared drafts, a focus discussion on the questionnaires was held with experts and project team members. Then, the investigation team carried out a pilot survey to test and improve the questionnaires.

Questionnaire 1 sought to investigate the generation and disposal of solid waste generated by urban households. The respondents were urban household residents. In the first page of the questionnaire, the purpose of the investigation and the concept of solid waste were explained. Questionnaire 1 contained 6 parts. Part 1 acquired basic information about the respondents and included 7 questions on their gender, age, family members, and so on. Part 2 had a fill-in-the-blank section regarding the variety and amount of solid waste generated by urban households in 2013. Part 3 to Part 6 investigated urban households' disposal methods for different types of solid waste and other specific information. Part 3 covered waste related to electrical appliances and electronic products and included 11 questions. Part 4 covered waste paper, plastics, ring-pull cans and glass bottles and included 9 questions. Part 5 covered waste related to old clothes, furniture and dry batteries and

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