International experience of garden waste recycling and its inspiration to China

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Abstract. The amount of garden waste produced in China is on the increase annually, but its recycling treatment attracts little attention, so that the recycling treatment rate stays low, which has gradually become an important issue that cannot be ignored for urban management. In order to better promote the treatment and re-utilization of garden waste in China, preserve resources, and achieve the sustainable development of urban ecology, a review is conducted in this paper on the experience of those advanced countries such as the United States, Japan and others in the policy-making, financial support and other practices of garden waste recycling, so as to provide the basis and reference required for the scientific, sustainable and reasonable practice of garden waste treatment and re-utilization in China.

1. Introduction

The garden waste (also known as green waste or yard trimmings) discussed in this paper refers to such plant waste materials as flower abortion, trees and shrubs, the trimmings produced in the process of urban and rural landscape maintenance and management, as well as the weeding, abandoned potted plants, natural plant debris and branches produced by wind, snow and rainfall, all of which are classified as municipal solid waste which is different from other urban domestic waste and construction waste. Garden waste is characterized by large volume, large occupying area, strong seasonality, the abundance of such organic substances as cellulose and lignin, non-toxicity[1], and high ecological value. With the rapid progress of urbanization and the growing demands of people for a better life and scenic ecological environment, the area of various green space in cities and towns is gradually expanding, in the meantime, the maintenance and management of gardens and green spaces is improved and specialized, while the production of flowers and seedlings continues to increase. Consequently, the amount of garden waste generated is on the rise constantly. For a long time, the treatment of urban garden waste has attracted little attention from the relevant authorities and the public. The vast majority of garden waste can only go to landfill or get incinerated along with domestic waste and construction waste. In some cases, garden waste is even disposed of at will, thus resulting in the serious waste of resources and exacerbating environmental issues. In light of this, this article sorts out the relevant policies of approaches to garden waste treatment adopted by foreign countries, based on which the analysis of the domestic situation is conducted to summarize the constructive experience and provides suggestions on the sustainable development of garden waste treatment and re-utilization for China.

2. Review of foreign garden waste recycle and utilization experience

Not only do those developed countries take legislative and executive measures to ensure the proper disposal and utilization of garden waste, they also pay much attention to the research and practice of
garden waste composting technology, so as to promote the scientific and reasonable development of
garden waste treatment. Among them, the United States, Japan and others have carried out scientific
classification and collection of garden waste, established large-scale composting and fermentation plants
for the treatment and utilization of garden waste, and implemented scientific and standardized process
management, thus building a well-developed garden waste recycling system. Through an in-depth
analysis of the practical experience gained by the United States, Japan and other countries in the
recycling of garden waste, this study is aimed to provide the reference required for the recycling of
garden waste in China.

2.1. America
In the United States, garden waste stems mainly from residential yard trimmings. According to
Environmental Protection Agency (EPA) data, the output of yard trimmings is increasing year on year.
In 2018, the output of yard trimmings amounted to 35.4 million tons, accounting for about 12% of the
annual output of urban solid waste. The approaches to garden waste treatment in the United States
include composting, land landfill and incineration for energy utilization. The proportion of garden waste
composting in the United States is also on the rise year on year, from 12% in 1990 to 63% in 2018[2].
The United States has a high degree of recycling of garden waste, which is achieved by the protection
of laws, policies and funds, the technical guidance provided by the government and associations, as well
as the active involvement of the society as a whole.

(1) Issue relevant laws and regulations. EPA launched the Resources Conservation & Recovery Act
(RCRA) in 1976. From the perspective of environmental legislation, the rational disposal of garden
waste plays an important role in the management of urban solid waste. In 1994, the “composting rules
for garden waste and municipal solid waste” (EPA530-R-04-003) [3] was published, with more specific
and scientific requirements and suggestions proposed from such perspectives as collection method,
treatment technology and odour control, design and layout of disposal facilities, technological process,
market promotion, product quality and community participation.

(2) Prepare and issue technical guidance manual. EPA has developed a variety of manuals, reference
books and effective plans in support of law enforcement, for example, the RCRA orientation Manual
(hereinafter referred to as “RCRA manual”)[4] not only provides guidance for the composting disposal
of urban organic waste such as garden waste and kitchen waste from a technical perspective, but also
defines the recycling product catalogue (including organic waste composting products) through market-
oriented application and promotion, thus supporting the federal government in the purchase of recycling
products and the development of policies aimed to promote the reutilization of composting products.

(3) Provide special fund guarantee. Apart from the policy support and guidance at the national level,
there are various funds set up by the state government[5-7] for improving the composting treatment rate
and utilization rate of garden waste, for example, the provision of machinery purchase loans for
treatment manufacturers, the requirement for the collection of garden waste to be charged so as to
subsidize the transportation costs of manufacturers, etc.

(4) The government, association, enterprises and the public take participation in various aspects.
With the special government policies as guarantee, the United States has set up a special composting
association dedicated to providing guidance on the treatment and utilization of garden waste. The
number of institutions or enterprises engaged in the treatment of garden waste rose significantly from
about 2200 in 1991 to 3800 in 2000[7].

2.2. Japan
Japan attaches much significance to the treatment and re-utilization of waste resources. By publishing
and enforcing a variety of meticulous and rigorous laws and regulations, economic incentives and well-
developed technical support, the Japanese government has reached consensus among the government,
enterprises and the public in waste treatment, which led to a series of remarkable results.

(1) A sound legislative system of urban environmental management has been developed. Japan
promotes the recycling treatment and reutilization of waste by enforcing such laws and regulations as
the basic environmental law, the waste treatment law and the renewable resources promotion law[8], in addition to endowing waste treatment with the principle of “grading”, including reduction, reuse, recycling and recovery[9]. In the meantime, economic incentives and promotion policies should be developed and put in place to promote waste reduction, recycling and reutilization. For example, the state enforced a 21% tax reduction policy applied to equipment used for environmental pollution control and a 15% tax reduction policy targeted at recycling equipment.

(2) Fine project management. For example, the “green recycling project” in Suginami-ku provides a variety of different approaches to treatment and reutilization from the perspectives of garden waste classification and different sources. For example, the thick trunk in the campus can be applied as manual work, bench or name board of trees. In addition, it is recyclable. The supporting technology is relatively mature and the degree of mechanization is high in the specific garden waste composting plant in Japan.

(3) Encourage the society to take active participation in the relevant work. In 2008, the Japanese Organic Utilization Association (Jora) was established under the support of enterprises, with the aim to provide opportunities and platforms for the cooperation between relevant organizations in the reutilization of organic wastes[3].

2.3. Germany
In Germany, the work related to recycling garden waste is performed from two perspectives. One is to formulate laws and policies while the other is to implement special plans.

(1) As for the laws, regulations, policies and measures on circular economy, ecological protection and waste recycling, they have been published at the national level. In 1976, engriffs regelung policy was implemented, which represents an ecological protection measure and the source of subsequent “circular economy and ecological compensation” policy[10]. In 1994, the Bundestag passed Gesetz zur Förderung der Kreislaufwirtschaft und Sicherung der umweltverträglichen Beseitigung von Abfällen (called as “the act of recycling economy”), which became the general principle special law aimed at the development of circular economy and the practice of waste disposal in Germany.

(2) From the perspective of carrying out the special plan, for example, Kassel plan was developed to promote the resource treatment and reutilization of garden waste under a specific project, and biodegradable plastic bags were proposed to help with the collection of garden waste[3].

2.4. United Kingdom
The United Kingdom attaches much significance to the exercise of tax, financial subsidies and other means of promoting garden waste recycling[6]. (1) Since 1996, the United Kingdom has started to levy certain taxes on the organic waste going to landfills for the purpose of reducing the waste entering landfills through the rise in landfill treatment costs. This economic measure has produced a significant effect on promoting the recycling of garden waste across the United Kingdom[6,9]. (2) Collection tools are provided for free. For example, in Kensington town and the Royal autonomous region of Chelsea, the government encourages residents to collect garden waste and distribute a certain number of collection bags to residents free of charge. Alternatively, residents can also pay for additional bags[4].

3. Current situation and existing problems of garden waste recycling in China
In China, the recycling of garden waste started late, as reflected in the flaws in the relevant laws and regulations, the low level of resource-based system, and the heavy reliance of treatment methods on landfill and incineration, all of which results in the low utilization rates of garden waste as a sort of organic resource. As the awareness of ecological preservation and restoration, resource conservation and sustainable development increases, China has published various policy documents and standards to guide the recycling of resources. For example, in 2007, the original Ministry of Construction issued Suggestions on the construction of energy-saving urban landscaping architecture, which proposed the natural ecological construction aiming at building resource-saving, environment-friendly society and promoting the sustainable development of urban landscape. The suggestion advocated the effort “to deal with pruned branches by composting, developing bio fuel, organic nutrient matrix and deep processing,
and so on, for reducing landfill capacity and reaching waste recycle. At the local level, Beijing, Shanghai and other cities have released a series of relevant policies and technical standards, which play a crucial role in promoting the recycling of garden waste.

### 3.1. Regulations and policies
Apart from national policies, Beijing, Suzhou, Jinan and other cities have also published their respective special regulations and policy documents on the disposal of garden waste resource, all of which propose the systematic construction of garden waste classification collection, transportation, treatment and reuse, as well as encourage the practice of composting, crushing and covering to dispose of garden waste. Table 1 shows the special policies currently enforced in China.

| District category | Names of Documents                                                                 | Issued Time |
|-------------------|------------------------------------------------------------------------------------|-------------|
| National Policy   | “Opinions on the construction of conservation oriented urban landscaping”          | 2007        |
|                   | Notice of Beijing Gardening and Greening Bureau on issuing the "Opinions on Accelerating the Scientific Disposal and Utilization of Garden Wastes" | 2018        |
| Beijing Policy    | “Implementation Opinions on Strengthening the Recycling Utilization of Greening Litter in the City” | 2010        |
|                   | “Implementation Measures for the Classification and Disposal of Urban Garden Waste in Suzhou City (for Trial Implementation)” | 2019        |
| Shanghai Policy   | “Opinions on Accelerating the Scientific Disposal and Utilization of Garden Wastes (for Trial Implementation)” | 2020        |
|                   | “Notice on Issuing the Implementation Plan for the Classification, Collection, Transportation and Disposal of Garden Wastes in Chengdu City (2019-2020)” | 2019        |

### 3.2. Planning and technical standards
Guangzhou, Kunshan and other cities have drawn up special plans for the treatment of garden waste. In combination with the specific development needs of an individual city, they have carried out planning and design of the garden waste classification collection, transportation and treatment mode, the adopted treatment technology, treatment facility layout and transfer, treatment plant construction, industrialization development and implementation plan, etc, which demonstrates the recognition given by the relevant government departments to the importance and urgency of the scientific disposal of garden waste, and the consideration given to the sustainable development of garden waste resource treatment from the perspective of top-level design. In respect of technical standard formulation, the state has published a national standard “technical specification for disposal and application of green waste” (GB / T 31755-2015) in 2015. Moreover, there are many local cities having issued technical specifications in combination with their own practice.

### 3.3. The status quo and problems of resource-based treatment
As urbanization level improves continuously across China, the landscaping industry has moved into a period of accelerated development. The area of urban green space has expanded significantly, which is accompanied by the increase of garden waste. The output of garden waste reaches a large scale, which makes it difficult to address. In this context, its disposal has started to draw widespread attention. At present, there are three main approaches to the treatment of garden waste[8]. The first one is landfill,
the second one is incineration with domestic waste, and the last one is resource utilization in small amounts, including composting, production of organic mulch, anaerobic fermentation, the production of biomass fuel, etc.

(1) However, there remains a lack of unified statistical means. According to the relevant statistical results, the total area of green space in Beijing surged from 38900 hectares in 2005 to 44800 hectares in 2009. Then, the output of garden waste rose to 1.9 million tons in 2005 and further to 2.36 million tons in 2007 [11]. Currently, most Chinese cities lack standard and unified statistical methods for counting the amount of garden waste, while the statistical department has yet include it in the relevant statistical category, thus making it difficult to collect the objective and accurate data on garden waste production. As urban green space area increases on a continued basis, the output of garden waste is gradually on the rise. In order to deal with garden waste more efficiently and scientifically plan and deploy the collection, transportation and treatment facilities of urban garden waste, it is essential to predict the output of urban garden waste precisely. At present, there are two statistical methods. One is that the related department to urban landscaping record statistics according to the amount collected, while the other is that it makes estimate according to the average value of sampling and the area of urban green space.

(2) The degree of resource utilization is low. According to the relevant statistical data, the total amount of garden waste from green space and street trees in Shanghai reach approximately 1 million tons annually, and the main resource treatment methods are composting and making organic mulch. So far, Shanghai has constructed a total of 29 garden waste disposal sites across 11 districts, with a total land area of more than 23000 square meters and an annual disposal capacity of over 67000 tons. It can be seen from above that the degree of recycling of garden waste in Shanghai is low. In Guangzhou, the annual average amount of garden waste is about 139000 tons. At present, the garden waste generated in Guangzhou is transferred mainly to Guangzhou urban garden waste resource recycling center for treatment, with the treatment scale reaching merely about 25000 tons / year b.

(3) The lack of policy-oriented garden waste recycling network system and matching infrastructure makes garden waste recycling challenging and costly. There are various garden waste, which is large in volume and widely distributed. In addition, there is no perfect collection, transportation and treatment system at present, as a result of which a large majority of garden waste can only be treated together with domestic waste or construction waste. In particular, it is unlikely to carry out site selection, layout and construction of garden waste recycling treatment station due to the absence of top-level design.

(4) The technology is flawed. Currently, China is reliant mainly on conventional open-air composting or trough composting, which requires a long treatment cycle. Compounded by low government funds investment and high processing cost, the enthusiasm of enterprises is easily dampened.

4. Inspiration of foreign experience on garden waste recycling in China

4.1. Strengthen top level planning and formulate special laws and regulations
The primary reason that hinders the development of the recycling of garden waste in China is that most government departments have yet to recognize the urgency of garden waste recycling and its crucial role in sustainable urban development. A combination of the lack of top-level design, the absence of relevant laws, policies and standards contributes to the recycling disposal of garden waste, the promotion of follow-up products, the establishment of marketing channels, etc. In the United States, Japan and other developed countries, well-developed laws and regulations and policy systems have already been put in place, which lays a foundation for the sustainable development of related work. Therefore, the enforcement of systematical laws and regulations, policies and technical standards is one of the important work required to carry out the recycling of garden waste. Firstly, it is necessary to optimize the collection and transportation system to improve treatment efficiency. It is recommended that the local government should pay attention to top-level design and consider the systematical establishment of classification, collection, transportation and treatment of the three major wastes including domestic

b Data coming from local administrative department investigated by authors in person.
waste, construction waste and garden waste. It is also essential to make full use of the existing relatively mature system of domestic waste collection and transportation, integrate the garden waste yielded from park and affiliated green space into the resource utilization system, and promote source classification, reduction, harmless treatment and resource recovery of garden waste to maximize the re-utilization of resources. Secondly, the government is supposed to enhance the cooperation between different departments. Since the resource-based treatment of garden waste involves various departments such as garden, urban management, environmental protection and planning, there is a necessity to establish an efficient resource-based system and ensure the landing of the treatment site. It is suggested that the government should combine the relevant works, for example, garbage classification, resource reutilization, start from the top-level urban design, and make arrangement as a whole, and optimize the functions and responsibilities of all departments. The key links of forest waste recycling treatment lay a solid foundation for the sustainable development of garden waste treatment.

4.2. Increase financial support and security
Currently, some Chinese cities have published relevant policies at the municipal or district level to incentivise and support the relevant enterprises to embrace the resource-based treatment and utilization of landscaping waste. However, there is still no clear financial subsidy system and relevant standards put into place. As required by the principle of "who produces, who is responsible", the generation unit of landscaping waste should be equal to domestic waste and a certain disposal fee is charged in China. However, the foundation treatment is almost free to collect and treat the garden waste generated by road or community pruning. The operation investment of enterprises is massive, which reduces the enthusiasm of enterprises about operation and development.

4.3. Strengthen technical process improvement and equipment research and development
On the one hand, the existing landscape waste treatment and composting technology encounters some problems, such as insufficient product fertility, long treatment cycle, single product and so on. As the output of landscape waste builds up, the treatment pressure is on the increase progressively, thus giving rise to such outstanding problems as how to better adjust the proportion of carbon and nitrogen, shorten the treatment cycle, improve the product maturity, and diversify the product category. Therefore, it is crucial to further explore the collaborative disposal process of garden waste and other perishable waste in line with the macro policy guidance on the construction of waste free city and the development of circular economy, and to carry out collaborative composting using the existing kitchen waste treatment facilities, so as to resolve such problems as low fertilizer efficiency, long fermentation time, and difficult landing of treatment site from a technical perspective. On the other hand, China is vigorous in promoting the development of the park system. There are an increasing number of community parks, street parks, small and micro parks, green squares, etc. According to the survey, the garden waste generated on the green space of such parks is basically swept into the municipal waste by sanitation workers everywhere, which causes a severe waste of resources. However, at present, the scale of site treatment for the recycling of garden waste is not as large required. Therefore, it is recommended to achieve the development of small equipment which is efficient and easy to operate for garden waste composting. Capable to be placed in all kinds of small park green space, the equipment can be used to either preliminarily or deeply treat the garden waste generated in the park, thus alleviating the burden placed on the plant for urban garden waste treatment.

5. Conclusion
The recycling treatment and utilization of garden waste provides a sustainable solution under the context of global resource recovery trend and climate change. It is important to ensure urban ecological security, improve the living environment, as well as promote resource recycling and green development. It is a significant content and specific measures of green and low-carbon city construction. Garden waste is supposed to be treated in line with local conditions, harmless nearby, reduced and resourceful. According to the exact characteristics of an individual city, it is necessary to explore and establish a
classification, collection, transportation and treatment system in line with the local reality, research and formulate the relevant policies, regulations, standards and incentive mechanisms, and promote the recycling treatment and utilization mode of garden waste comprehensively based on composting. In the meantime, combined with the promotion of waste classification, the top-level design and scheme implementation of department cooperation and urban organic waste resource treatment shall be explored. In combination with the implementation project, the sustainable development of garden waste resource treatment and utilization can be better promoted.

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