



## Review

## Municipal solid waste management in China: Status, problems and challenges

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## ABSTRACT

This paper presents an examination of MSW generation and composition in China, providing an overview of the current state of MSW management, an analysis of existing problems in MSW collection, separation, recycling and disposal, and some suggestions for improving MSW systems in the future. In China, along with urbanization, population growth and industrialization, the quantity of municipal solid waste (MSW) generation has been increasing rapidly. The total MSW amount increased from 31.3 million tonnes in 1980 to 212 million tonnes in 2006, and the waste generation rate increased from 0.50 kg/capita/day in 1980 to 0.98 kg/capita/year in 2006. Currently, waste composition in China is dominated by a high organic and moisture content, since the concentration of kitchen waste in urban solid waste makes up the highest proportion (at approximately 60%) of the waste stream. The total amount of MSW collected and transported was 148 million tonnes in 2006, of which 91.4% was landfilled, 6.4% was incinerated and 2.2% was composted. The overall MSW treatment rate in China was approximately 62% in 2007. In 2007, there were 460 facilities, including 366 landfill sites, 17 composting plants, and 66 incineration plants. This paper also considers the challenges faced and opportunities for MSW management in China, and a number of recommendations are made aimed at improving the MSW management system.

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## 1. Introduction

The Chinese population has increased over the past two decades and its economy has developed tremendously. China's development has also brought about an unprecedented increase in the amount of solid waste. No other country has ever experienced as large and as fast an increase in solid waste quantities that China is now facing (Xue and Chen, 2007; World Bank, 2005; Dong et al., 2001). Urbanization, population growth and industrialization are three key reasons behind the large magnitude of China's increase in total waste generation. In general, China still has a long way to go in the management of solid waste with respect to solid waste recycling, treatment technology and management strategy when compared with many more developed countries, e.g., Germany, Sweden, Japan, and the United States (Yuan et al., 2006). Throughout the country, the social, financial and environmental impacts of this growing waste generation are gaining attention and MSW management is becoming a major issue (Zerbock, 2003; Zurbrugg, 2002). Improvement in MSW collection, recycling and disposal will be an important goal for the governments of all cities

in China in the years to come, and all aspects of China's MSW management systems will have to undergo great reform in order to achieve this goal.

There have been a number of published papers which have reviewed the trend of MSW generation and composition, as well as MSW management including waste collection, recycling and disposal in different cities in China, e.g., Beijing (Qu et al., 2009; Xiao et al., 2007; Li et al., 2009), Shanghai (Hong et al., 2006; Zhu et al., 2009), Tianjin (Zhao et al., 2009a,b; Geng et al., 2007), Chongqing (Yuan et al., 2006), Hangzhou (Zhao et al., 2009a,b), Guangzhou (Chung and Poon, 2001), Tibet (Jiang et al., 2009), etc. Additionally, comparisons of MSW management among these different cities have also been conducted. Chung and Poon (2001) compared MSW management in two of the most developed cities in China: Hong Kong and Guangzhou. In addition, other authors have addressed different aspects relating to MSW management. Wang et al. (2008) investigated a new method of community recycling and collection, which is operated by a waste collection company through door-to-door service and supported by the municipal government in the Haidian District in Beijing. Zhuang et al. (2008) evaluated the possibility and effectiveness of a new waste separation system which classified household waste as food waste, dry waste, and harmful waste in a residential area of

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Hangzhou. And Cheng et al. (2007) reported on a waste-to-energy incineration technology based on co-firing of MSW with coal in a grate-circulating fluidized bed incinerator in Changchun.

While these other studies have mainly focused on specific aspects of MSW management in specific cities in China, this paper attempts to review the overall situation of MSW management in China. With this overall aim, this paper seeks to: (i) identify MSW generation, quantity and composition in China; (ii) review the different methods for MSW collection, recycling, treatment and disposal; (iii) identify the attitudes and behaviour towards MSW separation and recycling; (iv) investigate the current problems and barriers in MSW management in China; and (v) develop a vision for opportunities and challenges of MSW management in future.

## 2. Municipal solid waste generation and composition in China

Most Chinese MSW usually includes residential, institutional, commercial, street cleaning and non-process waste from industries (World Bank, 2005). MSW generation in China has increased rapidly in the past 20 years from 31.3 million tons in 1980 to 113.0 million tons in 1998 and the annual rate of increase is 3–10% (Wang and Nie, 2001). Currently, there are about 660 cities in China that produce about 190 million tonnes of solid waste annually and, account for 29% of the world's MSW each year (Dong et al., 2001; Yuan et al., 2006; Zhuang et al., 2008). In 2004, China surpassed the United States as the world's largest waste generator (World Bank, 2005). Table 1 shows an increasing trend of collected and transported MSW from 1981 to 2007. In 2006, the total MSW generation was approximately 212 million tonnes, and the MSW generation rate was 0.98 tonnes/capita/year (China Statistical Yearbook, 2001–2007; Raninger, 2009). Compared with other developed countries, China has been considered as having a relatively low per capita MSW generation rate. According to Yuan et al. (2006), China's per capita waste generation rate is 0.8–1.0 kg/capita/day, while a typical developed country generates 1.43–2.08 kg/capita/day (Troschinetz and Mihelcic, 2009). The MSW generation rate also varies among different cities in China, e.g., with rates of about 0.85 kg/capita/day in Beijing (Li et al., 2009), 1.11 kg/capita/day in Shanghai (Zhu et al., 2009), 1.08 kg/capita/day in Chongqing (Yuan et al., 2006), 1.51 kg/capita/day in Lhasa (Tibet) (Jiang et al., 2009), 1.17 kg/capita/day in Hangzhou (Zhao et al., 2009a,b), and 1.33 kg/capita/day in Hong Kong (Ko and Poon, 2009). Table 2 compares the generation rate of MSW between China and other selected OECD countries, and shows that China ranked second after the USA in terms of the total amount of MSW, but third from last in terms of MSW per capita.

Table 3 presents a comparison of MSW composition in various cities in China. In general, waste composition in China is dominated by a high organic and moisture content, since the concentration of the kitchen waste in urban solid waste makes up the highest proportion at approximate 60% (Yuan et al., 2006). In contrast, it is recognized that industrialized countries' waste consists of more recyclables and lower bio-degradable organic waste. The high ratio of organic waste in China is partly attributable to the diet, e.g., more fresh vegetables and fruit compared with Western culture, and preferences for food that is unprocessed and unpackaged. This

suggests that the high organic composition of MSW probably will not decline significantly even as industry grows, wealth increases and living standards improve. In this sense, kitchen waste will also continue to occupy a high ratio of the waste in China in the future.

Another major component of MSW in China is coal ash, which originates from household furnaces, as coal and wood are used for heating in the northern part of China and for cooking in major parts of the rural areas. However, this situation is changing rapidly as coal is increasingly being replaced by natural gas. The proportion of ash has clearly decreased in some cities (Zhuang et al., 2008; Xiao et al., 2007; Solenthaler and Bunge, 2006), and by 2030 it is estimated that all urban households will be using gas for home heating and coal ash will only be a minor component in the waste stream (World Bank, 2005).

The composition of MSW in China is extremely non-homogeneous and the variation is caused by differences between cities: the level of industrialization and income, consuming habits etc. In some of the larger cities, the composition of the waste is roughly similar to that in Western Europe and features a high percentage of paper and plastic (10–20%). Indeed, China's waste stream is growing fastest in paper, plastics and multi-laminates (World Bank, 2005). This composition is generally believed to be a sign of urbanisation and rapid economic development. However, with that said, the composition of MSW in China is still predominantly kitchen waste and differs greatly from that of the western industrialized world.

Even though nationwide waste generation rates are comparable, it is recognized that high-income urban residents in China have a higher generation rate than low-income residents (World Bank, 2005). In terms of the effect of income on waste generation, Abu Qdais et al. (1997) concluded that the waste generation rate was dependent on income level, and more household waste is generated with increasing residents' income. Dennison et al. (1996) also indicated that residents' income was positively related to the rate of household waste generated. In addition, Qu et al. (2009) reported that residents' income was negatively related to daily per capita generation of kitchen wastes and positively related to daily per capita generation of waste per capita generation of waste paper and plastics. Generally speaking, more affluent families have more opportunities to dine out in restaurants. This may be the reason why kitchen waste generation decreased with increased income. In low-income families, people tend to reuse plastic bags as a result of the policy of charging for plastic bags in every supermarket in China.

Table 4 compares MSW composition between China and other countries. Tchobanoglous et al. (1993) classified the distribution of components in residential MSW into low- (per capita income less than US\$750), middle- (per capita income US\$750–5000) and upper-income (per capita income more than US\$ 5000) countries. China belongs to the level between low- and middle-income levels. Raninger (2009) reported that the rapidly bio-degradable waste (food and kitchen waste), slowly bio-degradable waste (wood, paper, yard waste, composites) and non bio-degradable waste (plastic, metal, glass, ash) account for 78%, 10% and 12% of total amount of MSW in China respectively, while these same types of solid waste account for 12%, 47% and 41% of total amount of MSW in EU, respectively.

**Table 1**  
Collected and transported MSW in China (Data source: China Statistical Yearbook, 2001–2007).

	1981	1990	2003	2004	2005	2006	2007
Urban population ( $\times 10^4$ )	14,400	32,530	52,376	54,283	56,157	57,706	59,379
Collected and transported MSW ( $10^4$ tonnes/year)	2606	6767	14,857	15,509	15,577	14,841	15,214
Per capita quantity of MSW (kg/day/capita)	0.50	0.57	0.78	0.78	0.76	0.70	0.70

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