Solid Waste Management: Evidence from Zhenjiang Municipality-China

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ABSTRACT

China—the second largest economy in the world has experienced both rapid economic development and large-scale urbanization. These situations have led to municipal solid waste (MSW) management issues. China increases its MSW by about 8%-10% per year yet, the per capita MSW produced pales in comparison with levels of developed countries. However, the core aims of MSW management are public health and environmental safety. Therefore, the study identified the waste hierarchy pyramid as a key to achieving sustainable MSW management in various municipalities across China with emphasis on the 3Rs [i.e. reduce, reuse and recycle], and incineration or energy recovery to reduce the total quantities of waste generated and/or landfilled. Additionally, there is a need for the capacities of existing MSW technologies to be improved in order to conform to standards while meeting local demands. The study concludes on source separation of waste as a cog to the successful management of MSW.

Keywords: Solid waste management, municipal, disposal, source separation.

INTRODUCTION

China’s rapid economic growth coupled with urban expansion has brought about an improved life for the citizenry. Conversely, waste production has been colossal. An estimated 178.6 million tons of waste were produced in 2014 [National Bureau of Statistics of China, 2015]. In terms of solid waste, many researchers established its increase [Huang, et al., 2013; Wang, et al., 2011; Song, et al 2008; Tang & Zuo 2008]. For instance, in 2007; solid waste generated from household activities surpassed agricultural production waste as the top pollution hazard in rural China [Tang & Zuo, 2008]. In recent years, no country has experienced a rapid increase in solid waste production as China [Bouanini, 2013; Yuan, et al., 2006]; while the World Bank projected a growth of about 190 million - 480 million between 2004 and 2030 [World Bank 2005] with a growth rate of about 10% [ Pla, 2015].

The composition of municipal solid waste [MSW] differs among locations with significant changes over time [Kumar, et al., 2016]. Basically, MSW includes domestic waste, bulky waste, glass, paper, industrial waste, medical waste, market waste, road sweeping and litter among others. Rana, et al; 2015; classified municipal solid waste as food waste, commercial waste, agricultural waste, institutional waste,
industrial waste, constructional waste, rubbish, and street sweeping waste. Solid waste generated is mainly determined by population and its per capita waste generation. These are greatly influenced by economic growth, life style and food habits [Rana, et al., 2015]. Population growth has increased the amount of municipal solid waste [MSW] generated in China thus surpassing the United States [World Bank, 2005]. Per capita wise; 0.98 tons per year falls below developed countries [Zhang, et al., 2010]. Waste disposal, in China; is safe despite its rapid increase [Chen, et al., 2010]. Several researches have been done about MSW management in major cities across China. This study, therefore, seeks to explore the sustainable municipal solid waste management practices and/or systems in Zhenjiang city.

**Municipal Solid Waste [MSW] Management in China**

In the early years, the quantity of waste was very minimal. Back then, waste usually consisted of food and was reused as fertilizer. This reduced the number of items treated as waste [Cheng, 2017; Goldstein, 2011]. It is believed, nothing actually went to waste back then literally hence there was no formal MSW treatment or disposal facility before the 1980’s [Cheng 2017]. MSW reused as fertilizers changed over time as chemicals fertilizers replaced MSW; which were predominantly food. Consequently, huge amounts of MSW were dumped in streams, ponds, lakes as well as roadides. By the late 1980’s MSW had surrounded major cities like Beijing and Shanghai posing various environmental hazards which attracted many local governments attention [Dong, 2011]. It is estimated that about two-thirds of the 688 cities in China are surrounded by waste management sites particularly, landfills [Zhang, et al., 2015]. Consequently, China surpassed the United States of America as the world’s largest producer of MSW [Song et al. 2013].

Crucially, urbanization is among the factors for the burgeoning waste situation in most cities. The 1979 economic reforms led to massive economic and social transformations. Settlement patterns changed thus making more people opt for urban centres [United Nations, Department of Economic and Social Affairs, Population Division 2014]; as these urban centres promised jobs [Pla, 2015]. China witnessed the highest rural-urban migration between 1979 and 2009: 440 million to 622 respectively [Chan, 2013]. Yet, the greater use of pre-packaged foods coupled with logistical issues particularly waste collection, storage, transport and disposal is a major challenge in these urban centres [Pla, 2015]. This assertion concurs with the argument that urban dwellers embracing consumer society has led to about 8% to 10% yearly increase in solid waste output [Bouanini, 2013]. Presently, the per capita production of MSW is 1.12 kg in China’s cities [Zheng, et al., 2014], but it may be more in large cities such as Beijing, Shanghai, and Guangzhou. Beijing produced about 20,000 tons of garbage a day in 2009 [Shapiro, 2016].


Figure 2. The urbanization trend of China over the past two decades [Zhang, et al 2015; National Bureau of Statistics of China 2014].
Despite the rapid increase in waste generation; the per capita waste is low compared to other countries [Wei et al., 2012; Zhang et al., 2010].

**MATERIALS AND METHODOLOGY**

**Equation 1 Calculation of population** [Khajuria, et al., 2008; Weber, 2004]

\[ P (1+r) T \]

Where \( P \) = initial population people, \( r \) = percent growth rate/100 and \( T \) = years.

**Equation 2 Estimation of waste generation** [Khajuria, et al., 2008; Weber, 2004]

\( (population) \times (waste \ generation \ rate) \times (number \ of \ days \ per \ year) \div (number \ of \ pounds \ per \ ton) \)

**RESULTS AND DISCUSSIONS**

Assuming the municipality has a population of about 2.6 million with an estimated growth rate of 1.2 percent per a year. The period under consideration is the next 10 years with a waste generation rate of about 1.12 percent for a year.

Based on the above; to determine the population growth and waste generation for the period; equations 1 and 2 were used respectively.

**Eqn 1 Population Estimation**

Year 1 \[ 2600000(1+0.012)^1 = 2631200 \]

Year 2 \[ 2631200(1+0.012)^2 = 2694730 \]

Year 10 \[ 447290(1+0.012)^{10} = 5010730 \]

**Eqn 2 Estimation of Waste generation**

Year 1 \[ (2600000 \times (1.12) \times (365) \div (2000)) = 537817.28 \]

Year 2 \[ (2694730 \times (1.12) \times (365) \div (2000)) = 550802.812 \]

Year 10 \[ (5010730 \times (1.12) \times (365) \div (2000)) = 1024193.212 \]

From the table above; both population and waste generated increased within the period. Significantly, the city attracted people during these years. As most urban centres promise jobs, social amenities, recreation among others; such places attract most people as postulated by Pla, 2015, Bouanini, 2013 and Chan, 2013. Consequently, the annual waste produced increased which thus puts pressure on existing waste management facilities. For instance, in the next ten years, more landfills, incinerators and recycle plants might be needed to augment the current facilities. On the other hand, people should be encouraged to reduce waste and reuse materials if possible. In addition, the municipality should intensify source separation in order to ensure high caloric value of waste incinerated while at the same reducing wastes that are landfilled. Moreover, the figures above means, there will be competition for landfill sites in the near future. Also, there would be pressure on incineration and composting facilities. Therefore, it is necessary to first maintain or improve capacities of existing landfills as well as that of incinerators. In addition, there should be more investment in incineration, composting and recycling technologies to cater for the increases in wastes produced.

**CURRENT SITUATION OF SOLID WASTE MANAGEMENT IN ZHENJIANG**

**Waste generation and composition**

Waste generated in Zhenjiang is mainly a varied mix biodegradable and non-degradable items. Commonly, plastics, food remains, fabrics and glass are the components. In general, waste is highly biodegradable because vegetables and fruits make a major component of diet. Additionally, the high biodegradable nature of waste allows source separation and composting [Zhang et al., 2015; Zhang et al., 2010].

**Waste collection, transportation and disposal**

MSW collection, transportation and disposal is crucial in waste management particularly for public health, environmental and aesthetic purposes. MSW management considers storage, collection and transportation and disposal as crucial factors [Minghua, et al., 2009].

**Storage.** A good storage facility is key to effective waste management [Minghua, et al., 2009; Oluwande, 1984]. Litter bins are provided in both homes and on the streets. In homes, waste containers of varying sizes are provided for scheduled pick-ups by waste collectors. On the streets, waste bins with labels are put in bus stops and other vintage areas for waste collection. This allows easy source separation of waste [Pla, 2015; Chao, 2008; Tsai et al., 2007].

**Waste collection transportation.** Waste collection is done per assigned schedules using various vehicles and means. There are hand pickers who scavenge various waste collection points to pick recyclables from waste containers in both residential areas and
along the streets [Pla, 2015; Zhang, et al., 2015; Bouanini, 2013; UN Habitat, 2010]. Valuable materials are thus separated at source to ensure effective disposal [Pla, 2015; Zhang et al., 2015]. The automated vehicles used consider the size of waste bins or containers [Chen, et al., 2010; Zhang, et al, 2010; Chiplunkar et al., 1981]. Waste collected are transported to transfer stations and/or disposal sites. The quantity of waste produced makes daily collection and transportation necessary to prevent stench in the residential areas and streets [Minghua, et al. 2009].

Disposal. Waste management affects environmental management because the untreated waste effluents is a threat to ecosystems and human health [Bouanini, 2015; Sterner & Coria 2013]. As seen the in the waste management hierarchy, waste reduction and reuse are the major priorities in any waste management programme. Equally important on the pyramid are recycling and composting. That is, if waste cannot be reduced or reused; it should be recycled or composted. To achieve this, source separation should be highly encouraged to ensure valuable materials such metal, glass, paper among others are retrieved from the chunk of waste. However, that which cannot be reduced or reused; recycled or composted should be recovered – mainly heat and power [Ryu, & Shin 2012]. Finally, waste that cannot be reduced, reused or recovered should be treated and disposed in landfills.

Source: U.S. EPA

Recycling Scavenging, is key to recycling in most MSW municipalities in China. Waste pickers separate valuable materials from waste bins and sell at waste collection centres. While scavengers find it economically viable to undertake source separation, it saves municipalities a great amount of time and money especially; if source separation is properly done. Typically, waste is separated at source, sent to community waste centres, transported to centralized waste collection points and finally transported to a plant [Pla, 2015, Bouanini, 2013]. Recycling, is given prominence as it makes products available for cheaper prices as well as offer job opportunities. China hopes to recycle about 50% of waste paper by 2030[Bouanini, 2013].

Composting The nature of waste supports composting. Most wastes generated have biodegradable materials. Nonetheless, to attain effective composting rates; source separation should be encouraged. Likewise, consumers-especially farmers should be encouraged to patronize biodegradable fertilizers [Bouanini, 2013, Rech, 2013].

Incineration Land scarcity has made incineration a preferred waste disposal method. Despite huge capital investments involved, it provides the medium for the extraction of heat and power from waste. Again, it allows thorough disinfection and waste volume reduction of about 80% to 90%. Incineration has become a mainstay industry preferable to landfills. It has been successfully tried and tested in many cities and municipalities across China [Chen, et al., 2010]. Popularly termed Waste-to-energy [WTE], incineration facilities if poorly constructed have certain drawbacks mainly toxic air emissions and toxic sludge [Bouanini, 2013; Rech, 2013]. But, to address the issue of greenhouse gas emissions, incineration plants use extra filter technology [Zhang, et al., 2010].

Landfill It is a basic requirement for any waste management plan. Nevertheless, landfills have problems of secondary pollution, extensive use of lands and leakages if not properly managed. Equally, methane produced while garbage ferments render air unwholesome to communities around landfills [Zhang, et al., 2015; Bouanini, 2013; Rech, 2013]. Cities and municipalities have realised the high risk of pollution associated with landfills hence the establishment of incinerators across China. The view is to obtain heat and power from burnt waste. Critical here is source separation of waste. If properly done; it will increase the number of materials to be incinerated thus reducing total waste to be landfilled. The key idea is to minimize landfills with the view to either maintain or increase existing landfills capacities amidst effective regulation [Rech, 2013].

CONCLUSION AND RECOMMENDATIONS

MSW management is not peculiar to China. Centuries ago, nothing was considered waste in China but recent development has given rise to MSW concerns which this article reiterated. The burgeoning size of urban populations and lifestyles puts pressure on existing MSW schemes and
environmental management as a whole [Bouanini, 2013]. Nonetheless, the core aims of MSW management are public health and environmental safety. To this end, laws should be strengthened to ensure environmental safety and curtail MSW pollution. In addition, the waste hierarchy pyramid must be applied. That is, the people should be constantly educated to either reduce waste produced or at least; reuse materials. This would minimize the total waste produced for recycling, incineration and composting. Again, source separation campaigns are very important. MSW is characterised by high moisture which lowers incineration efficiency and heat value. Citizens must be told as a moral responsibility to separate domestic waste. Consequently, both citizens’ environmental knowledge and/or awareness and MSW separation abilities would be improved. Ultimately, while recycling would be improved; the quality of waste that would be fed to furnaces would see a greater improvement. Furthermore, scavenging should be formalised. Scavengers are central to waste recycling as they separate glass, paper and bottles among other recyclables from waste streams. As a result, recycling would improve as well as composting and incineration. As a result, recycling would improve as well as composting and incineration.

REFERENCES


