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Municipal solid waste management in Pudong New Area, China

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ABSTRACT

The increase in population, the rapid economic growth and the rise in community living standards accelerate municipal solid waste (MSW) generation in developing cities. This problem is especially serious in Pudong New Area, Shanghai, China. The daily amount of MSW generated in Pudong was about 1.11 kg per person in 2006. According to the current population growth trend, the solid waste quantity generated will continue to increase with the city's development. In this paper, we describe a waste generation and composition analysis and provide a comprehensive review of municipal solid waste management (MSWM) in Pudong. Some of the important aspects of waste management, such as the current status of waste collection, transport and disposal in Pudong, will be illustrated. Also, the current situation will be evaluated, and its problems will be identified.

1. Introduction

With continuous economic development and an increase in living standards, the demand for goods and services is increasing quickly, resulting in an increase in per capita generation of solid waste. Increasing population levels, booming economy, rapid urbanization and the rise in community living standards have greatly accelerated the municipal solid waste (MSW) generation rate in developing countries, especially in China. The World Bank pointed out that no country had ever experienced as large or as fast an increase in solid waste quantity as China (Yuan et al., 2006). China recently surpassed the United States as the world's largest MSW generator. Furthermore, China's annual solid waste generation is expected to grow from about 190 million tons in 2004 to over 480 million tons by 2030 (The World Bank, 2005). This poses enormous challenges for environmental protection and sustainable development. One of the effective solutions to such a problem is to adopt an efficient municipal solid waste management (MSWM) system. All aspects of China's waste management systems must undergo great changes in order to meet this challenge. The state's eleventh five-year plan (2007–2012) has allocated approximately 140 billion Euros to be invested in environmental protection, reflecting the determination and effort of the Chinese government in protecting the environment.

Pudong New Area (Pudong) is located in the eastern part of Shanghai and is one of China's most economically active cities. Massive governmental investment has helped Pudong grow from mere pastures to a modern city within 18 years. The waste characteristics and the solid waste management system in Pudong is representative of most Chinese cities. In this paper, MSW characteristics and the current status of MSWM in Pudong will be detailed to evaluate the current situation and identify problems.

2. Current situation of solid waste management in Pudong

2.1. A brief introduction of Pudong

On April 18, 1990, the Chinese government decided to allow large-scale development and construction in Pudong. After 18 years of development and construction, Pudong has undergone amazing changes, becoming a model of an externally oriented, multifunctional and modern urban district.

Pudong is situated at the middle latitude of China's coastal areas and is located in an estuary where the Yangtze River enters the sea, as shown in Fig. 1. Pudong lies adjacent to Shanghai's urban districts, with a solid and strong economic foundation, backed up by the Yangtze River Delta with rich resources and facing the Pacific and East Asian Region. It covers an area of 569.57 km^2, and has a pleasant climate year-round with an average annual temperature of 16.2° and an average annual rainfall of 1183 mm (Pudong Gov-

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Fig. 1. Map of Pudong in Shanghai, China.

ernment Website, 2008). Pudong is characterized by both urban and suburban areas. In 1990, the population of the Pudong was about 1.4 million, but had increased to 2.8 million by 2005.

In order to perform effective city administration, Pudong is divided into six functional areas geographically, as shown in Fig. 2. The functional area (FA) is an economic and administrative division aimed to eliminate dual urban–rural structure, increase linkage between development zones and townships, and introduce greater reforms. Furthermore, FAs represent an institutional innovation for waste management. At present, there are six functional areas in Pudong New Area (Table 1), namely:

- Lujiazui Functional Area (LFA),
- Jinqiao Functional Area (JFA),
- Zhangjiang Functional Area (ZFA),
- Waigaoqiao Functional Area (WFA),
- Sanlin World Expo Functional Area (SFA), and
- Chunsha Functional Area (CFA).

For each FA, a dedicated truck company is in charge of waste collection and transportation to the waste disposal facility.

Table 1
Fundamental data of functional areas of Pudong, 2005

Indicator	Land area (km^2)	Registered population by year-end (person)	Population density (person km^{-2})
LFA	42.77	453,049	10,593
JFA	90.52	368,859	4,075
ZFA	119.31	149,395	1,252
WFA	97.13	157,277	1,619
SFA	80.11	556,903	6,952
CFA	139.73	162,571	1,164
Total	569.57	1,848,054	3,245

Data source: (PSWAO (2006)).

2.2. Solid waste management in Pudong

2.2.1. Waste generation

As cities grow, land use becomes increasingly complex, and the waste generated increases in volume and variety (Omuta, 1987). In 2006, Pudong witnessed a steady economic growth, realizing a GDP close to 23.7 billion Euros, an increase of 13.4 Euros from the prior year. Accordingly, the quantity of solid waste generated in Pudong increased from 2418 tons/day in 2004 to 2854 tons/day in 2005. MSW is classified into three categories: urban waste, suburban waste and other waste (waste from street sweeping, businesses and public institutions) (Table 2).

In 2006, the amount of MSW generated in Pudong was about 3,108 tons/day, approximately one-fifth of the total amount produced in Shanghai. Based on the current population growth trend, the solid waste quantity generated in Pudong will continue increasing with the city's development according to the projected municipal waste generation for China (The World Bank, 2005). The daily output of MSW from 2004 to 2006 is shown in Fig. 3 (PSWAO, 2006).

The urban area in Pudong includes all of the LFA, and most of the JFA and SFA. The Puhuan company is responsible for the waste collection in these areas. The calorific value of urban waste is approximately 5,080 kJ/kg (PSWAO, 2006), which makes it suitable for combustion, so most waste is incinerated. However, suburban waste is usually first transported to suburban transfer stations and then to disposal facilities after compaction.

2.2.2. Waste composition

Compared with other cities in developing countries, MSW in Pudong has a high organic content and low calorific value, containing a large percentage of organic waste. Fig. 4 shows the composition data for solid wastes tested at the Dezhou waste collection point. The main components are food residues, plastics, fruit, paper, textiles, glass and wood. The waste has a heterogeneous composition comprising both degradable and non-degradable materials, and is collected without sorting. The majority of the non-degradable