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ORIGINAL ARTICLE

An overview of municipal solid waste management in Inner Mongolia Autonomous Region, China

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Abstract Rapid industrialization and urbanization in developing countries have created serious problems in municipal solid waste (MSW) management. New case studies can shed light on these problems and point the way to potential solutions for improving the overall eco-efficiency of MSW management. This paper employs a case study approach, analyzing MSW management in Inner Mongolia. This study encompasses all aspects of MSW management, including collection, separation, recycling, and disposal. Problems and challenges are identified through our analysis, and recommendations are raised by considering the local realities. Our main findings are: (1) while large cities have already established a solid foundation for MSW management, small- and medium-sized cities deserve more attention; (2) MSW in rural areas is even worse than urban areas; (3) enforcement of MSW regulations is ineffective and needs improvement; (4) lack of funds, R&D efforts and advanced technologies have impeded sustainable MSW management; (5) lack of coordination and communication among different stakeholders further damages the efforts for improvement of MSW management. Therefore, integrated efforts that combine the above concerns should be initiated so that the overall effectiveness and efficiency of MSW management can be improved.

Keywords Municipal solid waste management · Enforcement · Sustainable development · Inner Mongolia · China

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Introduction

Municipal solid waste (MSW) refers to those items such as product packaging, grass clippings, furniture, clothing, bottles, food scraps, newspapers, appliances, paint and batteries [1]. MSW management has been and will continue to be a major issue facing countries worldwide [2], especially in the cities of developing countries [3]. The annual growth rate of global municipal solid waste is about 3.2–4.5% in developed nations and 2–3% in developing nations [4]. Meanwhile, with limited resources, backward technologies for waste treatment and disposal, and ineffective enforcement of relevant regulations, serious problems on MSW management exist in developing countries, especially in the field of safe disposal and efficient recycling of MSW [2, 5]. Thus, there is a growing concern on how to improve MSW management in developing countries [6].

China, as the largest developing country, generated 190 million tons of MSW in 2004 and became the world's

largest MSW generator [2]. According to the World Bank's estimation (2005), the total amount of MSW in China will be over 480 million tons in 2030 [7]. Urbanization, rapid population growth and industrialization are three key factors resulting in the quick increasing of total MSW [8]. Currently, to better management of MSW has been considered as one of the key missions of China's national circular economy project [9, 10]. Academically, many studies on China's MSW management have been undertaken, especially at city level, such as in Guanghan [11], Guangzhou and Hong Kong [12], Beijing [3, 13], Hangzhou [14], Pudong new area [15], Tianjin [14, 16, 17], Three Gorges region [18], Shanghai [19], and even at country level [2, 4, 7, 8, 20]. But due to large size and imbalanced development situations, as well as different social, economic and cultural features, MSW management situations vary in different Chinese areas For instance, the per capita daily amount of MSW generated in the Pudong New Area of Shanghai was about 1.11 kg [15], while the figure for Lhasa city of Tibet is 1.51 kg [5]. Another example is that food waste accounts for 23.8–65.6% of the total MSW in Three Gorges region [18], but about 44-57% in Tibet [3]. Generally, comparing with developed countries, such as Germany, Sweden, Japan, and the United States [21], China's MSW management is still at its early stage. There is a great demand for further improving the overall efficiency of MSW management. Also, there are few studies at the provincial level (politically China is divided into 23 provinces, five autonomous regions (minority-dominated regions) and four municipalities (Beijing, Tianjin, Shanghai, and Chongqing, which are directly accountable to the central government). Consequently, in order to better understand the general situations in different Chinese provinces, there is a need to have more regional studies, especially in minority-dominated regions, such as Inner Mongolia Autonomous Region.

This paper fills such a gap by employing a case study approach in Inner Mongolia Autonomous Region (Abbr. Inner Mongolia). We first introduce their basic information and current MSW management situations, including MSW collection, transportation, recycling and final disposal. Barriers and challenges are identified and appropriate recommendations are raised by considering the local realities. Finally we draw our conclusions. We expect that our study could provide policy implications for further improving sustainable MSW management in Inner Mongolia.

Background information of Inner Mongolia

Located in the northern part of China, the Inner Mongolia Autonomous Region is a province-level region of the People's Republic of China. It stretches 2,400 km from west to east and 1,700 km from north to south, and it is the third-largest subdivision of China spanning about 1,180,000 km^2 and 12.3% of China's land area. It neighbors eight provinces and regions in its south, east and west and Mongolia and Russia in the north (Fig. 1), with a borderline of 4,200 km.

Inner Mongolia has a temperate continental climate, with an annual precipitation of 100–500 mm, 80–150 frost-free days, and 2,700 h of sunshine. The Greater Hinggan Mountains and the Yinshan Mountains divide the regions into areas with different climate features. The east part of the Greater Hinggan Mountains and the north of the Yinshan Mountains have lower temperature and less precipitation than the opposite areas. Owing to its special geological condition, Inner Mongolia features a harsh eco-environment. In recent decades, the inefficient environmental management and irrational exploitation on natural resources have brought many ecological challenges, such as drought, desertification, sandstorm, rapid decreasing of arable land and soil erosion.

The total population in 2008 was approximately 24.13 million, including 4.36 million Mongolian. The total urban population within Inner Mongolia was 12.48 million, accounting for 51.7% of the total population. Inner Mongolia consists of 12 city-leveled administrative divisions, including Hohhot, Baotou, Wuhai, Chifeng, Tongliao, Ordos, Hulunbeier, Bayannaoer, Wulanchabu, Xingan, Xilinguole, and *Alashan*. There are 20 cities in Inner Mongolia. According to the Chinese standards on city scales, these 20 cities can be categorized into nine small cities, four medium-sized cities and seven large cities (Table 1) [22].

With the discovery and exploitation of natural resources, such as coal, natural gas, rare metals, as well as the soaring demand of other Chinese regions, Inner Mongolia has experienced the fastest economic development since early 2000. The annual GDP increasing rate in Inner Mongolia was 16% in the last decade, which is higest among all the Chinese provinces. The total GDP in 2011 is 1.162 trillion RMB, while the per capita GDP in 2011 is 49,327 RMB, namely 7,540 USD (current exchange rate: 1 USD = 6.54 RMB) [22].

MSW generation and characteristics

With the rapid urbanization, increasing population and economic development, the total amount of MSW generated in Inner Mongolia in the last couple of years had increased from 3.30 million tons in 2004 to 3.61 million tons in 2008. Table 2 shows the changes of urban population, GDP and total amount of MSW from 2004 to 2008, where we can see that the urban population in Inner

Fig. 1 Location of Inner Mongolia in China

Table 1 City scales in Inner Mongolia

Prefecture-level administrative divisions	Cities	Urban Population (year-end of 2008) (10^4 persons)	City scale
Hohhot	Hohhot city	105.54	Large city
Baotou	Baotou city	135.58	Large city
Hulunbeier	Hulunbeier city	180.28	Large city
	Manzhouli city	16.54	Small city
	Zhalantun city	16.86	Small city
	Yakeshi city	36.44	Medium-sized city
	Genhe city	16.31	Small city
	Eerguna city	7.76	Small city
Tongliao	Tongliao city	119.47	Large city
	Huolinguole city	7.89	Small city
Chifeng	Chifeng city	107.19	Large city
Wuhai	Wuhai city	45.01	Medium-sized city
Wulanchabu	Wulanchabu city	71.82	Large city
	Fengzhen city	9.56	Small city
Erdos	Erdos city	46.89	Medium-sized city
Bayannaoer	Bayannaoer city	62.79	Large city
Xingan League	Wulanhaote city	23.64	Medium-sized city
	Aershan city	4.79	Small city
Xilinguole League	Erlianhaote city	9.22	Small city
	Xilinhaote city	14.40	Small city

Data source: Inner Mongolia Statistical Yearbook, 2009

According to the national standard, city scale is depends on its non-agricultural population in its urban and inner suburban districts, a "large city" means one which has a non-agricultural population of 500,000 or more in its urban and inner suburban districts; a "medium-sized city" means one which has a non-agricultural population of over 200,000 but fewer than 500,000 in its urban and inner suburban districts; a "small city" means one which has a non-agricultural population of fewer than 200,000 in its urban and inner suburban districts

Table 2 Urban population, GDP and total MSW generated in Inner Mongolia

Year	Urban population[a] (million)	GDP[a] (billion RMB)	MSW generated[a] (10^4 Tons)	Generation intensity[b] (kg/capita/day)
2004	10.93	304.11	329.29	0.83
2005	11.26	389.56	328.81	0.80
2006	11.63	484.18	336.02	0.79
2007	12.06	609.11	349.81	0.79
2008	12.48	776.18	360.79	0.79

[a] Inner Mongolia Statistical Yearbook, 2005–2009

[b] The authors

Mongolia increased from 10.93 million in 2004 to 12.48 million in 2008, with an average annual increase of 3.37%. At the same time, total GDP increased even faster than the population, with an average annual increase of 26.40%.

The total amount of regional MSW is influenced by socio-economic development level, consumption behaviors, culture, public awareness and climate aspects. Generally, the faster economic development and the higher percentage of an urban population indicate that more MSWs will be generated [23]. For example, Jin et al. (2006) concluded that the MSW generation in Macao can be attributed both to a rapid population increase and economic development [24]. Similar results were found in Beijing as well [3]. Chen et al. [2] argued that since the late 1990s, the urban population has had a greater impact than GDP on the total amount of MSW in China. In Inner Mongolia, we found that the MSW generation amount has been relatively stable on a per capita basis, GDP has not been significantly correlated with MSW generation between 2004 and 2008, and the total amount of MSW has been significantly decoupled from urban economic activity (Table 2; Fig. 2).

The average per capita rate of MSW generation in Inner Mongolia was 0.79–0.83 kg/day in 2008. In general, the per capita generation of MSW in Chinese cities ranges from 0.2 to 1.7 kg/capita/day [25], while in a typical developed country such a figure ranges from 1.43 to 2.08 kg/capita/day [26] (Troschinetz and Mihelcic 2009). But comparing with other developing countries, such a figure in Chinese cities is a little bit higher. For example,

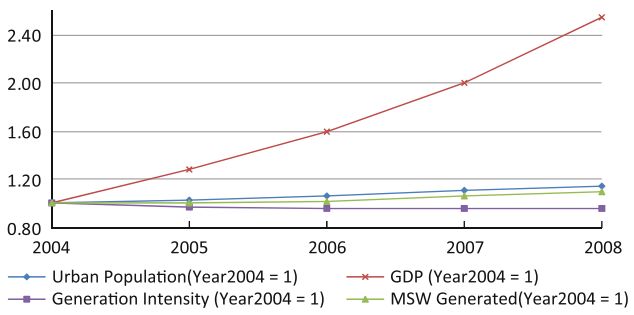

Fig. 2 Urban population, GDP, MSW generation and intensity in Inner Mongolia

the per capita MSW generation rate was 0.85 kg/day in Beijing [3], 0.92 kg/day in Hangzhou [27], and 1.05 kg/day in Chongqing [21], while the per capita MSW generation rate was 0.92 kg/day in Mexico [28], 0.57 kg/day in Nepal [29], 0.61 kg/day in Vietnam, and 0.52 kg/day in the Philippines [23].

Information on the components of MSW generated is fundamental to almost all aspects of MSW management [30]. The composition of MSW depends on a wide range of factors, such as food structure, cultural conditions, lifestyles, climate and income, local landscaping, etc. Zhang et al. [31] indicated that the composition of MSW in China is extremely non-homogenous and the variation is caused by differences between regions: the level of industrialization and income, consuming habits etc. According to their official statistics on MSW, the components of MSW in Inner Mongolia are categorized into three types, namely, organic waste, mineral waste, and recyclable waste. The percentage of such components varies in cities with different scales. Table 3 lists such a difference, where we can see that the total weight of mineral wastes in small cities is about 74% of the overall weight of MSW, the main MSW components in medium-sized cities are mineral wastes and kitchen wastes, comprising 54% and 34% of the total weight of MSW respectively, and organic waste is the largest MSW in large cities, comprising 55% of the overall weight of MSW [31]. It's interesting that the component of mineral waste (mainly referring to ash/dust) varies between different scale cities, namely, 63% in small cities, 41% in medium-sized cities and only 3% in large cities, while the component of organic waste in large cities is 55%, but only 34% in medium-sized cities and 15% in small cities. The main reason is that district-heating system is widely applied in large cities, but not popular in medium-sized cities and only few in small cities. Citizens in small- and medium-sized cities mainly rely on burning coal for heat in winter and the length of winter in Inner Mongolia is almost six months, resulting in significant amount of ash and dust. Although the Inner Mongolia government has decided to establish more district heating systems in small- and medium-sized cities, due to economy of scale factor, such an initiative is still in its early stage. But with the increasing public attention on urban air quality and stricter

Table 3 Composition of MSW in Inner Mongolia (weight, %)

City scale	Mineral waste		Organic waste	Recyclable waste					
	Ash/dust	Debris and other inorganic wastes		Paper	Textile	Wood	Plastic	Metal	Glass
Small	63	11	15	4	1	2	2	1	1
Medium	41	13	34	4	1	2	1	2	2
Large	3	13	55	5	1	3	10	2	8

Table 4 Basic statistics on MSW disposal, treatment and infrastructures

Cities	MSW disposal (10^4 tons/year)	Harmless treatment (10^4 tons/year)	Landfills	Composting plants
Hohhot city	41	39	2	1
Baotou city	72	70	3	0
Hulunbeier city	18	0	0	0
Manzhouli city	18	5	1	0
Zhalantun city	10	0	0	0
Yakeshi city	8	0	0	0
Genhe city	5	0	0	0
Eerguna city	3	0	0	0
Tongliao city	21	21	0	0
Huolinguole city	11	0	0	0
Chifeng city	37	30	2	0
Wuhai city	22	18	1	0
Wulanchabu city	19	0	0	0
Fengzhen city	9	9	0	0
Erdos city	18	18	1	0
Bayannaoer city	15	14	1	0
Wulanhaote city	14	14	1	0
Aershan city	3	0	0	0
Erlianhaote city	7	0	0	0
Xilinhaote city	9	8	1	0
Total	360	246	13	1

environmental regulations, as well as more expensive coal price and disposal cost, governmental officials in small- and medium-sized cities have to promote the application of district heating system. Another alternative is to replace coal by natural gas or biomass since both of them are local rich resources. Moreover, in order to create better urban environment, family farm will be phased out. From long term point of view, we believe that the percentage of ash/dust will significantly reduce, while the organic waste will become the main MSW (Table 4).

With regard to organic waste, the proportion of such a waste in large cities (55%) are very similar to other Chinese large cities, such as Pudong New Area of Shanghai (48%) [15], Beijing city (63.39%) [3], Chongqing city (59.2%) [21]. This reflects that citizens in large Chinese cities have similar consumption pattern. This figure is rather small in small- and medium-sized cities, because many citizens there still raise poultry at home and feed them leftovers, while citizens in large cities are not allowed to feed and raise poultry at home. Therefore, the proportion of organic waste in small- and medium-sized cities is smaller than that in large cities.

In terms of recyclable wastes, such a percentage in small cities and medium-sized cities is around 11–12%, while that of large cities is about 29%. Recyclable wastes include waste paper, textile, plastic, glass, and metal. Such wastes can be recycled and should be regarded as potential "resources".

Hazardous wastes include used batteries, discarded fluorescent tubes and bulbs, expired medicine, unused paints, solvents and other chemicals. However, according to the official statistics of Inner Mongolia government, such a waste was not listed as one type of MSW. But due to its toxicity and potential impacts on the local ecosystem, it is necessary to add it into their MSW statistics system so that appropriate treatment and safe disposal can be conducted and supervised.

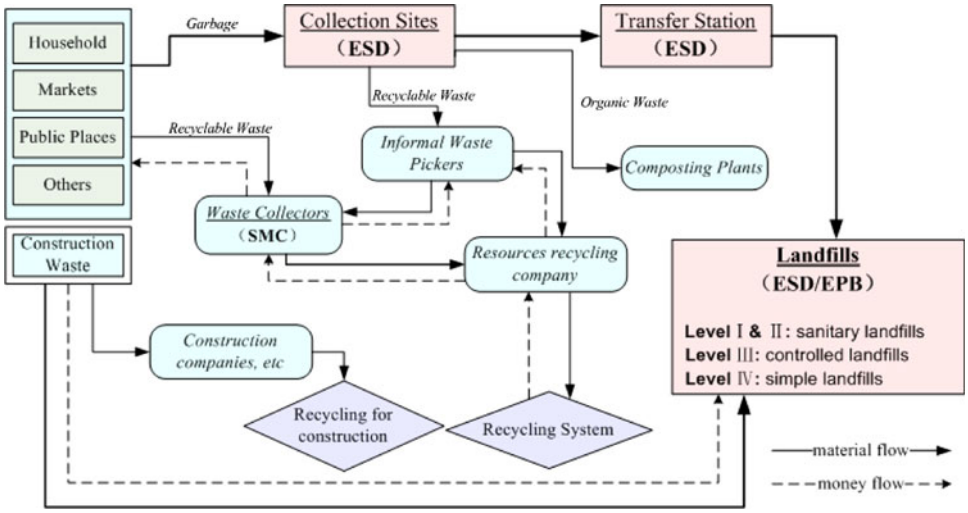

Fig. 3 Flow chart of MSW in Inner Mongolia

Current status, challenges and suggestions on MSW management in Inner Mongolia

Administrative framework of MSW management in Inner Mongolia

The relevant agencies on MSW management at provincial level in Inner Mongolia include Environment Protection Bureau (EPB), Environmental Sanitary Division (ESD) under the Housing and Urban–Rural Development Bureau (HURD), and Supply and Marketing Co-operatives (SMC). The provincial EPB is responsible for supervising the enforcement of relevant regulations conducted by the city EPBs and collecting detailed data from all the city leveled EPBs, as well as coordinating MSW among different cities, while the city EPBs are in charge of issuing warnings, imposing fines, revoking permits, and issuing various kinds of orders for managing MSW. Such orders may address a broad range of possibilities, such as requirements related to treatment facilities, suspending production and even the closure of a facility. As such, provincial ESD is in charge of issuing administrative measures on MSW collection, separation facilities and landfills, while the local ESD is the legal administrator for operating MSW treatment facilities, including MSW collection centers, separation centers and landfills. Finally, provincial SMC is a semi-governmental agency and the legal body for managing recyclable wastes, including enacting regulations on collecting, delivering and transaction of recyclables, establishing and operating markets for second-hand recyclables, and supervising cross-boundary transaction of recyclable wastes. All the local SMCs are sub-branches of provincial SMC and under its supervision. It's clear that each agency has its own administrative functions; however, due to lack of communication among the three agencies, none of these agencies are subordinate to one another. Consequently, cross-departmental issues always exist. In order to solve such a problem, a new solid waste management commission should be created and should address the integration of MSW management with administrative authority to develop, coordinate and implement relevant functions. The functions of this new authority should include carrying out data collection and analysis, monitoring day-to-day operation and preparing strategic planning for integrated MSW management, encouraging source reduction, source separation, reuse and recycling, and designing and constructing appropriate MSW facilities.

Waste collection and delivery

The general flow chart of MSW in Inner Mongolia is shown in Fig. 3. Collection, transportation, recycling and disposal are part of the primary system of MSW material flow in Inner Mongolia cities.

The collection methods of MSW are different between urban and rural areas. With a better urban plan, most urban residential communities are managed by licensed companies, called as property management companies. Such companies are responsible for cleaning, landscaping, waste management, public facility maintenance and security issues by charging their tenants. They put waste containers in front of each apartment building. The residents usually put their MSW into plastic bags and discharge these bags into such containers; most of MSW is not source-separated. Then each morning the staff members of the property management company remove the waste to a small MSW transfer site for simple separation. Valuable wastes, such as paper, plastic bottles and metals, are then separated and sold out. Then, the Environmental Sanitation Division (ESD) is in charge of collecting and delivering such MSW to the larger MSW transfer stations for further separation. For those residential communities

that are not managed by such companies, residents discharge their waste into the public waste containers provided by the ESD. But before ESD employees collect such waste, unmanaged waste pickers come first to separate and collect recyclable waste for their income. These waste pickers usually come from poor rural areas and lack education. In order to just access the valuables, they frequently break the plastic garbage bags, making these containers dirty and the surrounding areas polluted. Waste is then delivered by the ESD to MSW transfer stations. Besides these popular channels, many residents often keep valuable wastes to resell, especially for PET bottles, waste packaging materials, and metals (aluminum and steel/iron). The local SMC has established many collection sites within urban areas and therefore is in charge of collecting such wastes directly from local residents. The advantage of this channel is that the residents can keep such wastes in a relatively clean place, thus reducing the potential for loss.

Compared with MSW management in urban areas, MSW management in rural areas deserves more attention because no formal collection system exists. Most villages have their own MSW rules, namely, sending their MSWs to a designated site and then contracting a special team to collect such wastes and deliver them to local landfills. But since Inner Mongolia boasts large grasslands, in some remote areas where only a few nomadic people live, the normal MSW practice is to simply dump waste in open land, without any special treatment. Although the total amount of MSW in rural areas is relatively small, the negative impact on the surrounding environment is significant. For instance, it's popular for rural citizens to dump hazardous waste in local agricultural fields, some of which are close to the local rivers, posing both environmental and health risks on local communities. However, both enforcement officials and local citizens do not recognize such risks and regard this practice as normal. Most of them do not know the potential impact of dumping such waste on the local soil and water quality and even accept the view that the local ecosystem can absorb this impact through natural processes. Consequently, there is a need to a program to improve the public awareness on MSW management. Such a program should encourage better MSW with TV promotions, newsletters and regional symposia and workshops. These awareness raising activities can help build understanding, since such initiatives provide forums at which experiences from different parts of the country and from different institutions could be objectively reviewed and lessons drawn. These activities can also create opportunities for stakeholders to strengthen their mutual understanding, trust and respect, which will become a solid foundation for further collaboration.

Waste recycling

One important perspective of China's overall MSW management system is a large amount of both formal and informal waste sorting and recycling [7]. Formal businesses refer to those legally established firms with commercial licenses and tax-paying records. The majority of these businesses are the national Supply and Marketing Co-operatives (SMC), which have set up many sub-branches both at the provincial level and local level. But besides this formal activity, the participation of the informal sector is an important characteristic of waste recovery and recycling in developing countries [32]. In China, informal agents remain the major collectors of recyclables, having been involved in this field since the mid-1990s when the government stopped the waste redemption services previously offered under the planned economy system [2]. According to the World Bank [7], around 1,300,000 persons work in the formal waste recycling system and around 2,500,000 persons work in the informal sector.

In Inner Mongolia, the formal recycling system is mainly operated by the local Supply and Marketing Co-operatives (SMC). At the end of 2006, there were 3,223 formal recycling sites and about 11,090 workers (including 2,800 immigration workers coming from other provinces). About 900 sites with 2,000 workers were operated by SMC, which accounted for about 27.9 and 18.0% respectively. There were about 300 recycling firms in Inner Mongolia, 120 of which were operated by SMC. According to provincial SMC in 2007, the recycling rates of waste metal and paper were approximately 80%, and those of plastic and glass were 50% and 30%, respectively. Therefore, there is a great potential for Inner Mongolia to further increase the recycling rate of these key items. The main reason is that due to lack of source separation, many valuable wastes were mixed with other garbage and dumped to landfills. Consequently, source separation initiatives should be set up across the whole region, such as pilot projects on a small scale, so that the potential benefit can be measured. Education efforts should also be considered so that the public can better separate their MSW at source. In addition, the Japanese garbage bag system, namely, putting different items into different color garbage bags, should be considered.

Waste disposal

MSW disposal is a complex and multidisciplinary problem that should be considered from the environmental, social, technical, and economic aspects [33]. The harmless disposal ratio of MSW in Inner Mongolia is about 68.3%, only a little bit higher than the average level of China (66.76%) [34]. Harmless disposal ratio is a key indicator for the

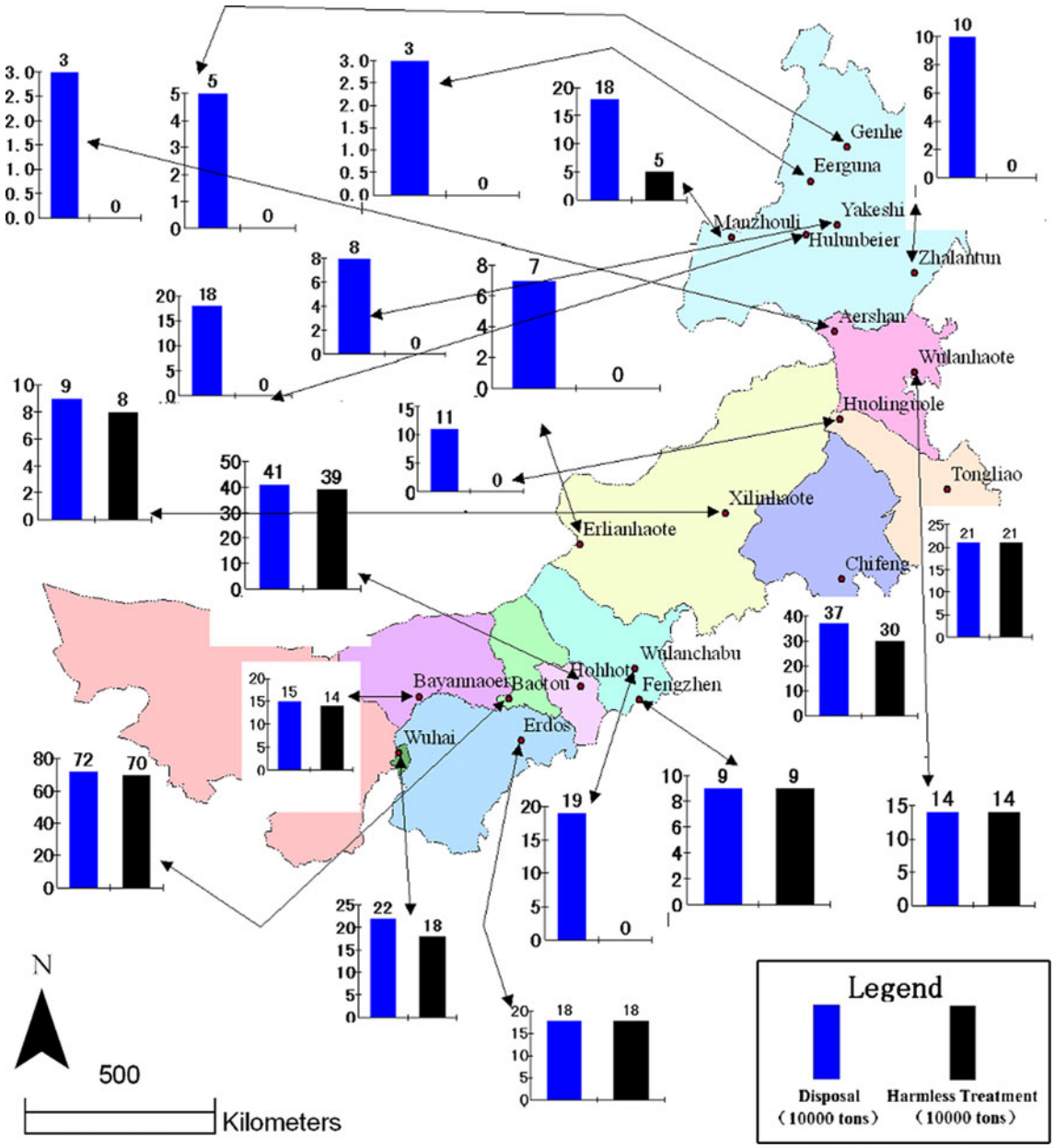

Fig. 4 Distributions of MSW disposal and treatment in Inner Mongolia

Chinese government to evaluate the safe disposal level of MSW. The main methods for harmless treatment include incinerating, landfilling, and composting. Currently, landfilling is the dominated method for MSW disposal in Inner Mongolia (Fig. 4). Both incineration and composting facilities are still lacking. Some cities do not have their own landfills and have to deliver their MSWs to neighboring cities, such as Tongliao, Wulanchabu and Fengzhen. But with the increasing amount of MSW and limited capacities of current landfills, it is crucial for these cities to establish their own landfills. Due to high costs and concerns over potential dioxin emission, incineration is not a viable option. In addition, owing to lack of source separation, composting is also not an effective option. The reality is that most of the landfill sites are open dumping areas, posing a serious environmental and social threat to the local communities. In 2008, there were 13 landfill sites in Inner Mongolian cities with a total designed capacity of 5,829 tons/day, accounting for 87.9% of MSW disposal, and one composting site with capacity of 800 tons/day, accounting for 12.1% of MSW disposal. There are several challenges for operating landfills in Inner Mongolia, including lack of capacity for more MSWs, inadequate collection and inappropriate treatment of leachate, lack of methane collection system, and insufficient compressing and covering operation. Such a practice has resulted in both

groundwater and soil contamination, as well as increasing demands on new landfills. Therefore, there is a need to invest more money so that more advanced landfills can be established, especially in those cities where currently no landfill exists. Research efforts related with improving the operation of landfills should also be encouraged. Such research components should focus on developing and testing innovative solutions to resource recovery from landfills, the control of illegal dumping and the improvement of leachate control, as well as methane collection and application (such as methane-based power plant).

Conclusions

The rapid economic development and improving living standards in developing countries has required more effective and efficient MSW management. The case of Inner Mongolia has demonstrated that heterogeneity on MSW management exists due to different economic development level, social demand, culture, consumption pattern, and environmental awareness. While large cities have set up a solid foundation for better MSW management, those small- and medium-sized cities are still facing serious challenges, such as lack of funds and advanced technologies, lack of environmental awareness, ineffective enforcement on relevant regulations, and lack of cooperation. Situations in the rural areas are even worse, deserving more consideration. An integrated MSW management framework is yet to be established. Consequently, in order to improve the overall management effectiveness and efficiency in Inner Mongolia, more innovative efforts should be initiated. For instance, the optimization of an energy consumption structure and the operation of district heating systems can significantly reduce the total amount of ash/dust in small- and medium-sized cities. Organization reforms, such as an establishment of a cross-departmental MSW management commission, can address the integration of MSW management issues so as to better develop, coordinate and implement relevant functions. Such a reform requires effective enforcement of relevant regulations, since it involves a substantial degree of discretion at the field level among field regulators. If field regulators are not environmentally sympathetic and not given sufficient institutional support, the effectiveness of MSW management will be compromised and its importance diminished. Thus, it's critical to enhance their training, their belief paradigm, the perception of their role and policy legitimacy. Another finding is that MSW management should address the local needs by considering the local realities. While incineration is becoming more popular in other Chinese large cities, it may not be a suitable option in Inner Mongolia due to its higher costs and potential environmental threats. Therefore, the most appropriate option is is not necessarily the most expensive and sophisticated one. Finally, public awareness on MSW management is still very low, especially in the rural areas. Consequently, further capacity building programs may be necessary so that local citizens can improve their awareness and skills. Generally, the case of Inner Mongolia represents a typical Chinese region's MSW management, with rapid industrialization and urban population. The policy implications for this case can also be referred by other Chinese regions so that the overall efficiency on MSW management at the regional level can be improved and regional sustainable development can become a reality.

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