Characteristics of community domestic waste separation: separation amount, physical and chemical characteristics

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Abstract. With the improvement of people’s living standards and the highly progress of urban construction, the management of domestic waste has become increasingly important. To a large extent, the treatment and utilization of domestic waste depends on the physical and chemical composition of the separated waste. However, there is an insufficient research on the characteristics of community waste after mandatory classification. To fulfill the existing research gap, a community that has started with waste separation was chosen for waste generation and separation. Three ways including weighed by community residents, weighed by community cleaners and weighed by automatic electronic scale were conducted in the present study. From households, food waste contained the biggest component, 49%, while the residual waste counted for 32% and the residuals were recyclable waste. When weighed by cleaners, the average amount of separated household food waste was on the range of 0.07-0.23 kg/d/person. In addition, an automatic electronic scale was invented to realize real-time weighing, and the quality waste bin, the peak weight as well as the concentration time for separation were recorded. When compared to the generation of food waste, 6% to 56% of household food waste was separated. In addition, physical and chemical components were conducted for conducting further analysis. The results demonstrate that food waste contains a high purity with a percentage of 98.76%.

1. Introduction

With the improvement of people’s living standards and the advancement of urban construction, domestic waste management has become one of the issues faced by urban governance. Based on the “2020 National Annual Report on the Prevention and Control of Solid Waste Pollution in Large and Medium Cities in China” [1], the domestic waste generation amount of Beijing in the year 2019 has reached 10 million tons, which has significantly affected public health and social development. Therefore, Beijing has officially implemented the “Beijing Municipal Domestic Waste Management Regulations” on May, 1st, 2020, which strictly divides domestic waste into four categories.

Domestic waste is a mixture of various wastes. The treatment and utilization of municipal domestic waste strongly depend on the physical components and physical and chemical properties of the separated waste [2]. Therefore, waste classification is a kind of management behavior as well as an environmental behavior. Regarding internal factors, knowledge and attitude on classification will generate an impact. Among the external factors, distance and conditions exert an important role.
In the meanwhile, the physical composition and amount of domestic waste generated by residents also reflect the willingness and quality of residents’ classified disposal, which is of great significance for promoting the further improvement of residents’ classification method [3-4].

The main components of domestic waste in the United States contain paper, plastic, textile, glass, metal, food waste and garden waste. However, after composting, recycling, and removing incombustibles from domestic waste, only the components of paper, plastic and textiles were used for solid fuel. Although the components of domestic waste in Japan vary from city to city, it is usually dominated by food, paper, and plastic.

The varies of composition of municipal solid waste changes greatly by regions, seasons as well as periods in China. There is a great randomness at the microscopic level. Actually, the composition of waste is much complicated. There are approximately 10 kinds of rough classification and hundreds of fine classifications. The various components of waste are intertwined and it is difficult to accurately classify. Due to the uneven distribution of garbage, sampling and classification method will have a relatively large impact on the analysis. However, the main component of urban domestic waste in China is generally food waste, and it is presenting an increasing trend.

The current research on Beijing’s domestic waste composition and properties has focused on the waste before the mandatory classification. After the mandatory classification, the physical composition and production of other waste and kitchen waste in Beijing’s domestic waste have experienced tremendous changes.

In order to fulfil this gap, the current study will take the classified domestic waste as the research object, and investigate the characteristics of household food waste and residual waste in a certain community of Beijing. In addition, our study intends to provide a theoretical basis and reference for the planning of end-processing facilities.

2. Materials and Methods

2.1. Research community
A community that has started with waste separation was chosen for the present research. This is a closed community with one residential building and one “waste separation” station. There are 308 households with around 1000 residents in total.

Following the extensively applied waste separation requirements, waste in this community is separated into four categories: household food waste, residual waste, recyclable waste, and hazardous waste.

2.2. Weighted by community residents
Twenty households were selected for volunteers in the community. The waste generated every day was weighted for a continuous month.

2.3. Weighted by community cleaners
Additionally, another 7 communities in the same district were also used for research. Cleaners in these communities are asked to weigh the number of trash bins produced every day and the weight of each bin. The current work lasted for two weeks.

2.4. Weighted by automatic electronic scale
In order to realize the real-time weighing of the trash bin, we invented an electronic scale that can automatically count the quality of bins. The trash bin weight at each moment is recorded in the system. We arranged an electronic scale for household food waste bins in this community.
2.5. Physical component distinction
Almost 15 kg of waste was poured out from trash bin and then each component was manually stored to food waste, plastic, packaging paper, toilet paper, textile, glass and tiles [5]. Each component was weighed separately.

2.6. Chemical composition analysis
Chemical composition and analysis are carried out, such as crude protein, crude fat, crude fiber, elemental analysis, and salt content. The detection method is referred to as described in Ref. [6].

3. Results and discussion

3.1. Characteristics of community waste weighed by residents
According to the waste separation instructions, residents divide household waste into four categories at home. During one month, there was no record of hazardous waste due to the small production. With an average production of 0.29 kg/d/person, the production of household food waste was on the range of 0.09 kg/d/person to 0.79 kg/d/person. The production of residual waste was on the range of 0.06 kg/d/person to 0.68 kg/d/person, with an average data of 0.19 kg/d/person. Recyclable waste produced 0.01 kg/d/person to 0.40 kg/d/person, and the average production is 0.11 kg/d/person.

Figure 1 shows the proportions of household food waste, recyclables and residual waste. Household food waste produced the most significant amount in daily life, with the balance of 49.15%, followed by residual waste, accounting for 32.20%. Since recyclables are not generated every day, the daily generation accounts for relatively 18.64%.

When recyclable waste was collected and transported to the resource recycling system instead of the sanitation system, the proportions of household food waste and residual waste are 60% and 40% respectively.

![Figure 1. Component of waste generation from households.](image)

3.2. Characteristics of community waste weighed by cleaners
The cleaners kept a record of the number of waste bins produced every day and the weight of each bin (household food waste and residual waste). It is of note that the amount of household food waste here is not the produced amount, but the separated amount. Moreover, not all of the residents participated in waste separation anytime. The residual waste bin contains both household food waste and residual waste, while there only remains food waste in food waste bins.

The separation amount of household food waste is 0.20-0.68 kg/d/household, while the generation amount of residual waste is 0.47-1.86 kg/d/household. Assuming that there are three persons in each...
household, the average amount of separated household food waste is on the range of 0.07-0.23 kg/d/person.

Figure 2 (a). The daily separated amount of household food waste. Figure 2(b). The daily generation amount of residual waste.

3.3. Characteristics of community waste weighed by automatic electronic scale

The automatic electronic scale can record the real-time of waste bin weight during 24 hours a day. One-week’s data were employed for analysis, as shown in figure 3. Residents throw waste from 6:00 to 23:00. The peak of household food waste delivery occurred between 19:00-20:00.

The empty waste bin weighs 9.4 kg, and the bin is only changed once a day, which is usually at 18:00. Therefore, during this one week, the household food waste separated amount is on the range of 0.17-0.29 kg/d/household at the average level of 0.22 kg/d/household, in other words, 0.05-0.10 kg/d/person with the average data of 0.07 kg/d/person.

Figure 3. Real-time weight of household food waste bin.
3.4. Comparative of different methods
The comparison of characteristics of community domestic waste separation under three methods was presented in Table 1. Since recyclables have a certain economic value, residents can get part of the income through selling instead of throwing into waste bins. As a result, the generation of recyclables cannot be effectively counted via cleaners or automatic electronic scale.

Compared with the food waste generation from households, amount 6% to 56% of household food waste could be separated.

Table 1. Comparison of the characteristics of community domestic waste separation

|                      | Household food waste generation kg/d/person | Residual waste generation kg/d/person | Recyclable generation kg/d/person | Household food waste separated kg/d/person | Residual waste generation kg/d/person |
|----------------------|---------------------------------------------|--------------------------------------|---------------------------------|------------------------------------------|--------------------------------------|
| Weighed by residents | 0.09                                        | 0.06                                 | 0.01                            | /                                        | /                                    |
|                      | 0.79                                        | 0.68                                 | 0.4                             | /                                        | /                                    |
|                      | /                                           | /                                    | /                               | 0.07                                     | 0.16                                 |
| Weighed by cleaners  | /                                           | /                                    | /                               | 0.23                                     | 0.62                                 |
|                      | /                                           | /                                    | /                               | 0.05                                     | /                                    |
| Weighed by automatic electronic scale | /                                           | /                                    | /                               | 0.17                                     | /                                    |

3.5. Characteristics of waste composition
Physical and chemical compositions of classified waste were conducted (Figure 4). The moisture content of food waste is 76%. With a percentage of 98.76%, the food waste contains a high purity. In residual waste, food waste still occupies a large proportion, with 33%. In comparison with the previous proportion of nearly 50%, there is a significant reduction. It was followed by contaminated toilet paper and plastic, with the proportion of 28% and 22% respectively. The content of packaging paper, advertising paper and others occupied 8%.

Figure 4 (a). Composition of household food waste.

Subsequently, chemical components of food waste were tested. Crude fiber, carbohydrate, protein and crude oil are the main composition. Crude fiber accounted for the largest proportion, exceeding 51%, followed by carbohydrates with the proportion of 26%. With the amount of less than 10%, the percentage of oil remains relatively low.
4. Conclusion

In order to illustrate the generation characteristics of community domestic waste, three ways were conducted, respectively, weighed by community residents, weighed by community cleaners and weighed by automatic electronic scale. Household food waste generation occupies the largest amount, while the proportion of food waste separation varies greatly, ranging from 6% to 56%, which is significantly affected by the behaviour of residents. Therefore, in-depth research on sustainable behaviour is needed for conducting further research. Physical and chemical components were carried out. The results demonstrated that food waste contains a high purity with the percentage of 98.76%. The percentage of each fraction in residual waste was detected as food waste (33%), toilet paper (28%), plastic (22%), packaging paper (8%) textile (4%), glass (4%) and others.

Acknowledgments

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References

[1] Ministry of Ecology and Environment of the People’s Republic of China. (2020) 2020 National Annual Report on the Prevention and Control of Environmental Pollution by Solid Waste in Large and Medium-sized Cities. http://www.mee.gov.cn/hjzl/sthjzk/gtfwwrfzl/.
[2] Ahamed, A., Yin, K., Ng, B. J. H., Ren, F., Chang, V.W.C., Wang, J.Y. (2016) Life cycle assessment of the present and proposed food waste management technologies from environmental and economic impact perspectives. J. Clean. Prod. 131: 607-614.
[3] Ekere, W., Mugisha, J., Drake, L. (2009) Factors influencing waste separation and utilization among households in the Lake Victoria Crescent, Uganda. Waste Manag. 29:3047-3051.
[4] Hage, O., Soderholm, P., Berglund, C. (2009) Norms and economic motivation in household recycling: Empirical evidence from Sweden. Resour. Conserv. Recycl. 53:155-165.
[5] Wu, X. H., Yue, B., Huang, Q. F., Wang, Q., Li, Z. L., Wang, Y. T., Yu, J. Y. (2018) Investigation of the physical and chemical characteristics of rural solid waste in China and its spatiotemporal distributions. Environ Sci Pollut Res. 25:1-13.
[6] Li, Y.Y., Jin, Y.Y., Borrion, A., Li, H. L., Li, J. H. (2017) Effects of organic composition on mesophilic anaerobic digestion of food waste. Bioresour. Technol. 244: 213–224.