

# Treatment of Municipal Solid Wastes: Foreign Experience and China's Reference and Associated Policies

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## Abstract

Municipal solid wastes (MSW) have become an important factor constraining China's economic, social and environmental development and affect the lives and health of residents nowadays, too. Therefore, how to effectively deal with the growing MSW has become an important issue in China. This study shows that the main reasons leading to the dilemma of Chinese waste management are the unfair administrative way of solid waste management, the lack of economic incentives and the unfair recycling use and management. To solve these problems, it is necessary to learn the experience from successful countries in waste management and to take policy measures from market-oriented operation, charging system, producer responsibility, recycling scheme and so forth. At the same time, it is necessary actively to create conditions to bring government, residents and businesses together to realize the industrialization of China's MSW disposal and virtuous circle.

**Keywords:** Municipal solid wastes; Market; Charging system; Producer responsibility; Recycling system

## 1. Introduction

With the continuous development of urbanization, municipal solid wastes (MSW) continue to grow, which has triggered a series of ecological, environmental, economic and social problems and posed a serious threat to the sustainable development of city and the quality of residents' life. In the process of rapidly economic growth, China is also facing increasingly serious problems of MSW. During the period of 2004 to 2011, MSW amount had an average annual growth of 1,107,500 tons, and in 2011 its total amount reached 16,395.3 tons. How to effectively reduce MSW and promote waste recycling has become an urgent problem for China.

In China, Urban sanitation department is responsible for the removal of MSW including infrastructure construction and management, which is costly but inefficiently. Mixed recovery is still a common way in China's waste collection, which caused great difficulties in the sorting and subsequent processing of wastes. Sanitary landfill, incineration and compost accounted

for 61.38%, 15.85% and 1.14% in 2011 respectively and a lot of recyclable resources are wasted in the process.

Developed countries have also experienced severe MSW problems in the process of industrialization and urbanization. After management innovation and technological improvement for many years, many of them have entered a virtuous cycle with waste reduction, recycling and harmless disposal. The countries like Germany, Sweden, Norway and Japan have achieved particularly significant success in this field. They have established a complete system of MSW management after decades of study and practice and their successful experience is worth to learn.

Traditional approach takes harmless as the main manner in MSW disposal, focusing on the final link of waste disposal, that is to say, minimizing the damage to environment is the ultimate purpose of MSW disposal. Some countries such as Germany and other countries introduced the concept of circular economy in MSW, which treats the wastes from its generation, recycling, utilization and final treatment as a complete economic process and thereby is in accordance with the orderly procedure of 'source control-recycling-harmless disposal'. This circular economy concept has deeply influenced every aspect of MSW management in those countries and achieved the comprehensive goals of waste reducing, recycling and harmless to environment.

The concept of circular economy would no longer treat waste as garbage, but as available resources. For example, Kitchen waste contains a lot of organic matter, which can be used for composting; most papers, glasses and scrap metals are good renewable resources, which can be recycled directly; incineration is the right method to dispose high calorific MSW, using the heat to generate electricity and so forth. MSW management should take circular economy theory as a guide, focusing on comprehensive management.

After the 1970s, abroad studies about waste disposal are increasing, mostly in the effect of economic factors on waste generation and recycling rate (Baumol, 1977). As for how to reduce waste generation and increase recovery rate, many scholars believed that some economic stimulus measures should be taken, such as charging policy including 'pay by amount' (Reschovsky and Stone, 1994; Dahlén and Lagerkvist, 2009, etc.). Studies in MSW have a later starting in China and most of them were the summarization of foreign experience, mainly in the aspect of marketization (Fengya Bin, 2001; Huayou Li and Xuezhixiao, 2003, etc.).

Overall, the range of foreign studies is narrow, and the event study method is mostly employed to explore the economic stimulus impact on household wastes, which provide certain reference for the MSW management of China. Domestic researches focused on either the mode of operation or the technical approach, and the summaries of methods for foreign experience is fragmented lacking of systematic property and operability, rarely suggesting any management policies being applicable to China. This paper tries to explore the successful experience of developed countries in the market promotion of MSW management to provide some reasonable and feasible suggestions for China.

## **2. The market-oriented operation of foreign MSW disposal**

During a very long period of time, MSW disposal was treated as public services provided by government. However, in this situation, government needs to put a lot of money into MSW disposal and handles a full range of services, which leads to high costs and low management efficiency. A lot of successful experience in MSW disposal shows that the introduction of market mechanisms and the reduction of government's administrative role is a trend.

## **2.1 Operation mode**

In China, MSW services are provided by municipal sector, while many foreign countries use the power of both government and enterprises to deal with MSW problems. Public-private partnerships, fully market-oriented operation and community treatment widely used abroad are several different modes on MSW treatment.

In many cities of the United States, specialized enterprises are responsible for urban solid waste, and residents charge a certain amount of waste fees for the enterprises that made contracts with the municipal sector. However, the cost of waste disposal is difficult to be computered. If contracted by a single company, it is possible to cause irreparable investment-income situation and difficult to improve the efficiency of waste disposal. For example, Phoenix city has experienced this situation before. To this end, this city was divided into several areas, and the government and the private sector each bears the waste disposal work of half of regions respectively, and thus the competition between the government and the private sector is formed, which stimulates both to be committed to improve waste treatment efficiency ( Xiang Zhong and Jie Xue, 2004 ).

In Germany, municipal sector gives communities the right to manage MSW disposal, so communities have greater autonomy and may decide to deal with waste by their own or by enterprises through contracting. The flexibility of this way is stronger and easier for community management. At the same time, It is also a good way to reduce the regulatory pressure of municipal sector. However, because communities are usually small-scaled, either of these two choices may lead to high costs, the cooperation with neighboring communities to expand the scale and share the cost becomes a viable option.

## **2.2 Charging according to the amount of garbage**

Many countries charge to the residents by a certain amount of waste, that is, more the waste amount produced and more the waste fee charged (Bilitewski, 2008). Dahlén and Lagerkvist (2010) through researching Norwegian waste charging mode found that pay by amount has many advantages such as reducing the amount of waste collected (15% -90%) , increasing the transparency of waste management costs, strengthening the recycling system, encouraging families to treat themselves and so forth. It can be seen that pay scheme by amount has the significant effects of controlling from source including achieving the goal of reducing waste and increasing recycling rates. Judging from the situation abroad, charging scheme by amount is usually divided into the following modes.

### **2.2.1 The combination of fixed fee and floating fee**

German adopted the mode that a basic fee plus the service cost. In addition to pay the fixed fee, residents are also required to pay variable fees according to household waste quantity generated in their families. As a result, residents would be able to influence their waste disposal fee through their own behaviors, which helps to reduce waste generation (Andreas Nieweler, 2003). In the real operation, trash removal companies usually measure the wastes generated by volume or by weight and record them as a proof for charges.

### **2.2.2 Product fee scheme and tax for enterprises**

Except for charging residents waste collection fees, Germany has also set up disposal fees specifically for the corporate producers (called product fee), which charge mainly to the packaging business. Constrained to product fee scheme, production companies have to implement intensive production, which helps to reduce excessive packaging and raw material waste. At the same time, the products with simple packages will generate less solid waste accordingly. Therefore, the product fees of firm used as the funds of MSW disposal help to ease the financial pressure of the government. To some degree, taxes reduce waste

generation and conserve resources. In addition, the taxes of environmental resources have a positive impact for some of the municipal solid waste treatment, too (Huayou Li and Xuezhi Xiao, 2003).

### **2.3 The industrialization of waste disposal**

Waste treatment is a national cause, which needs the participation of governments, private sectors and residents. The common practice such as Germany and other EU countries is that they have adopted social organization forces and enterprises to participate in MSW disposal, and all of those were bought together to form a specialized waste recycling organization. The bidirectional recovery system (DSD) in Germany is one of typical examples.

Germany laws require both producers and sellers to be responsible for product packaging recycling. In order to avoid the high costs of separately recycling, 95% enterprises including production, packaging and sale have set up a joint venture company called as the green point (DSD) specialized in waste recycling. DSD company provides the disposable packages with 'green point' logo for the companies entrusted and charges them 'green point fee'. After those 'green point' packages were collected, they will be transferred to waste disposal companies that signed a contract with DSD (Aoki, 2004). The establishment of 'green point' recycling system saves not only a lot of waste recycling costs for the production and packaging companies, but also makes a significant contribution for the German waste treatment industries.

### **3. The basic approaches of abroad MSW disposal**

Aside from source control, improving recycling rate is effective to reduce MSW, too. A higher recycling rate may not only make the wastes into valuable resources, but also reduce a large part of MSW in the process of recycling, making the terminal treatment pressure relatively smaller. To improve waste recycling rates relies on scientific management as well as technological advance.

#### **3.1 Classification recycling system**

##### **3.1.1 Fine classification and timely collection and recovery**

Japan is the most successful country in waste sorting and recovery, and it has a very comprehensive garbage collection system and high waste recycling rates. This is closely related to Japan's policies and methods on the sorting, collection and recovery.

In many Japanese cities, MSW is generally divided into broad categories like combustible waste, non-combustible materials, resource waste, bulky waste and hazardous waste and on this basis some items are classified into more detailed categories. Some cities hand out garbage classification brochures to residents often containing more than 20 pages with 500 or even more terms. In addition, residents have to follow the classification regulations of wastes to treat the various types of wastes to make the recycling easier. The fine sorting of MSW provides a great convenience to subsequent recycling (Wensheng Zeng and Fanrui Wu, 2010).

In recovery, some communities put a row of recycling bins, and some made schedules that collect specific categories of wastes at a specific time and place. For example, in Tokyo, Monday morning is the time to collect non-burnable garbage, and resources received in Tuesday morning, while Wednesday and Saturday morning are for the collection of burnable garbage and so forth. Many communities require the collecting time usually before the eight in the morning. Though in some communities it would be extended to noon, the wastes would be taken away during the day, so as not to cause environmental pollution or attract pests (Guang Hong, 2006).

##### **3.1.2 Curbside recycling service and garbage delivery center**

The function of curbside recycling and the role of garbage delivery centers usually are studied as an important factor affecting the recovery of garbage. The study of Sidique et al (2009) found that, the curbside recycling and delivery centers of garbage may effectively enhance the recovery rate. Therefore, in densely populated areas a wider range of radiation center should be set up and many places should set up separate collection of trash on the street. The local garbage company will be responsible for the curbside recycling of garbage to be transported to the nearest garbage central place and then additional processing is made again.

### **3.2 Deposit-refund scheme for recyclable garbage**

The deposit-refund scheme means that sellers make a deposit for consumers and producers in advance, and again return the deposit to them until the obligations is fulfilled. "Mandatory beverage container deposit system" adopted by Germany in 1988 set that, consumers need more to pay a fee as a deposit when they buy drinks to ensure that the use of beverage containers will be returned to the store and recycled. In addition, "Packaging Ordinance" released by Germany in 1991 also stipulated that, the deposit may be returned, only when the product packaging is returned to sellers. The implementation of this scheme helps to reduce the discards of recyclable materials, and makes the recycling and use of recyclable materials more user-friendly and reduces recovery costs.

### **3.3 To increase the investment of recovery and use education**

Callan and Thomas (2006) found that recycling effect would be much better for the communities putting more money into recycling education or equipment than those inputting less. Although the consistency between environmental awareness and real behavior is not high, residents with more sorting and recycling knowledge would do better under the implementation of mandatory recycling policy. In fact, the recovery rate may be enhanced to 2%, when \$ 1 per capita is invested in environmental education per year (Sidique et al, 2009).

The purposes of strengthening environmental education are not only to improve environmental awareness, but also to let residents to get more knowledge of waste sorting to make the household to sort and process the wastes as required. In Japan, government often provides residents brochures with waste sorting containing the detailed information of sorting knowledge. Germany invests heavy funds in environmental education and takes full advantage of rich educational resources such as natural history museums and forest parks to educate residents to be close to nature and love the environment in their childhood, so waste classification education has been deeply rooted.

## **4. The real status and problem of Chinese MSW disposal**

With the development of industrialization and urbanization, the MSW problem is growing. If the increasing MSW can't be properly taken, it will cause soil pollution, water pollution, air pollution and other ecological and environmental problems, which cause serious damage to the living environment. Although China has steadily increased its investment in MSW, the situation is still not optimistic and many problems still exist.

### **4.1 Lagging ideas**

Germany and other developed countries have introduced the concept of circular economy to waste disposal in early 1970s. They focused on source control to reduce the amount of waste generated and process wastes in every links, and in the last link the remains would be much less. However, even today China still focuses on the final link with the targets of harmless treatment. From the perspective of the amount, the total waste amount of China

has been showing an increasing trend ( see Fig. 1), and the amount of garbage generated from the source has not been controlled. In addition, though China's MSW harmless disposal rate has reached 77.9% by 2011, approaches are still dominated by landfill (see Fig. 2), which took up a lot of lands (data source: National Bureau of Statistics).

This kind of lagging idea in waste disposal leads to the problem that Chinese MSW can't be completely resolved. Only to take circular economy concept as a guide and set reduction, recycling and harmless as a comprehensive goal, Chinese MSW treatment may be upgraded to a scientific development path.

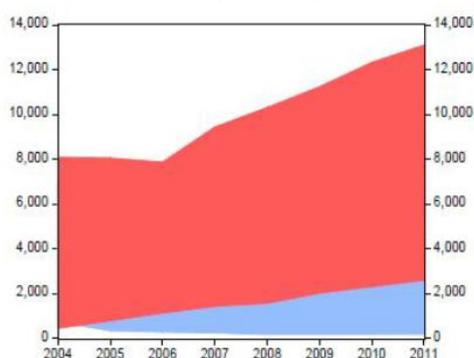


Fig. 1 Transported MSW from 2004 to 2011

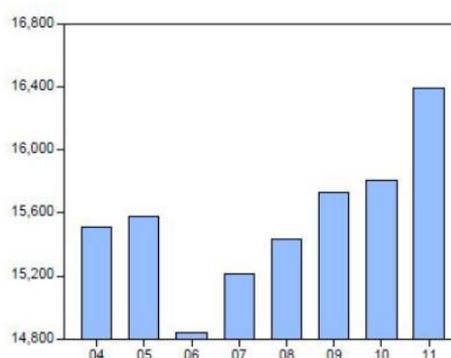


Fig. 2 The proportion of harmless processing of MSW from 2004 to 2011

#### 4.2 Unreasonable management system

In China, MSW disposal is a responsibility of municipal department. In fact, the government is in charge of the whole process from infrastructure construction to final disposal, which increased the government's financial burden.

In addition, under the current system the lack of incentives is the main reason resulting in the high costs and low efficiency of waste disposal. Because the MSW disposal services are not directly related to providers' interests of services, it is very hard to control costs. Therefore, administrative management scheme leads to the inefficiency of China's waste management and recycling.

#### 4.3 The defects of conventional charging system

In many countries, the funds of MSW disposal are derived from taxes or from personal or family fees. Disposal fees are usually divided into two groups of fixed fee and variable fee. However, China adopted an annual fixed fee approach. Although the fixed fee of waste disposal charges relatively simple, it may cause a lot of problems.

On the one hand, the fees are not linked with waste amount, resulting in residents and enterprises to tend to stand by and regard waste disposal as entirely responsibility of government, which is not conducive to reduce waste and to realize the target of reduction. On the other hand, most cities in China charge less than the cost of waste disposal, and this requires financial subsidies, which add financial burden to government and at the same time the target of waste disposal is also difficult to be achieved. Traditional charging approach has been unable to meet the needs of Chinese MSW disposal.

#### 4.4 Garbage sorting and recycling system based on mixed collection

Aside from source to control waste production, improving recycling rate is also a very effective way to reduce waste. A scientific classification recovery scheme may not only improve recycling rate, but also save a lot of resources. At the same time, it may greatly reduce wastes in recycling and reuse process, relieving pressure on the end treatment.

However, the mixed collection of MSW is still in dominance in China, which causes great difficulties to subsequent recycling. Although curbside trash bins marked “recyclables” and “non-recyclable” were set up in many places, wastes are always put in the wrong ones and household waste sorting hasn’t been implemented. Because there are not supporting incentives and coercive measures, waste sorting and recovery scheme was not effectively implemented in China.

#### **4.5 Imperfect laws and the low-level participation of citizen in waste disposal**

China has not still relevant law or regulation to regulate the producers’ responsibilities of MSW, while waste disposal is completely treated as public services provided by the municipal department. Because of the lack of relevant regulations, associated producers and sellers are not responsible for the waste generated in production and packaging process, which caused the common phenomenon of excessive packaging and resulted in a large waste of resources and environmental pressure.

In addition, because there is few recycling education or sorting regulation for family in China, residents lack waste sorting knowledge and awareness to do preliminary classification with their household wastes. As a result, China's waste recycling policies can not be implemented effectively.

#### **5. Associated measures to solve the disposal problems of MSW in China**

Developed countries have also experienced the difficulties like China in MSW disposal. However, after management innovation and technological progress for many years, many countries have established a complete system of MSW disposal. It is important for China to learn from those countries’ successful experience in MSW disposal.

##### **5.1 The implementation of the market-oriented operation of urban MSW management**

Comprehensive services provided by government from waste collection to final disposal are the main reason resulting in high costs and low efficiency in China’s MSW disposal. Therefore, it is necessary for China to introduce market mechanisms and gradually decrease the government's administrative role in the garbage disposal, which is an inevitable selection for China.

The first is to practice public-private partnership mode. In the establishment of large-scaled waste treatment plant, government may adopt the BOT (Build-Operate-Transfer) mode. As a result, government will save a lot of money and waste management efficiency will be promoted since enterprises care their own profits and losses, too.

Secondly, the mode of competition between government and private sector may be made. In this situation, municipal department gives the right of enterprise specializing in waste disposal to make waste collecting and disposal through the form of contract permitting the enterprise to charge residents the waste disposal fees. In order to prevent monopoly and the consequence of low efficiency in waste disposal, a city may be divided into several areas and each of government and private sector bears half of regions’ waste disposal work, which result in a completion between government and private sector to make them to reduce costs and improve the efficiency of waste disposal.

Finally, community processing is a good way to manage MSW, too. In this mode, municipal department empowers communities to dispose wastes independently and communities may decide to handle their own waste or choose fair enterprises to take waste disposal. It is a flexible and convenient way for communities to manage wastes and a good method to reduce pressures for government, too. However, because communities are usually small, the high costs would be unbearable. In this case, to cooperate with neighboring communities to expand the scale and sharing the costs will be a viable option.

## **5.2 The implementation of charging scheme through the pay by amount**

In waste charging scheme, China may learn from western countries through the pay by amount way, which requires residents to pay appropriate waste disposal fees to control waste generated.

### **5.2.1 The combination of fixed fees and floating fees**

This is a charging mode that a basic fee plus the cost of garbage services. In addition to fixed fees, the residents are required to pay the fees of waste disposal according to the amount of waste generated by individuals or families. The fee must compensate for the costs of waste disposal and thereby the fees vary with the change of costs every year. As a result, residents may pay less through controlling their household wastes, which would be helpful to reduce waste generation.

In practice, trash removal companies would measure and record wastes from each family by volume or by weight, and the record would be a proof of charging.

### **5.2.2 Pre-paid and garbage quota scheme**

Pre-paid means residents have firstly to buy particular garbage bags of different contains from municipal department, but waste removal companies would only clean up garbage bags that meet the standard and requirements. Because the purchase of a specific garbage bag costs residents extra money, they tend to use less garbage bags through controlling waste amount.

In addition, municipal department may implement garbage quota scheme considering local reality. In this scheme, the waste within given quota will be charged a fixed fee, while excess waste beyond the quota charges an extra fee. Segmented pricing approach can be taken, that is, greater yields means higher rates.

## **5.3 Introduction to producer responsibility scheme and garbage taxes on relevant enterprises**

Producer responsibility scheme means "polluter pays", which lets enterprises to bear their responsibilities in MSW disposal. It is another important measure for China to achieve the source control of MSW.

The core of producer responsibility scheme is to set up a charging scheme specifically for producers. Constrained by waste disposal fees, producers had to practice intensive production, so it is conducive to reduce the phenomenon of excessive packaging and raw material waste. At the same time, because the products bought by residents are simply packaged, solid waste generated will be reduced accordingly.

## **5.4 The establishment of a scientific and effective recycling system with mandatory recycling policy**

### **5.4.1 Fine classification and the recycling education of residents**

In waste sorting, China should learn from Japan's sophisticated classification methods to classify wastes into broad categories like combustibles, non-combustible materials, resources, bulky waste, hazardous waste and so forth.

The purpose of fine classification is to encourage residents to sort their household wastes initiatively so that subsequent recycling processes will be more convenient. However, because waste sorting knowledge is very complex, it is necessary to teach residents how to sort household waste correctly. In addition, government may also give residents detailed manuals on waste classification and appropriate treatment.

### **5.4.2 The implementation of mandatory recycling policy**

In order to ensure that residents do waste sorting as required, it is necessary to implement a mandatory recycling policy, which is mainly reflected on waste removal. A row of different recycling bins should be placed in communities, and there is a specific time and place for specific categories of waste. Different wastes must experience family classification with appropriate treatments such as washing beverage containers and crushing the tray and so on. Anything not meeting the sorting requirements will not be recycled.

#### **5.4.3 The practice of deposit-refund scheme on recyclables**

This policy requires consumers to pay a fee for recyclable packages of products what they bought. And only when packages were returned to the store as required, the deposit can be returned. This scheme not only helps to reduce discarding recyclables, but also makes the recycling of recyclable materials to become more simple and cheaper.

### **6. Conclusions**

MSW disposal requires government, residents and business to work together and take their own responsibilities. It is only way to promote Chinese MSW disposal. Residents should control the generation of household waste and play an active role in the initial classification. Of course, all these need the incentives of charging scheme like the pay by amount. At the same time, environmental protection education for residents from government or social organizations is very important, too.

As for producers, enterprises should control raw material consumption to reduce potential waste generation. In addition, enterprises should take social responsibility through setting up organizations in certain industries to promote domestic waste disposal efficiency.

In order to make residents and enterprise act more correctly and initiatively, government must make appropriate guidance and strengthen supervision in this area to create a complete legal and institutional environment for MSW disposal. On the other hand, government also needs to reduce or even give up the providing of MSW disposal services to let the market to do it.

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