Study on urban domestic waste recycling process and trash can automatic subdivision standard

Huaming Peng1*, Junxiang Zhou1
1School of Design, South China University of Technology, Guangzhou, 510000, China
*Corresponding E-mail:hmpeng@scut.edu.cn

Abstract. Objective In order to propose a garbage classification standard suitable for automatic subdivision of intelligent classified trash cans, and to improve the garbage recycling process. Methods Based on the status of urban domestic waste recycling process, process analysis and comparison method was used to analyze the related problems. According to the composition and nature of urban domestic garbage, the automatic subdivision standard suitable for intelligent classified trash cans was proposed. Result It is concluded that the traditional process has the problems of centralized treatment and vague positioning of each subject. Therefore, the keys should focus on the front-end classification to removal centralization, distinguish the positioning of each subject clearly and use technology to drive the classification. From these, the paper analyzes the composition and nature of recyclable garbage and harmful garbage to propose the automatic subdivision standard. Conclusion Only by making full use of people's subjective initiative, using intelligent classified trash cans as carriers to subdivide automatically, can improve the garbage recycling process. This has important practical value and significance for solving the problem of urban diseases in China.

1. Introduction
The garbage siege is a typical urban disease caused by the growth of China's economy and the people's living standards. With the acceleration of urbanization, garbage as a misplaced resource must be taken seriously and recycled under the environmental pressures such as shortage of land resources and limited energy. As a waste front-end treatment link, the important goal of waste sorting is high efficiency, low cost, safety and hygiene. The method of garbage classification is one of the keys to determining the success or failure of waste separation and utilization. [1] In the paper, the garbage recycling process is used as the research object to explore its existing problems, and corresponding suggestions are put forward. Based on this, the automatic subdivision criteria of trash cans are proposed by studying the nature and composition of garbage, aiming to provide theory for garbage recycling in China.

2. Overview of urban domestic waste
Since the reform and opening up, the generation and treatment of urban domestic garbage has gradually changed. The annual amount of urban domestic garbage in the country has changed from more than 31 million tons in 1982 to more than 200 million tons in 2017. The garbage production in 2020 is expected to reach about 323 million tons [2]. China's garbage growth rate is 10%, which exceeds the annual growth rate of garbage worldwide (8.42%). The annual urban waste generated accounts for nearly one-third of the world's annual garbage.
China is actively building garbage disposal facilities, improving the garbage collection and transportation system, and solving the garbage disposal pressure. In 2016, there were 940 garbage harmless treatment plants in the country, and the harmless treatment rate reached 96.6% [3]. China's harmless treatment facilities continue to grow, and the construction of domestic waste incineration power plants has increased year by year with the development of the economy. At present, China's harmless treatment technology has certain problems. Due to technical limitations and unsatisfactory results of waste sorting, incineration is prone to dioxin and will cause secondary pollution. The neighboring shelter will not be resolved [4]. Composting has higher requirements for feeding. The unsatisfactory waste classification has caused the compost to fail to achieve the expected results. While the landfill cannot meet the requirements of waste disposal in the case of shortage of land resources, and the landfill leachate is responsible for the pollution of groundwater resources, which is an urgent need to be solved. In the case that the technological breakthrough cannot be realized in a short period of time, a more complete garbage classification and recycling system can effectively reduce waste of resources, reduce the amount of garbage disposal, make the garbage components more concentrated, and improve the efficiency of harmless treatment facilities, reducing secondary pollution.

In China, starting from 2000, 8 cities including Beijing, Shanghai, Guangzhou, and Shenzhen were set as "pilot cities for domestic garbage classification and collection", and "big diversion and small classification" were basically adopted [5]. The 2010 "Technical Guide for Domestic Waste Treatment" promoted secondary resource utilization and waste reduction, and clearly pointed out that domestic waste recycling includes waste paper, waste glass, waste metal and waste plastics. In 2011, China increased the treatment of domestic waste. The "Notice on Further Strengthening the Work of Urban Domestic Waste Disposal" plans to fully implement the classification of domestic waste by 2030. In March 2017, China officially started the waste classification in a large-scale manner. The Implementation Plan of the Domestic Waste Classification System determined that 46 key cities will implement the mandatory classification of domestic waste in the urban area, and proposed that the domestic garbage recycling rate should reach more than 35% by the end of 2020. Compared with 35%, Zhou Chuanbin, Lu Bin, Chen Zhuqi and others have found that China's garbage recycling rate in 2015 is only 15% [6], far lower than the average level of global domestic waste recycling (including renewable resource recovery and composting), that is about 26%, while the average level of high-income countries is 33%. It can be seen that there is still a certain gap between China and developed countries.

3. Analysis of recycling process of urban domestic waste

The reason why China emphasizes the classification of wastes, in addition to the reasons for resource recycling, is that the rapid increase in the amount of waste generated exceeds the processing capacity and construction speed of waste innocuous treatment facilities, making the current garbage accumulation. There is an urgent need to reduce waste disposal through waste classification [7].

In the early stage of garbage sorting implementation, China's garbage collection and transportation adopts mixed collection and transportation, and the garbage disposal pressure gradually shifts to the front-end processing center. As the garbage in all directions is mixed to the sorting center, due to the large amount, various types and complex components of garbage, the sorting pressure of sorting centers and other institutions has increased sharply, and the employee's work intensity is high, resulting in high costs and low efficiency in waste disposal front-end processing. What's more, the end processing is performed without classification, resulting in a huge waste of resources. In the era of increasing labor costs and paying attention to efficiency, relying on the construction of sorting centers and hiring more employees to solve the problem of garbage sorting is not feasible, economical, and environmentally friendly. Relying on technology to drive garbage classification can solve problems more easily. Therefore, the automatic sorting center came into being. However, when the multi-source garbage is classified by the automatic sorting equipment of the sorting center, the multi-to-one garbage sorting mode will have the same problems with that of the early garbage manual sorting, such as
inefficiency, accumulation, and centralized processing. The urban domestic waste process at this stage is shown in figure 1.

![Figure 1](attachment:image1.png)

**Figure 1.** The centralized disposal process of traditional urban domestic waste.

The reason for the centralization and garbage accumulation phenomenon in the manual sorting and automatic sorting of the sorting center is that the boundaries of the responsibility of each subject are blurred in the actual waste sorting process, and even the obligations of some subjects are neglected, resulting in failure to reach the expected effect of the classification of domestic waste. Among them, residents and trash cans both play a very small role, and the combination of them only has a collection function. It can be seen that in the case that the front-end processing is not perfect, the garbage recycling process is lengthy, and the division is unbalanced [8].

Only when there are many-to-many, can we solve the many-to-one processing problem quickly. That is, it can decentralize the process, alleviate the processing pressure of sorting center, improve efficiency and reduce costs. To this end, the government began to advocate the participation of residents in the sorting, and trash cans separated by large categories of garbage gradually appeared on the market. The main function was to passively sort and recycle all kinds of recyclable garbage and harmful garbage. Residents carry out garbage disposal according to the classified trash cans, which relieves the pressure of subsequent garbage disposal to some extent. Under this circumstance, the residents are responsible for the task of garbage sorting, and the trash can still only play a collecting role. As shown in figure 2.

![Figure 2](attachment:image2.png)

**Figure 2.** The process of throwing large categories of garbage by residents.

At the same time, companies and technicians began to develop automatic classification trash cans. These trash cans can actively divide the garbage mixed by residents into various large types of garbage, and the residents only play the role of throwing garbage. The birth of the automatic sorting trash can plays a certain role in the situation that the classification consciousness of residents needs to be improved. The specific process is shown in figure 3.
Figure 3 The process of automatically sorting large categories of garbage in urban trash cans.

In summary, compared with the traditional garbage recycling process, the residents-trash cans links in the latter two processes play a considerable role in sharing the work of the sorting center, but the functions between them have not yet been clearly distinguished and played. These processes either focus on the classification of residents and ignore the development space of garbage cans, or focus on the automatic sorting technology of garbage cans and ignore the characteristics of residents sorting.

4. The key to solving the problems of garbage recycling processes

Through the study of garbage recycling processes that have been implemented or tried in China, it is found that the emphasis of different processes is different, and there are mainly problems such as centralization of disposal and indistinct distinction of the roles of each subject. To solve the related problems of the process, we need to start from the following aspects.

4.1. Focus on front-end classification and remove centralization

Peng Yuli [9] and others used AHP to analyze garbage disposal process and considered that the front-end classification and collection of domestic garbage was the best scheme for garbage treatment. Through the above process study, the main reason for the centralization is that it does not pay attention to front-end classification collection. Therefore, in order to solve the problems of centralization and garbage accumulation, we must pay attention to front-end classification. In view of the fact that the awareness of garbage classification of residents needs to be improved, incentives and credit measures can be taken to stimulate them to classify garbage. At the same time, enterprises can also be encouraged to build garbage sorting facilities such as trash cans and carry out garbage disposal jointly through PPP model.

4.2. Define each link subjects and distinguish their functions

In the last two cases of garbage recycling process mentioned above, the functions and characteristics of each subject are not taken into account after considering the front-end classification as a whole. The result of resident-trash can links in two processes is that the garbage is divided into various large types of garbage, whether resident classification or automatic sorting in trash cans. In order to classify the source garbage, it is necessary to accurately locate the human and trash cans, which are characterized by large cardinality, to distinguish and combine them and to make full use of their functions. Residents are the main body with subjective initiative. They can classify and even classify garbage carefully. With the development of technology, garbage bin is not only a collection bin, but also a device with automation technology. Resident-trash can link is the first half of front-end classification, which needs to be distinguished from the follow-up sorting center. How residents put garbage and how trash cans classify and collect are the key points of garbage front-end treatment. It needs accurate positioning to achieve the effect of garbage classification.

4.3. Using technology to drive garbage classification and realize wisdom environmental protection

With the development of large data, artificial intelligence, sensors and other technologies, urban domestic waste disposal can fully realize wisdom environmental protection advocated by the state. Intelligent management of garbage data, storage, collection and transportation routes is an important
means to improve the classification and treatment of urban domestic waste. Among them, the trash can is in the key position of carrying on the garbage classified by residents and opening up the follow-up classified treatment. More important, it can play a greater role on the basis of the resident classified delivery, such as automatic subdivision, which needs the support of technology. As the physical carrier of garbage front-end classification, it can carry a variety of intelligent hardware to become the key point of intelligent environmental protection. How and to what extent the intelligent trash cans classify automatically involves the follow-up research and design of its automatic classification standard. On the basis of the first two key points, using science and technology to drive garbage classification can effectively solve the problem of garbage treatment in China.

5. Research and analysis of automatic subdivision Standard for trash cans
According to the key points to solve the problem of garbage recycling process mentioned above, it can be understood that the premise of effective front-end classification is to distinguish the positioning of each link subject, and technology is its important support. As the contact point for waste disposal, the intelligent, automatic and efficient trash can is the key to realize wisdom environmental protection. The automatic subdivision technology is the main function different from the classification of residents and also an important research direction in the future. With advances in technologies, intelligent trash cans can guide residents to deliver large categories of trash and achieve automatic subdivision. In another words, paper, plastic, metal, glass, textiles and harmful waste can be further subdivided automatically after sorting. In this direction, the paper analyzes the composition and nature of various types of recyclable garbage and harmful waste, and combines the requirements of subsequent end treatment, including three methods of garbage recycling [10], requirements for harmless treatment facilities and requirements of waste recycling manufacturers, have developed standards for automatic subdivision of trash cans.

5.1. Paper: advanced waste paper, inferior waste paper and special waste paper
In the Waste Paper Classification Grade Specification (SB/T 11058-2013), it is divided into eight categories according to the source and use of waste paper, including waste cartons, waste newspapers, waste card paper, waste kraft paper, waste books and magazines, waste coated paper, waste page paper and special waste paper. This division applies to all aspects of waste paper recycling, sorting, processing, sales, and quality inspection. The main way of recycling of paper is the production of cardboard and white paper. Waste cartons, kraft paper, card paper and coated paper can be used for the production of cardboard. Waste newspapers, books, magazines and page papers can be used for the production of white paper, including newsprint, printing paper and toilet paper. Special waste paper refers to a specially treated waste paper containing high-humidity agent, asphalt, hot melt adhesive and other chemical substances, and its recycling process is different from other waste paper. Therefore, the initial classification can be carried out according to these three categories in garbage cans.

5.2. Plastics: thermoplastics and thermosets
Plastics used in daily life include thermoplastics and thermosets. Thermoplastics can be softened melted and reprocessed by repeated heating and easily recycled. There are mainly six kinds of waste plastics, namely polyethylene (PE), polystyrene (PS), polypropylene (PP), and polyvinyl chloride (PVC), acrylonitrile-butadiene-styrene (ABS) and polyethylene terephthalate (PET). Thermosets softens through the first heating to cause cross-linking reaction and solidifies and hardens irreversibly, and can not be softened and reused by heating again. Thermosets are currently used primarily as fillers for thermoplastics, paving in construction, and as gasoline and fuel after cracking. [11] The recycling forms of the two plastics are different. When trash bins can automatically subdivide, it can classify according to thermoplastics and thermosets.
5.3. Metal: steel, alloy and non-ferrous metals
The recyclable metals in urban domestic waste are mainly non-productive scrap metal, that is, metal products that have lost their original use value used by residents, enterprises and institutions for living materials and agricultural production. It includes waste iron and steel, such as waste kitchen utensils, waste agricultural tools, waste steel household supplies, etc.; waste alloy steel, such as waste stainless-steel tableware; waste non-ferrous metals, such as daily necessities made by copper, lead and other. The classification of the three categories meets the classification requirements of the subsequent recycling manufacturers. The automatic subdivision in trash cans can be classified according to these categories.

5.4. Glass: colored glass and colorless glass
In the Waste Glass Classification (SB/T 10900-2012), waste glass refers to glass that has been produced in the production and life of society and has lost all or part of its original use value and can be recycled and processed as raw materials. It is divided into three categories according to their state of nature and existence: flat waste glass, daily waste glass and special waste glass, and are subdivided according to color such as white, silver, green, brown and variegated [12]. Many foreign countries such as Belgium and France also recycle glass according to color [13]. The reason why it is classified according to color is that color is an important factor in the process of subsequent use. For example, colorless flint glass cannot be made from colored glass, while 10% green or flint glass can be added to produce amber glass, and cullet without color screening can only produce light green glass containers. Therefore, glass recycling must be based on color to select the cullet after consumption. In the process of recycling and automatically classification in the trash can, waste glass can be divided into colored glass and colorless glass and be subdivided in sorting center.

5.5. Textiles: wearable clothing and non-wearable textiles
In addition to the yarns, scraps, etc. produced during the production process, waste textiles also contain used textile garments and their textile products. People's consumption level is improved and clothing replacement is accelerated, which leads to the elimination of used clothing. Compared with other recyclable garbage, waste textiles have special characteristics. Large proportion of textiles used directly after recycling. Other waste textiles with larger damage are reused by other physical and chemical methods. For example, waste textiles can be cut into rags; blended textiles can be processed to produce flame retardants, pressed into sound-insulating materials, wall insulation materials, etc. [14]. The chemical method is mainly to re-synthesize the old clothes to produce polyester fiber or alcohol-dissolve and regenerate functional fibers. The primary classification of textile recycling in many companies is classified according to wearable and non-wear able methods [15]. If such classification is performed in the automatic subdivision trash can, the recycling of wearable clothes can be greatly improved, and the subsequent sorting process can be reduced.

5.6. Harmful waste: batteries, mercury-containing waste and packaged waste
Harmful waste refers to heavy metals, toxic substances or wastes that have actual or potential hazards to the human health, including waste nickel-chromium batteries and waste mercury oxide batteries, waste fluorescent tubes, mercury-containing thermometers, mercury-containing sphygmomanometers, waste pesticides, waste drugs and their packaging, waste paints and solvents and their packaging, waste mineral oil and its packaging, disinfectants and their packaging. Harmful waste are distinguished from recyclable waste, but it does not mean that harmful waste has no reuse value. The heavy metals in the waste battery can be extracted and recovered; the mercury in the waste lamp and thermometer can be recycled by high temperature evaporation and condensation, the fluorescent powder can be re-manufactured by chemical treatment, and the remaining glass and metal can be recycled; similar to waste textiles, the relatively clean package, such as the waste paint bucket, is washed and returned to the original unit for reuse or for packaging of the composite solid powder material, and the rest is incinerated. From the above, in the treatment of harmful waste, mainly heavy
metals, packaging materials, etc. are recovered. When recycling in the trash can, harmful waste can be classified and recovered according to batteries, mercury-containing waste, and packaged garbage.

6. Analysis of garbage recycling process of automatic subdivision in trash cans

Through the preliminary research on the recycling process of various types of recyclable garbage and harmful waste, the nature of waste and the subsequent recycling requirements, it can be found that many types of garbage can be subdivided and collected in the process of garbage collection. After determining the standard of automatic subdivision for the trash can, the garbage collection process is rearranged, as shown in figure 4.

Figure 4 The process of automatic subdivision in trash cans.

Compared with the above three recycling processes, in the garbage recycling process in the case of residential classification and automatic subdivision in trash cans, the main functions of each stage are distinguished clearly and the process is generally smooth and average. This recycling process gives full play to the subjective initiative of residents, pays attention to automatic subdivision in garbage collection, avoids pollution problems during the collection and transportation of recyclable garbage, and reduces sorting procedure in sorting centers. The process solves the problem of the centralization of the traditional recycling process and improves the efficiency.

7. Conclusion

In the case of the increasingly serious phenomenon of garbage siege, only by distinguishing the positioning and functions of each subject in the garbage recycling process and using science and technology to drive waste classification, can the waste treatment process be operated efficiently and thus solve garbage problem. By comparing the traditional garbage recycling process with the proposed garbage recycling process, it can be concluded that when the classification of residents is emphasized and more intelligent and automated garbage cans are used as carriers, multi-segment and multiple classification can be realized, and the process can be balanced. It can improve the efficiency of garbage sorting and recycling to a greater extent, solve the current situation of garbage siege, and quickly carry out urbanization construction.

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