

LANDFILL DATA FROM CHINA: ADDRESSING INFORMATION NEEDS FOR METHANE RECOVERY

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ABSTRACT

Urban populations and their waste generation are increasing worldwide, and the majority of the waste is disposed of in landfills. Over 80 percent of waste generated in China is landfilled, in a variety of ways. Over 5 percent of the landfills are sanitary landfills conforming to U.S. standards, nearly 40 percent are landfills that do not conform to such standards, and over 50 percent are open dumps. Landfills are a major source of emissions of methane, a potent greenhouse gas. Increasing the percentage of waste put into sanitary landfills would result in greater methane emissions because of increased anaerobic reactions. However, China's National Action Plan on Urban Solid Waste Landfill Gas Collection and Utilization emphasizes sanitary landfills with methane recovery, and this could have benefits such as greater sustainability, improved public health, increased energy efficiency, and reduced global warming. A lack of reliable data on solid waste generation and management is a fundamental problem in estimating landfill contributions to methane emissions inventories, determining the potential for methane recovery, and identifying best candidate sites for methane recovery projects in developing countries. The U.S. Environmental Protection Agency (EPA) is developing an international database on solid waste generation and management in major urban areas, focusing initially on China, India, Brazil, Mexico, South Korea, and select sub-Saharan countries. This paper provides preliminary findings from China on the amount and characteristics of urban waste generated, the characteristics of urban waste, landfills, and current management of methane emissions at landfills. Specific information on landfills in five major urban areas, including Beijing, Tianjin, Shanghai, Nanjing, and Harbin, is also discussed.

1.0 INTRODUCTION

Methane, a potent greenhouse gas, is the second largest contributor to global warming among anthropogenic greenhouse gases after carbon dioxide (CO₂). Although it comprises a relatively small percentage of the atmosphere, it is 21 times more effective at trapping heat in the atmosphere than carbon dioxide over a 100-year time period, and currently accounts for over 15 percent of expected future warming from climate change (Metz et al., 2001). Although methane is emitted from both natural and anthropogenic sources, anthropogenic sources account for more than half of current global methane emissions (Watson et al., 2001). Waste management (landfills and wastewater treatment) accounts for over 18 percent of these anthropogenic sources (U.S. EPA, 1994).

Landfills worldwide produce an estimated 20 to 60 teragrams (Tg) of methane per year through the production of landfill gas (LFG). LFG, which comprises approximately 50-60 percent methane, 40-45 percent CO₂, and trace amounts of other volatile organics and halogenated organics, is generated when organic material decomposes anaerobically. Recovering LFG and the methane it contains can make significant strides toward mitigating climate change. Although a more potent greenhouse gas than CO₂, methane remains in the atmosphere for a much shorter period: only 8 to 12 years compared to 50 to 200 years for CO₂ (IPCC, 1996). In addition, LFG recovery projects can have other major economic and environmental benefits. LFG can be used as a medium quality fuel in electricity generation and co-generation, industrial uses, and residential and commercial cooking and heating. Local economies can benefit from the sale or use of this electricity, and from increased local employment for drilling, piping, construction, and operations. Methane recovery can also reduce the dependence on nonrenewable resources such as coal and oil, reducing emissions of air pollutants such as SO₂, NO_x, and particulate matter (PM) that contribute to local smog and acid rain.

With population growth, economic development, and increased urbanization, methane emissions from landfills in developing countries now account for nearly 40 percent of annual global landfill methane emissions (U.S. EPA, 2001), and are expected to increase in the future (IEA, 1996). Important factors in this increase are the continuing priority of many developing countries to reduce unmanaged dumping and develop larger, solid waste disposal sites, which typically have higher methane emissions (Metz et al., 2000). Although almost 80 percent of waste generated in developing countries is landfilled, much of it is deposited in open dumps. As these dumps are replaced with covered landfills, methane emissions will increase substantially. However, there are also substantial opportunities for capturing methane emissions in these countries. If 70 percent of the estimated 290 million tons of municipal solid waste that China is expected to produce in 2010 is deposited in landfills with methane collection systems, the landfill gas recovered could be equivalent to 40 to 280 billion m³ of natural gas (Li, 1999).

2.0 THE INTERNATIONAL SOLID WASTE DATABASE AND LANDFILL METHANE PROJECT

A fundamental problem in expanding methane recovery efforts in developing countries is the lack of reliable data on solid waste. Most estimates of methane emissions from landfills are based on a “top-down” approach, in which the quantities and types of decomposable waste deposited are estimated and multiplied by assumed rates of methane generations (Smith and Bogner, 1997). These estimates have not taken into account the many site-specific factors that affect emissions, including cover types, climatic regimes, and management practices, and are not helpful in developing the site-specific estimates necessary for determining the feasibility of LFG recovery projects. LFG recovery projects are also hampered by other informational barriers, including a paucity of information about waste systems and landfills, such as location and waste in place; poorly maintained or missing records; and a lack of information on waste composition (U.S. EPA, 1993).

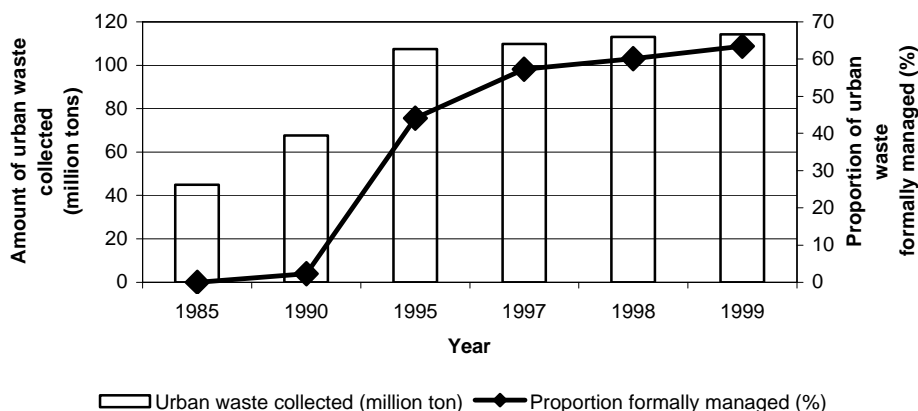
To address this lack of reliable data, the EPA is compiling a database on municipal solid waste management practices in India, China, Brazil, Mexico, South Korea, South Africa, and selected countries in sub-Saharan Africa. The database will include information on solid waste generation, composition, and management practices in key urban areas. It will also provide detailed information on the landfills, such as ownership, location, capacity, lifespan, waste acceptance rate, and type of pollution controls. This project will fill data gaps and provide a user friendly and searchable database to be shared with all stakeholders. The database will be useful at local, national, and international levels for informed decision making when setting policies, identifying sustainable development projects, developing methane recovery projects, and analyzing solid waste management practices in urban areas. The added benefit of a comprehensive database is its usefulness for policy making on sanitation, public health, and environmental issues. Finally, the database is expected to improve greenhouse gas emissions inventories at the global, regional, and national levels.

The first step of the project has been to identify existing literature and contacts in the countries of interest. Limited data on municipal solid waste are being obtained through publications and databases maintained by nonprofit and multilateral organizations such as the World Resources Institute, UN Environmental Programme, UN Development Programme, U.N. Habitat, World Bank, and Asian Development Bank. National and municipal statistics of varying coverage and quality have also been found in national government agencies. The most accurate data are being found at the local level through surveys of municipalities responsible for collecting and managing waste. Data are collected in each country through interviews with relevant national and local officials who maintain records on waste disposal and related topics. To date, preliminary data have been collected from selected urban areas in China, India, Brazil, and sub-Saharan Africa.

3.0 PRELIMINARY LANDFILL DATA FROM CHINA

Preliminary landfill data for China have been collected regarding waste disposal, waste composition, collection and transfer systems, and the organizational and financial aspects of waste management. These data were collected at both the national level and from five urban centers: Beijing, Tianjin, Shanghai, Nanjing, and Harbin. No comprehensive data on landfills exists at the national level. However, general statistics could be obtained from the Annual Statistical Report of Urban Construction (Department of Urban Construction, Ministry of Construction), the Survey of the Status of Urban Waste Disposal and Pollution in China (State Environmental Protection Agency), the China Environment Yearbook, and the China Building and Construction Yearbook. In addition, most of the 30 provinces and districts, as well as some major cities, publish local data and statistical yearbooks that provide some summary information on the total amount of urban waste generated and number of waste disposal facilities. Most of the remaining data were collected from local governments and landfill managers. Local governments, in particular departments of Environmental Sanitation,

Figure 1. Amount of urban waste and the proportion of waste formally managed.



Source: Director, Department of Standards, Chinese Ministry of Construction.

departments of City Appearance, and local environmental protection bureaus, had the most accurate and up-to-date information on landfills in their cities.

3.1 URBAN WASTE DISPOSAL

With its rapid urbanization and economic development, urban waste has become a major issue in China. Municipal solid waste generation in China is growing by 8-10 percent annually. Annual generation of urban waste reached 114 million tons in 1999, and per capita annual waste generation is about 440 kg. In some rapidly developing cities in southern China, per capita waste production is much higher, almost as high as that of developed countries. The total amount of existing solid waste is currently more than 6 billion tons, occupying over 50,000 ha.

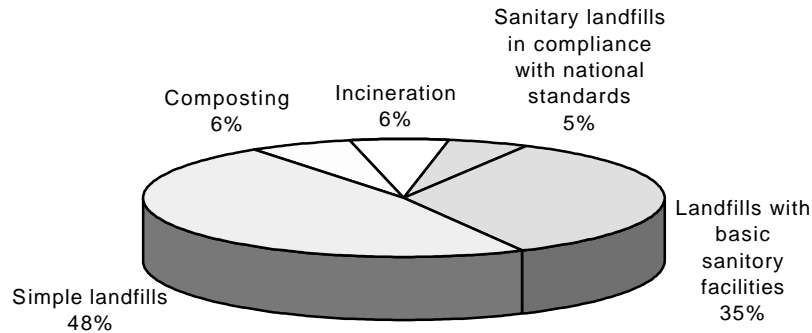
Formal management of urban waste in China did not start until late 1980s (Figure 1). Before 1990, less than 2 percent of urban waste was formally managed. Considerable effort has been put into the urban waste management since then. As of 2000, there were 696 urban waste disposal facilities, and the proportion of urban waste managed formally had increased to 63.4 percent. Most facilities are landfills, which have the relatively low construction and operating costs. According to a survey conducted by the SEPA, landfills account for 88 percent of total urban waste management facilities and accept 94 percent of the urban waste collected (Figures 2 and 3). Only 10-30 percent of these facilities are being managed in compliance with national standards of sanitary landfills. Incineration and composting facilities, which each account for 6 percent of waste management facilities, manage only 3 percent of the collected waste.

3.2 URBAN WASTE COMPOSITION

Urban waste is generally composed of three groups of materials: organic waste (kitchen waste, garden waste, etc.), nonrecyclable inorganic waste (coal ash, cinder, dust, etc.), and recyclable waste (paper, plastics, glass, metal, etc.). Because waste composition is closely related to the local economy, consumption, and climate conditions, the actual composition can

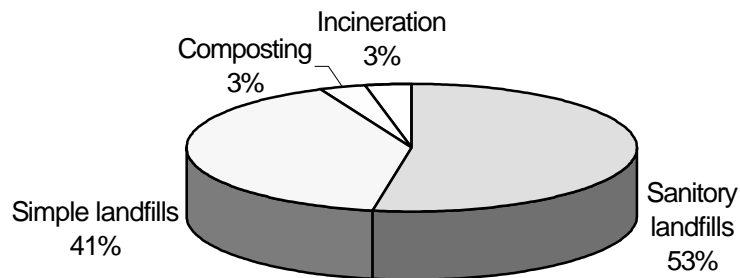
vary substantially among different localities. The composition of municipal solid waste in China is also changing, with kitchen waste replacing coal cinder as the largest component. This corresponds with the shift from coal to natural gas as a major source of fuel for domestic use. In addition, the proportion of both organic waste and recyclable waste continues to increase as living standards improve in most Chinese cities. Table 1 lists the estimated waste

Figure 2. Types of urban waste management facilities in China.



Source: Division of Solid Waste Management, Department of Pollution Control, SEPA.

Figure 3. Urban waste managed by different types of management facilities.



Source: Division of Solid Waste Management, Department of Pollution Control, SEPA.

composition of some cities in China, compiled from analysis done in the late 1990s.

Table 1. Urban waste composition for selected cities in China

City	Waste composition (%)			Water content (%)	Relative weight (kg/m ³)
	Organic	Inorganic	Recyclables		
Beijing	46.66	21.46	31.88	53.9	404
Shanghai	42.22	55.31	2.47	37	898
Guangzhou	36.35	57.43	6.22	30	543
Shenzhen	56.41	19.53	24.06	43.63	--
Shenyang	34.96	58.14	6.9	44.12	640
Chongqing	41.61	52.68	5.71	45	600
Jinan	32.68	61.35	5.97	13	370

3.3 COLLECTION AND TRANSFER SYSTEMS

In most of China's dense urban centers, residents are provided with adequate waste collection systems, in the form of daily garbage collection and street sweeping. Most common are drop-off spots in each neighborhood, from which domestic waste is collected either daily or twice daily by government-employed "city appearance workers," often using manually operated carts. This domestic waste and street sweeping are then transported to a transfer station, where it is unloaded, compacted, and reloaded into 4-5 ton capacity garbage trucks for transport to waste disposal facilities. Transfer stations are typically small drop-off buildings with a capacity of 10 to 50 tons scattered throughout the cities.

3.4 ORGANIZATIONAL AND FINANCIAL ASPECTS OF WASTE MANAGEMENT

In China, the major central government agency responsible for urban waste management is the Department of Urban Construction of the Ministry of Construction. At the local level, responsibility for municipal solid waste collection and disposal rests primarily with municipal and district governments (districts are semi-autonomous sub-units of a city). It is usually under the jurisdiction of the Department of Environmental Sanitation or the Department of City Appearance. The people involved in municipal solid waste management administration, garbage collection, street sweeping, waste transportation, and disposal are government employees. The State Environmental Protection Agency (SEPA) is responsible for formulating relevant policies and regulations on environmental protection for waste disposal facilities, and environmental standards for gas and liquid discharges from these facilities. Local Environmental Protection Bureaus (EPBs) are responsible for enforcing these environmental standards, including monitoring ambient environmental quality and qualities of discharge from these facilities. Because municipal solid waste management is publicly financed, the Ministry of Finance, the State Development Planning Commission and their local branches are also involved in the process.

3.5 LANDFILLS IN FIVE MAJOR CITIES IN CHINA

Table 2 shows summary waste management and landfill data for Beijing, Tianjin, Shanghai, Nanjing, and Harbin. Beijing, the capital of China, has an urban population of 9.2 million, and covers 16,808 sq km. Beijing generates around 4.5 million tons of urban waste each year, about 45 percent of which is transported to four major landfills near the city. One composting site and a few small incineration facilities accept an additional 10 to 15 percent of the waste.

Tianjin, a municipality on the banks of the Haihe River and the Grand Canal, is directly administrated by the Chinese central government. It is the country's most important port and a major transportation center of Northern China. Tianjin has an urban population of 5.93 million, and covers 11,300 sq km of low-lying alluvial plain. Approximately 2.3 million tons of urban waste is generated in Tianjin annually. Its only major sanitary landfill began operations

in 2000, and accepts approximately 40 percent of the waste generated. Several open dumps accept an additional 5 to 10 percent of the waste.

Table 2. Summary waste management and landfill data for selected cities

Municipality	Province	Population served (million) ^a	Total waste generated (million ton/year) ^a	Per capita waste (ton/year)	Proportion of waste formally managed (%) ^a	Number of major landfills ^b
Beijing	-	9.38	4.5	0.48	60	4
Tianjin	-	5.93	2.45	0.41	53	1
Shanghai	-	10.1	5.4	0.53	72	1
Nanjing	Jiangsu	2.73	1.0	0.37	75	3
Harbin	Heilongjiang	3.37	1.29	0.38	65	2

Sources:

a. Municipal and Provincial Yearbooks, 2001.

b. Local governments.

Shanghai, China's largest industrial and commercial center, is also the country's most populous city. Situated on the Yangtze River Delta, it covers 6,185 sq km and has an urban population of 10.1 million. Shanghai generates about 5 million tons of urban waste each year. Its only landfill, the largest in China, accepts approximately 55 percent of that waste. Its existing capacity will be exhausted by the end of 2003. Incineration facilities currently accept 10 to 15 percent of the waste, but will most likely play an increasingly important role in the future because of Shanghai's high population density and limited land availability.

Nanjing is the capital of the relatively well-developed Jiangsu province. Located on the middle and lower reaches of the Yangtze River, it is one of China's four major scientific research and educational centers. It has an urban population of 2.73 million and covers 6,516 sq km. Nanjing's three major landfills accept over 85 percent of 1 million tons of waste generated annually. At its largest landfill, Shuige landfill, a GEF-funded landfill methane power plant is in operation with a capacity of 1,200 kW. Researchers at Nanjing University have been investigating the feasibility of recovering methane from the Tianjingwa landfill, and plans are currently under way to construct a pilot methane power generation plant at the facility.

Harbin, the capital of Heilongjiang province, is the largest city in Northeast China. Located on the Songhua River, it is a favorite summer resort in China. It has an urban population of 3.37 million, and covers 53,067 sq km. Harbin generates around 1.29 million tons of urban waste each year. Its two major landfills accept approximately 50 percent of the waste generated. An additional 10-15 percent of the waste is deposited in small open dump sites scattered throughout the city.

4.0 CONCLUSION

This paper presents an overview of solid waste management in China and some summary statistics on five major urban areas. These data were

collected as part of an ongoing project by the U.S. EPA to compile a database on municipal solid waste management practices in selected countries. The searchable database will contain statistics on solid waste generation, composition, and management practices in key urban areas. It will also provide detailed information on individual landfills, including ownership, location, capacity, lifespan, waste acceptance rates, and pollution controls. The database will aid public policy decision-making with regard to such issues as climate change, water pollution, sanitation, and public health.

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