

Municipal Solid Waste Management in China

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Part 1 MSW Management in China Mainland

INTRODUCTION

No country has ever experienced as large or as fast an increase in solid waste quantities that China is now facing. In 2004 China surpassed the United States as the world's largest waste generator, and by 2030 China's annual solid waste quantities will increase by another 150% - growing from about 190,000,000 tons in 2004 to over 480,000,000 tons in 2030(Delvoie 2005). This growing waste stream has significant impact for the society, environment and economic development.

The Quantity and Composition of MSW in China

The definition of municipal solid waste (MSW) should include all waste generated since the municipality may be required to assume responsibility if there is no longer sufficient impetus to remove the material from the waste stream. This report defines MSW as all waste originating in urban areas from residential, industrial (non-hazardous), commercial and institutional sectors.

Most Chinese municipal solid waste generation data is presented in three categories: municipal, industrial, and hazardous waste. 'Municipal waste' usually includes residential, institutional, commercial, street cleaning, and non-process waste from industries. In some cases, construction and demolition waste is also included and can dramatically skew the generation rate, especially in times of high economic growth and related construction activity. 'Industrial waste' is usually limited to 'process waste' such as process by-products like scrap metal, slag, and mine tailings. 'Hazardous waste' usually refers to industrial hazardous waste generated as a by-product of the manufacturing process, medical waste, small-scale generation of hazardous waste from households, institutions and commercial establishments, and occasionally small amounts of radioactive waste, e.g. smoke detectors and medical process waste.

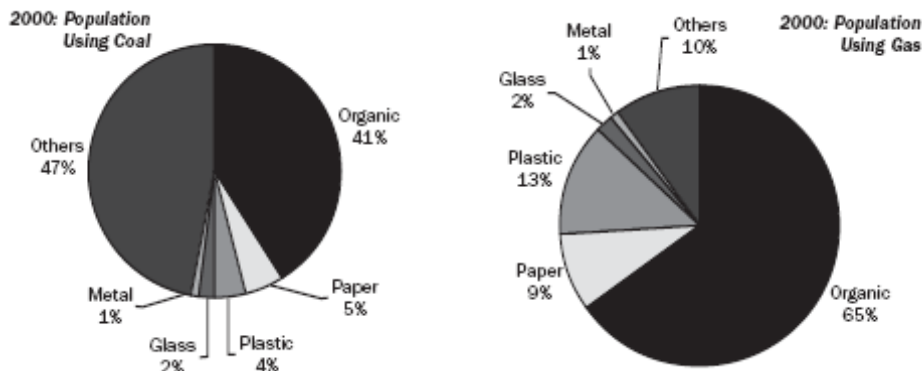
The categorization of wastes in China is not always consistent or comprehensive from city to city and adversely affects the utility of the database. And most available information in China is based on 'waste collected' data rather than 'waste generated' data. However, waste generated data is more useful since it includes recyclable secondary materials, and encourages more full-cost accounting of the overall MSW system and program financing. Data presented in this report are waste generated estimates.

Table1: Projected Municipal Waste Generation for the Urban Population in China

Year	Projected Urban Population (thousands) ¹	Low Waste Generation MSW		Expected Waste Generation MSW		High Waste Generation MSW	
		Rate (kg/p/day)	Generation (tonnes)	Rate (kg/p/day)	Generation (tonnes)	Rate (kg/p/day)	Generation (tonnes)
2000	456,340	0.90	149,907,690	0.90	149,907,690	0.90	149,907,690
2005	535,958	0.95	185,843,437	1.00	195,624,670	1.10	215,187,137
2010	617,348	1.00	225,332,020	1.10	247,865,222	1.30	292,931,626
2015	698,077	1.05	267,538,101	1.20	305,757,726	1.50	382,197,158
2020	771,861	1.10	309,902,192	1.30	366,248,045	1.60	450,766,824
2025	834,295	1.15	350,195,326	1.40	426,324,745	1.70	517,680,048
2030	883,421	1.20	386,938,398	1.50	483,672,998	1.80	580,407,597

data source: United Nations, 2002

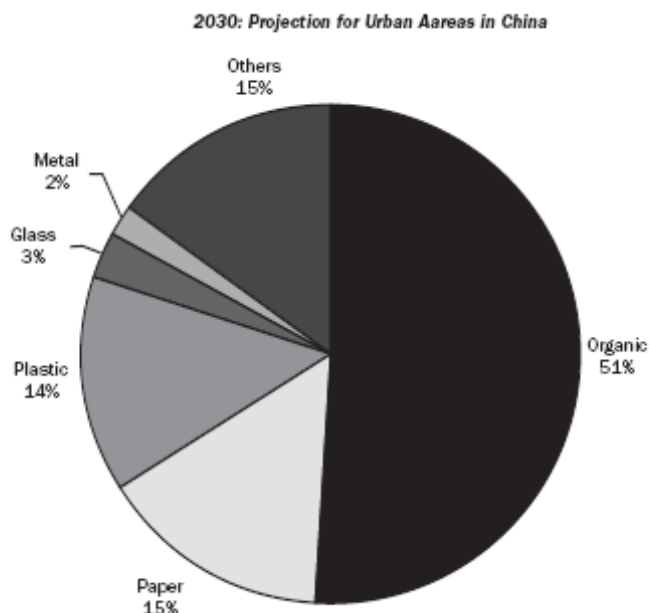
Figure 1 Projected Municipal Waste Composition in Urban Areas of China—As Generated



Municipal Waste Generated from Population Using Coal = 49, 500, 000 tonnes

Municipal Waste Generated from Population Using gas = 100, 500, 000 tonnes

Total Municipal Waste Generation in 2000 = 150,000,000 tonnes



Total Municipal Waste Generation Expected in 2030 = 484,000,000 tonnes

The data in Figure 1 is prepared by AMEC Earth & Environmental, based on existing government data and field visits to three representative cities (Kunming, Shanghai,

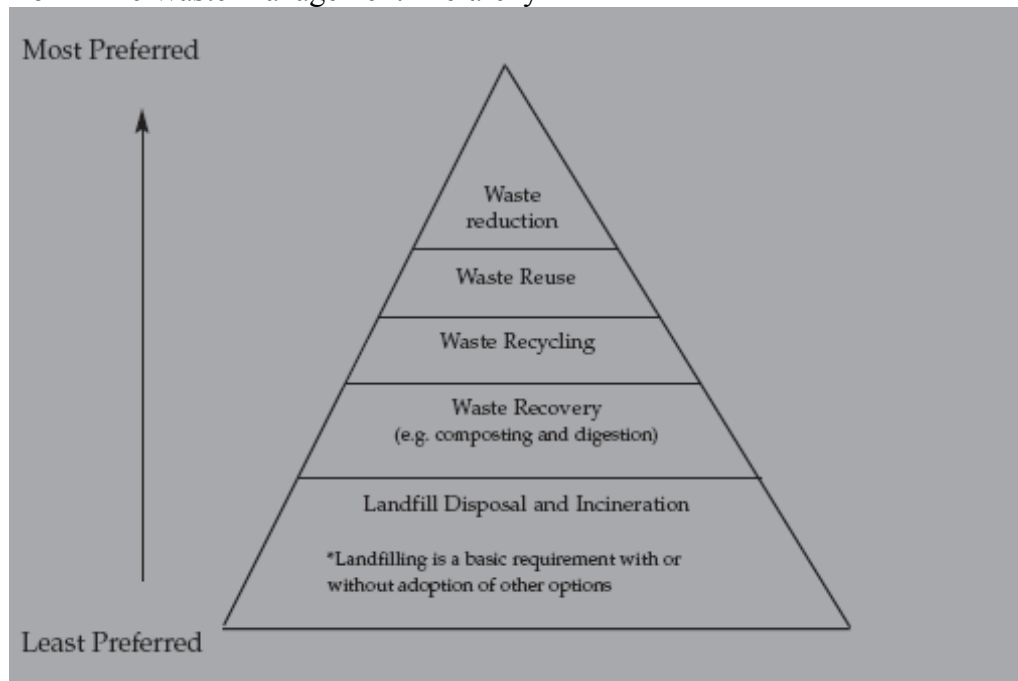
Chongqing)

Figure 1 shows the priority and importance of the organic fraction of the waste management. In 2030, even with a marked increase in packaging waste, paper products and plastics and a complete reduction of coal ash, organics will still make up more than 50% of the waste stream. These organics are poorly suited to incineration due to their high water content, and have the propensity to generate leachate when landfilled. China's waste stream is growing fastest in paper, plastics and multi-laminates, such as plastic coated paper. (WB 2005)

The ISWM Strategy of MSW Management in China

Chinese government tried to respond to this challenge, by moving up the “waste management hierarchy” promoting waste reduction, reuse and recycle, before other waste disposal methods are pursued. “Integrated sustainable waste management” (ISWM) is the concept accepted as the principle of MSW management in China, which is based on the waste management hierarchy.

Box 1 The Waste Management Hierarchy



This report following analyzes MSW management in China from different hierarchies.

LANDFILL IN CHINA

Landfill is one of the low hierarchy treat methods to treat the solid waste. According to Wikipedia, it is a site for the disposal of waste materials by burial and is the oldest form of waste treatment. Landfill and incineration have been the most common methods to treat solid waste and now it is still popular in many places around the world(<http://en.wikipedia.org/wiki/Landfill>), especially in China.

China now is facing a great problem of increasing quantity of solid waste and landfill is one of the most common treatments considered by the government now. According to a World Bank report (2005), China's cities will need to develop an additional 1400 landfills over the next 20 years. It will be a big issue for both China and the world. As the trend is unavoidable, careful consideration and management is extremely needed in China now.

In the past ten years, China has made great improvement in waste management, especially in landfill management. Most larger cities are aggressively moving towards sanitary landfilling as their main disposal option. (WB, 2005) But still, for a lot of cities in China, the standard of sanitary landfilling is not achieved completely. The management of landfill becomes the most serious problem now and in the future.

We are facing a lot of serious problems in the process of landfilling in China now. The key issue among them is lack of overall consideration, management and operation. There are a lot of problems in different aspects.

From the aspects of construction, the overall operating conditions need urgent attentions and especially the slopes in the landfill are mostly inadequate. And also the phenomenon of over design exists a lot. For some cases, after the over-design, the constructions of subsequent phases are premature. According to the report of World Bank (2005), some synthetic liners are exposed to the elements and huge additional volumes of leachate are generated. These problems are serious in the past and need better management and much more consideration and construction.

From the aspects of the leachate, there are also a lot of troubles in this part. The collection of the leachate is inadequate and the treatment is not well organized. It is possible for them to contaminate the underground water or lead to great damage to the soil around. The contaminated soil become the "brownfields" and it will cause a lot of serious sequences. It will impact the public health and environmental quality, especially the land values will decrease a lot. There are likely at least 5000 of these sites now in Chinese cities. The cost to clean them up is significant higher than the cost to have disposed of the waste properly in the first place. (WB 2005)

From the aspects of gas, very little landfill has gas collection at present. If we can gather these gases, we can decrease the greenhouse gas emission a lot. According to the estimation, the proportion of potential saving in greenhouse gas emission can be as high as 70%. Considering the global warming and the carbon trade, it means a lot in the future. And also we can generate electricity from it, or at least, we can deal it with gas flaring.

In addition, the reuse of the landfill is needed in the near future. A lot of landfill sites are dumped without any attention nowadays. Golf sites and other use form of the landfill should be considered carefully in the future to save the space and also to improve the management after the landfill finishes.

Although there are a lot of shortcomings in China right now, still in some site, these disadvantages are being quickly remedied and government has done some significant improvements, such as the waste treatment workshop in Guangzhou. They have improved

their conditions of landfill very quickly according to the international standard.

COMPOSTING IN CHINA

Composting is the process of producing compost through aerobic decomposition of biodegradable organic matter. After composting, gas can be generated and they can be used to generate electricity or to be lighted up.

China has a great demand for composting as the size of brownfields is increasing all the time. Due to the increasing city population and the soil become more important to the citizens. The remains of the composting are good medicine to improve the quality of the soil and increase the yield of the soil.

Also the composting can reduce the emissions of the greenhouse gases. Although it is more expansive than landfill, the product through the process is more useful and it takes smaller space. It is particular important for a country like China who has such a big population and relatively small distance between cities.

But still, there are some serious situation existing in the composting.

First is also about the management of composting. Composting is more expansive than landfill. To increase the proportion of composting, more invest is needed. There is a economic issue between it and the development.

Second, careful classification is required before the composting begins. Otherwise, the remains of composting may have high level of heavy metal or other chemicals, which will lead a bad result. Higher technology and more careful attention need to be taken by the operators, and it is also a big issue to think about.

Third, the standard of composing is not very good set up in China. More detailed national operational standard and regulation is needed before building more composting sites.

To sum up, there is still a long way to go before China can catch up with the developed country and reach the international standard, but we are trying to do, and significant improvement has taken place already.

INCINERATION IN CHINA

Background

China has become the largest producer in the world in terms of MSW generation. In the year 2004, China urban area solid waste generation has exceeded 19million tons. (World Bank, 2005) The large quantity of MSW has posed China a great threat to the effective management of the waste. Incineration, together with composting, landfill and dumping

site has become the major solution to the MSW in China. By the year 2002, there are 19 Municipal waste incineration plants, with 7 thousand tons capacity per day. (B.Solenthaler and R. Bunge 2004)

In terms of capacity, incineration is not the major solution to China's MSW management. However, it is still very important component in China's waste management system. Below, we will analysis the advantages and disadvantages of incineration in China.

Advantages of incineration in comparison with landfill in China

In the circumstance of China, incineration has the following advantages comparing with landfill. The quantity of MSW in China is very big. The large quantity requires a way to effectively reduce the volume and weight of the waste. However, Landfill requires space and land, which is becoming scarce in China. MSW is highly concentrated in urban area, where land use is a crucial due to the scarcity of land. China is a country with large population density. In the east and costal region, where the economy is more developed, the concentration of population is much higher. In these regions, the conflict between urban expansion and land scarcity is becoming more salient in recent years.

Challenges of incineration in China

From environmental perspective, the challenges from incineration are very serious. The major concern of waste incineration is the emission of heavy metal and Dioxins. Chinese government has set the standard for the Dioxins. On 1st. June 2000, Chinese SEPA(State Environment protection Agency) has issued "Standard for Waste Incineration Pollution Control" It sets the standard for the Dioxins emission as 1.0 Nano gram/M³. However, the same standard for EU, North America and Japan is 0.1 Nano gram/M³.(WB 2005)

There are three major types of emission from incineration: stack emission, fly ash and bottom ash. According to B. Solenthaler and R. Bunge, the concentration of nonferrous metals in China is only 0.24%. Comparing with Switzerland of 3%, the Chinese number is very lower, which makes it impossible to utilize the bottom ash for nonferrous metal recycle. (2004)

However, the Hg contamination in both fly-ash and bottom ash is a serious problem. According to World Bank, the 50% of the Hg deposited in the North America lake comes from Chinese waste incinerator.

Heat recovery: The composition of China's MSW is quite diverse. The composition in some big cities, such as Beijing and Shanghai, are similar to that of western countries. However, in most of the small and medium cities, the composition is different. The composition of waste determines the heat value of the incineration. The average heat value of China is 5 MJ/kg, which is lower than that of requirement of heat value of 6MJ/kg for incineration. Thus, the supplement fuel is required for incineration. This makes it impossible to gain net energy generation to compensate the high investment. (Solenthaler and Bunge 2004)

REUSE AND RECYCLE IN CHINA

In the hierarchy of MSW management, reuse and recycle are less preferred than source reduction. In reality, however, we could not avoid producing waste if the whole world needs to work well. Because the human life now has been closely related to all sorts of products, no one could wait for the creation of waste-free goods for a living in society. For example, if we want to eliminate every chance of producing waste, we shall not get a fully-equipped computer. Therefore, what really count is how to properly deal with the already existing waste, namely, to we can fully exploit the potential use of waste through integrated operating system before incineration or its final dumping into landfill.

MSW reuse history and current situation in China

When China was in the period of “planning economy”, the amount of circulating goods was very small, and living necessities were controlled by the central government. The situation of reuse and recycle in China evolved with the economic development, this is obviously true after China’s “open door” policy from 1979 and entry into WTO in 2001. Not only the quantity has increased greatly, but also the categories of reuse. Nowadays in China, the reused goods and materials focus on as follow: Glass bottles, Old tyres, Used battery, Discarded vehicles components, Electronic appliances, Construction waste material, etc.

Reuse of bottles is a common category due to increasingly consumption of drink and milk. The way of collecting beer bottles is running by retailers and small waste collecting group; almost all the beer bottles are of same size and shape throughout the nation, so this facilitate the reuse of bottles by different brewing companies.

The practice of reusing old tyres after “open door” proved that it is a good way to save raw rubber and reduce pollution (CTRRA, China Tyre Repair and Reuse Association). Battery reuse features a similar pattern.

Large and formal corporations take the responsibility of disassembling vehicles, and the state is going to set up a super scale base for reuse of cars in Tianjin, where boasts one of the largest factories for electronic accessories , cell phones, and automobile works.

For small household things, people could choose to sell them in second-hand market, including furniture, home electronic appliances, wearing, books, and tools, etc. Most of them will be bought by floating population and urban poor people, or by private waste-collecting workshops, and then transport to rural area. This kind of market will boom especially when there are some resident-building reconstructions occurred.

The rule of the reuse market is that if the outdated ones could be repaired or re-assembled, they will enter the urban market with a new face; if there is no market for them in cities, dealers will try the villagers, who have an urgent requirement for the “new” products due to major amount of rural population. This is especially true for popular goods, such as cars and home electronic equipment such as TV sets, refrigerators,

VCD/DVD players, cell phones, MP3 players, and so on. Due to its controversial and influential characteristics, the electronic waste reuse will be discussed separately in the following part.

Reuse of Electronic equipment

The industry of **electronic waste** reuse and recycling restricted to several coastal provinces such as Tianjin, Fujian, Guangdong, and Shandong. Because the imported electronic wastes could easily be processed when they reach the harbour, to date, most of the electronic wastes are from abroad. For example, in Dongguan (Guangdong Province), there lots of shops dealing with television sets, discarded electronics components and equipment cases. The old TV sets from overseas are taken apart, reassembled and then readied for sale as “new” ones, with the price ranging from US\$40–60. (World Watch)

Economic impacts of recycling in China

The special feature on waste recycling in China, probably the common feature in developing countries, is that manual labourers will sift through unsegregated waste to search for materials that can be sold in the recycling market. These waste pickers are part of the informal sector but play a significant role in reducing the load on municipal waste management (Wikipedia).

The recycling market prospers with the rapid development of the economy. For instance, in Shanghai, less than 1,000 of 10,000 discarded handsets are recycled monthly (World Watch). The development of economy needs more and more raw materials, which greatly outweigh domestic industry of recycle. When recycling industry could not meet the development of manufacturing industries, they turn to import waste from developed countries. In addition, landfill charges are souring dramatically in these wealthy nations, so sending the waste abroad makes it relatively cheaper. For example, regulations in Europe tend to strengthen this situation, because they require local authorities and businesses to recycle more.

China’s entry into WTO facilitates the process of importing all sorts of waste, and she has become the world’s largest waste dumping nation(EASUR 2005).But the state-supported company could not compete with private workshops without license, because they could always manage to import waste even through smuggling, which partly due to ineffective regulations and be incapable of investigating all imported goods in China. The small scale recycling has been done in backstreets with little environmental standards.

Health Problems and Environmental Considerations

Eighty percent of the world’s electronic waste has been exported to Asia, 90 percent of which flows into China(Puckett 2002). Most of the time, family recycling workshops are the final stops of these junk, people disassemble them manually, wearing just rubber gloves or even nothing. They are fully exposed to toxic metals such as lead, cadmium, and mercury, and to hazardous compounds such as acids and PCBs(GreenPeace 2005).

China’s electronic waste situation reveals that commonly used recycling practices can

harm the environment more than the waste itself (World Watch). Investigations by Greenpeace found that workers usually use acid to dissolve metals contained in the electronics, washed residues are directly channeled into nearby water bodies. Components incapable of being recycled are sent to landfills or openly burned, with a release of additional toxic smog into the atmosphere (GreenPeace 2005).

Regulations on MSW recycling

China has gradually awared that developed countries are exporting their pollution to China and have imposed strict laws governing what can be exported. For instance, "Waste Home Appliance and Electronic Products Recycling and Management Rule" has been drafted by the National Development and Reform Commission and is going to be formally implemented in 2007. According to the draft of the Rule, the obligation of home appliance dealers and service providers to accept and dispose of obsolete appliances has been defined. The release of the Rule is anticipated to well-manage the tangly situation in China's electronic waste recycling market (World Watch). This shows that authorities expect home appliance manufacturers and electronic retailers will cooperate to make contributions to the electronic waste reclaiming and recycling process.

Actually, some electronics retailers have already been preparing for the coming rule; for example Suning Electronic Appliance Group and Zhejiang-based manufacturer Huaxing have signed a agreement to work on electronic waste recycling, which includes that from January 2007, Beijing Suning will send all the waste and used home appliances through its 'Changing the Old for New' policy to Huaxing for disposal (World Watch).

CONCLUSION

- a. Standardization of MSW definition, categories, and measurement is necessary in China to make sure information availability for decision-makers, researchers and industries, etc.
- b. It is a lack of the consistant policies and regulation of waste management through the whole country. Building up a national legislation and policy frame is essential to promote integrated sustainable MSW management.
- c. The quantity of MSW grows dramatically in urban areas of China, thus source reduction is a key challenge and priority to the MSW management.
- d. The operation condition of landfill should be improved They need to be sloped to minimize leachate, developed in stages, and operated according to international standards for 'sanitary landfills'. More attention should be paid for post closure uses

of landfills.

- e. Incinerators in China are growing in popularity but their growth is often driven by artificial and non-sustainable subsidies and non-transparent financing structures, as well as a lack of understanding and experience about incineration facilities. Comprehensive cost-benefit analysis is needed in all cases.
- f. Creating a holistic reclaiming, processing, and recycling (reuse) system, standardize current differentiated regional recycling networks is necessary for recycling industry.

Part 2 MSW Management in Taiwan

INTRODUCTION

Before 1984, there are no properly measures or policies for the disposal of municipal solid waste (MSW) in Taiwan. Large portions of municipal wastes were disposed of into the field randomly, and it sometimes caused several sanitary problems. To avoid this, Taiwan government composed “Municipal Waste Treatment Act” in 1984 which mainly applies sanitary landfills to treat municipal wastes. Taiwan Environmental Protection Administration (TEPA) assists local governments to establish several landfills for their own disposal of MSW. However, with the gradually increasing demand of land use, the amount of wastes, and citizen requirement for good environmental quality, using landfills to manage the waste disposal had become another environmental problem. Additionally, the appearance of opposing opinions from residents against the local landfills also gains the difficulties to continue operating landfills. Therefore, the Taiwan government revised “Municipal Waste Treatment Act” in 1991 which applies the incineration approach instead of the original one—landfills. The government not only budgeted for 21 incinerators, but also gave an impetus to Build-Operate-Transfer (BOT) projects which would reduce the financial loading of government for another 15 incinerators just in order to handle the huge amounts of daily wastes. However, dioxin emission from incinerators has become a significant issue and the concept of “zero waste” has gradually formed recently. The utilization of waste incinerators for tackling the MSW problem in a sustainable way has been doubted. The TEPA further added several measures for waste recycling and waste source reduction to the Act in 1997 and 2000. These measures including “Compulsory Garbage Separation”, “Cooperative Resource Recycling”, “Composting Recycling” and “Fee per-bag” have successfully enhanced the MSW reduction and recycling efficiency. Under these effective measures, the total recycling ratio of MSW is approaching 30 %, and the amounts of reduction are about 0.6 million tons right now. Some significant and successful measures would be explicitly reviewed both in waste reduction and recycling aspects as the following.

WASTE REDUCTION

“Fee per-bag” Measure

“Fee per-bag” measure which was an economic instrument to reduce the MSW from the source was initiated in 2000 in Taiwan. Under this measure, people should purchase a special trash bag, which costs about 1.5 Euro for a 40L-bag, for their non-recyclable garbage disposal. The local government also provided free service of collection for recyclable garbage and composting. It successfully encouraged the public to separate the resource waste in the beginning stage of waste generation. To strengthen the implementation of “Fee per-bag” measure, some other supportive measures as followings were also conducted to cooperate with. (Chen, 2005)

1. Increasing the frequency of collecting recyclable waste (3 times per week) and adding additional collecting points for recyclable waste in the daytime.
2. Decreasing the frequency of collecting non-recyclable waste.
3. Establishing local recycling stations in each community.
4. Promoting flea markets to encourage the exchange of second hand goods.
5. Initiating “Compulsory Garbage Separation” measures to enforce public waste separation on the second stage of “Fee per-bag” measure in 2005.
6. Implementing “No-Touch-Ground Garbage Collection” measure which is about direct collection of household waste from each area at a scheduled time.
7. Giving an impetus to the privatization of recycling businesses.

WASTE RECYCLING

“Cooperative Resource Recycling” Measure

“Cooperative Resource Recycling” project was implemented in 1997. The strategic scheme shown in Fig.1 intended to strengthen the network of waste recycling among local community, local government, collection organization, and recycling funds levied from manufacturer. (Hung, 2005) Through the economic incentive which is the subsidy, mainly from recycling funds, to the units involving in waste separation, it ensured the stable and highly willing recycling system and also enhanced the efficiency and effectiveness of waste recycling.

Fig. 1 “Cooperative Resource Recycling” Strategic Scheme

“Composting Recycling” Measure

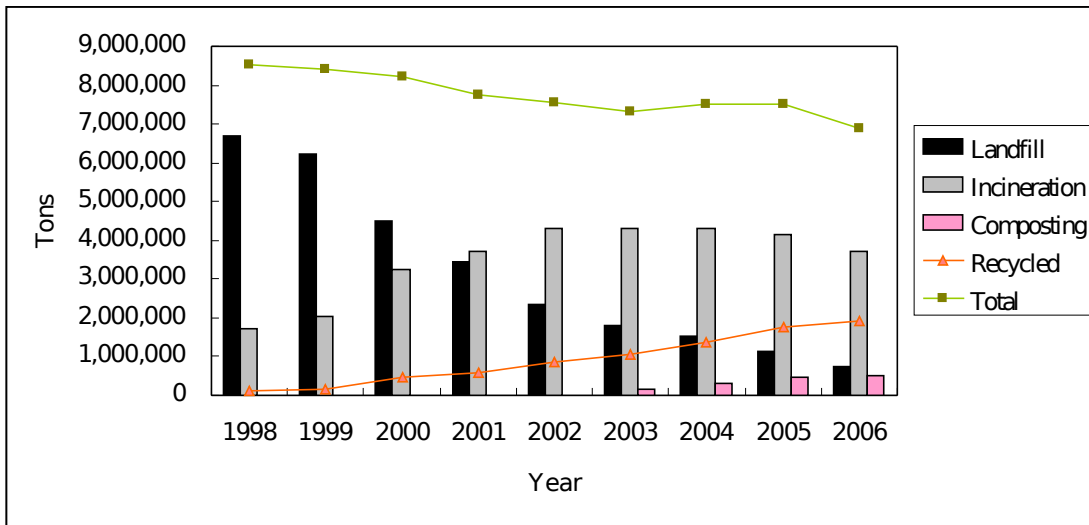
Due to the traditional Chinese diet habits, the MSW in Taiwan contains a large portion of composting, which is about 20%~ 30 %. (Chiou and Chiang, 2005) However, during the MSW treatment processes, large containing of composting in MSW sometimes might easily generate odors in landfills and also reduce the efficiency of incineration. It is better to separate the composting from the daily MSW. From 2001, TEPA initiated the “Composting Recycling” project and assisted the local government to build up their own composting recycling system. Through the local collection and recycling of composting, it would reduce the amounts of MSW from the source in one hand, and mitigate the loading of the utilization of local landfills and incinerators in the other hand. Besides, TEPA also subsidizes the establishing of composting recycling plants and promotes the market of composting products in order to enhance the economic incentives of recycling composting.

MEASURE PERFORMANCE

Under active measures implemented from 1997, we could find significant outcomes of MSW measures which are shown in Fig. 2. (TEPA, 2006) According to the trend line, the total MSW generation has decreased to 6.8 million tons in 2006, and the reduction rate equals to 2% per year. Decreasing amounts of MSW treated by landfill could be seen in this chart. In the other hand, the amounts of recycled waste and composting have gradually increased. It indeed shows the success on the measures of source reduction and waste recycling. The decreasing trend of MSW treated by incineration after 2002 could

be also found in Fig.2. It may be resulted in the increasing amounts of composting.

Fig. 2 the trend of MSW treatment in Taiwan



Source: Taiwan White Paper of Environmental Policy (TEPA, 2006)

CONCLUSION

In order to achieve the target of “zero waste” in 2010, TEPA continuously reinforces the measures of waste recycling and reduction. In the future, how to enhance the efficiency of waste recycling system should be the core of successfully implementing these measures. The privatization of waste collection and recycling business could be considered as a better approach to improve the performance of waste management nowadays. However, a feasible structure of the MSW management and access to the market of recycling products are still needed to be improved continuously. Furthermore, the suspending of landfills and incinerators will become another issue after significant MSW reduction in the future.

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