ENVIRONMENTAL AND EARTH SCIENCES RESEARCH JOURNAL
Vol.2, No.4, 2015, pp.5-10
http://dx.doi.org/10.18280/eesrj.020402

FEATURES AND DISPOSAL STRATEGIES OF LIVING GARBAGE IN CHINA

Ying Su[1], Yongdong Zhao[1]* and Ruiyu Jiang[2]

[1]College of Civil Engineering, YanCheng Institute of Technology, Yancheng, 224051, P. R. China;
2 Key Laboratory for Advanced Technology in Environmental Protection of Jiangsu Province, Yancheng Institute of Technology, Yancheng 224051, P. R. China.

Email: sying@ycit.cn

ABSTRACTS

The paper analyzes the composition and distribution of living garbage in China, and introduces the commonly used waste-to-energy technology. Energy utilization is the direction of refuse disposal, which needs to be zoned as waste component in China features a great north-south difference between urban and rural areas. For rural garbage, efforts should be strengthened in sorting recovery on one hand and composting organic matter on the other hand; while for urban garbage, efforts should be strengthened in developing RDF (refuse derived fuel) for utilization of heat value and in research on gasification and liquefaction of waste with high moisture.

Keywords: Living garbage, Waste component difference, Waste disposal, Waste-to-energy.

1. INTRODUCTION

With the continuous deepening of urbanization in China and constantly improved living standards for urban and rural residents, the amount of increasingly complex living garbage has rocketed dynamically. However, the development of capacity and technology of garbage disposal can hardly meet actual needs, differentiated waste management particularly. Currently, the per capita living garbage generation for urban residents is 1kg per day, with an annual increase rate of 5%-8%. The amount of urban living garbage generation came close to 300 million tons in 2012, representing around 26% of the global garbage. The nationwide volume of garbage clearance was 170 million tons in 2012, recording an increase of 6 million tons from a year earlier and an annual increase rate of 3.5%[1].

By analyzing the composition of living garbage in China, and by comparing different approaches to waste disposal, the paper proposes thoughts and strategies of garbage disposal in the light of current domestic situations.

2. VOLUME OF LIVING GARBAGE CLEARANCE AND DISPOSAL APPROACHES

After recovering and reusing household refuse by various means (such as waste reclamation), primary ways adopted in disposing refuse are landfill, incineration and compost. The nationwide volume of garbage clearance and percentage of diverse disposal from 2009 to 2013 are shown in Table 1 as follows:

Table 1. Amounts of garbage clearance and ways of garbage disposal from 2009 to 2013 [2-6]

year	Volume of living garbage clearance /million tons	Total amounts of harmless treatment plants /number	Sanitary landfill /number	incineration /number	others(the approach before 2010 is compost) /number
2009	157.337	567	447	93	27(16)
2010	158.048	628	498	104	26(11)
2011	163.953	677	547	109	21
2012	170.809	701	540	138	23
2013	172.386	765	580	166	19

Note: the figures in brackets represent the amount of compost plants.

From Table 1, it is seen that the amounts of living garbage clearance and harmless treatment plants increase with years to accommodate the continuous growing production of living garbage. At present, landfill is the main approach to household garbage disposal, with an average percentage of 78.4% during five years. Incineration comes second, accounting for 18.1%. Other ways take up 3.5%. In 2013, incineration occupied 21.7% of the whole ways of garbage disposal, rising by about 30% compared with the year 2009. The percentage of other ways fell to almost half of that of the year 2009.

The reason why sanitary landfill becomes the primary approach to urban waste treatment is that it requires a less initial investment, and that it works faster. Despite the advantage, there remains burning problems such as incomplete disposal, plant maintenance, and water pollution caused by landfill leachate. With the growing demands and improved technologies of living garbage disposal, incineration plants witness a continuously increasing emergence instead. This phenomenon results mainly from the constantly upgrading technologies of garbage sorting management and pre-processing, by both of which not only problems arising from high demands on garbage components during incineration disposal are gradual solved, but garbage is recovered and reused as a sort of substantial energy.

Therefore, waste-to-energy treatment has become the direction of development for approaches to living garbage disposal.

3. COMPONENTS AND DISTRIBUTION OF LIVING GARBAGE

Due to uneven development between rural and urban China, there are prominent features of rural economic development level and lifestyles. Also, significant differences exist between rural and urban living garbage.

Yue and other personnel [2] have analyzed and concluded the component of rural garbage in China, which is shown in Table 2 as follows:

Table 2. Components and features of living garbage in rural China [7]

zone	Garbage components								Moisture content (%)
	leftovers	muck	paper	metal	glass	fabrics	plastics	others	
Southern China	43.56	26.56	6.44	0.57	2.93	2.92	8.90	10.84	-
Northern China	25.69	64.52	2.29	0.68	1.73	2.77	4.35	7.77	-
Average value	35.97	42.38	4.82	0.62	2.45	2.86	7.10	9.58	38.68*[3]

Notes: The symbol "*" represents an average value calculated from data in the article of Han zhiyong [8], and the symbol"-" means that there is no related data.

It is seen that what mainly constitutes living garbage in rural China is muck. Leftovers contents top the list of rural garbage in southern China, while muck contents come as first in northern China.

According to major achievements in journals of Chinese academic papers (2005-2015), theses, and dissertations, the paper analyzes and concludes current garbage components in parts of Chinese cities in Table 3 as follows:

Table 3. Garbage components in parts of Chinese cities

zone	cities	Garbage components									Moisture content (%)	Heat value kJ/kg
		leftovers	muck	paper	metal	glass	fabrics	plastics	Wood and bamboo	others		
North	Beijing [4]	63.4	6.5	11.1	0.3	1.8	2.5	12.7	1.8	0.1		
	Qingdao [5]	69.0	6.6	9.5	0.9	2.2	3.0	8.4	0.3	0.1	55.9	4889.0
	Shihezi [6]	59.0		5.6	3.6	7.3	2.5	9.6		12.4	48.4	
	Lanzhou[7]	60.1		12.2	0.9	2.1	0.5	16.7	0.7	5.7		
	Huhehaote [8]	33.2	32.3	3.4	0.5	6.5	5.6	7.4		8.3	30.9	5242.0
	Dalian [9]	41.9	1.2	8.8	0.6	5.0	2.0	18.6		22.0	59.7	4620.0
	Wulumuqi [10]	62.1	6.4	2.4	0.8	2.4	2.6	5.4	2.5	15.4	47.0	-
	Average value	388.7	53.0	52.9	7.5	27.2	18.7	78.6	5.3	64.0	48.38	4917

zone	cities	Garbage components									Moisture content (%)	Heat value kJ/kg
		leftovers	muck	paper	metal	glass	fabrics	plastics	Wood and bamboo	others		
south	The average value of five cities in Sichuan [11]	63.1	4.84	9.7		0.75	2.42	15.3	0.92	2.83	57.6	5094.8
	A certain city in south of China [12]	46．4	3.5	7.2	0.1	1.9	3	28	3.4	6.6	62.2	-
	Xiamen (on average) [13]	63.1	4.8	9.7		0.8	2.4	15.3	0.9	2.8	57.6	4965.2
	Shanghai [14]	46.4	3.5	7.2	0.1	1.9	3.0	28.0	3.4	6.6	60.2	5080.0
	Fuzhou [15]	50.7	2.5	13.4	0.8	4.9	3.0	18.4	0.7	5.6	52.0	
	Hangzhou [16]	68.2		9.1	0.9	3.3	2.9	13.3	1.3	1.1	53.6	4626.0
	Suzhou [17]	76.0	-	10.0	0.2	6.6	-	7.1	0.0	0.1	60.7	5198.0
	Shenzhen [18]	64.5	-	6.7	0.3	2.0	1.2	10.1	0.1	15.1	53.3	6462.0
	Average value	59.5	2.7	10.3	0.4	3.0	3.4	16.6	1.1	4.6	57.2	5238
Nationwide average value		57.5	6.6	8.9	0.7	3.4	3.1	13.9	1.2	10.3	52.8	5077

From Table 2 and Table 3, it is seen that the component of living garbage is intimately related to rural and urban living standards and regions from which it is produced. The main characters are as follows:

(1) differences in components

① urban-rural aspect

Judging by the average level over the country, compared to rural garbage, the content of leftovers, paper and plastics is higher in most cities (except for Lanzhou). Organic matters and what can be recovered as energies have much higher percentage in urban waste than in rural waste.

② south-north aspect

The main difference between southern areas and northern areas is that there are more muck and less plastics and paper in urban areas of southern China, and more leftovers, paper and plastics and less muck in rural areas of southern China.

(2) moisture content aspect

The moisture content is at an average of 52.8% for urban living garbage, and 38.68% on average for rural living garbage.

(3) heat value aspect

The tables show that heat value of living garbage is higher in southern areas than in northern areas, and higher in urban areas than in rural areas.

Plastics and paper contain a higher heat value. For leftovers, the organic matters in it contribute to the increase in heat value, which is affected in turn by its moisture content [19, 20]; the inanimate matter itself has no heat value, but the heat value in living garbage per unit will fall if the content of inanimate matter is higher.

It is seen that living garbage in China differs between regions, requiring a zoned treatment. For the waste-to-energy technology, it waits to be analyzed according to components and local economic conditions.

4. WASTE-TO-ENERGY TECHNOLOGY IN LIVING GARBAGE DISPOSAL

Living garbage full of organic matter can be seen as biomass, which can be treated into energies mainly through chemical conversion and biotransformation.

(1) chemical conversion

Through chemical conversion, biomass transforms into direct energy, such as heat energy and electric energy. Chemical conversion generally features a fast chemical reaction rate, a high efficiency, and a stable reaction system, covering mainly combustion, pyrolysis, gasification and liquefaction. Emerging technologies in this area include supercritical water gasification and oil production from subcritical liquefaction.

(2) Biotransformation

Through biotransformation, biomass transforms into combustible energies, such as biogas, bio-oil, and hydrogen. Biotransformation is mainly achieved through anaerobic digestion and zymolysis. Anaerobic digestion is applicable to the situation of China as a mature technology, when it was initially called the biogas technology that produced numerous CH_4 and CO_2 and a small amount of H_2S. Nowadays, the main biomass for biogas fermentation is organic waste and livestock manure. Landfill and compost, another two approaches to anaerobic digestion, have different focus. Compost focuses on direct usage of nutrient components of living garbage without damaging its stability, while there is no direct usage of nutrition or energy involved in landfill which may gradually be replaced with new developing technologies of living garbage disposal.

The paper concludes problems of and technical solutions to waste-to-energy technologies with regard to specific characteristics of garbage components in our country in Table 4 as follows:

Table 4. Problems of and technical solutions to waste-to-energy technologies

waste-to-energy technologies		Chemical conversion		biotransformation	
		incineration	Others (pyrolysis, gasification and liquefaction)	landfill	compost
requirments	sites[21]	Smallest 60-100 /$m^2 \cdot t^{-1}$	smaller	Largest 500-900/$m^2 \cdot t^{-1}$	Larger 110-150/$m^2 \cdot t^{-1}$
	Treatment cost [21]	Highest ￥80-140 • t^{-1}	higher	Lowest ￥35-55 • t^{-1}	Medium ￥50-80/ • t^{-1}
	Garbage components[22]	The average net heat value is above 5000kJ/kg	Inanimate component should not be too high	/	Biodegradable organic contents are above 40%
Major problems		High moisture and low heat value for urban living garbage; more inanimate matter (such as ashes) that is hardly collected, cannot burn directly or burns unsteadily for rural living garbage	higher inanimate contents that is hardly collected for rural living garbage, adding to heat loss	high moisture, difficult operations	low waste sorting level, high content of heavy metal, and compost conditions that are hardly controlled
Points of and solutions to technical control		RDF process, and mixed combustion	Less practical application, requiring strengthened research	Collection and management of CH_4	Improvement of pre-processing and process operations management (such as temperature control)
Applicable site		Southern cities, large and medium-sized cities	cities	Cities and villages with many sites	villages

Notes: With the process of crushing, separating, drying and molding, garbage turns into RDF [30, 31], a solid fuel with higher heat value and stable combustion.

It is seen that compost [23] and landfill of organic matter are effective approaches for rural garbage to transformation into energy, while the approaches of incineration, gasification and liquefaction better fit the situations of large and medium-sized cities.

5. CONCLUSIONS

Waste-to-energy technology is the direction of development for Chinese living garbage disposal, which should also allow for components and local economic conditions so as to produce a tailor-made solution within local means.

(1) To keep rural flavor in boundless Chinese villages, focus should be centered on management, collection and reuse of living garbage. This paper suggests composting organic matters and return inanimate garbage into soil.

(2) Accessible cities are recommended to actively develop recycling of living garbage and promote refuse disposal with reduction, energy utilization and harmless treatment. For large and medium-sized cities with advanced economy, limited space, and costly land, waste with an average heat value of 5000kJ/kg should be transformed into energy as much as possible by ways of incineration.

(3) The paper proposes an enhancement of current technologies, new trails blazed for energy recovery, and development of new biomass technologies such as gasification and liquefaction of supercritical water.

ACKNOWLEDGMENT

The project was supported by the joint research fund between Collaborative Innovation Center for Ecological Building Materials and Environmental Protection Equipments (NO.GX2015201).

REFERENCES

1. 2013-2017 Annual Research and Consultation Report of panorama survey and Investment Strategy on China Industry, Zero Power Intelligence Group. Rept. SP-1, Shenzhen, Guandong, Nov. 2013.
2. B. Yue and Z.B. Zhang, "Characteristics of rural household solid wastes in China," *Environmental Science & Technology*, vol. 37, pp. 129-134, 2014.
3. Z.Y. Han and Z.L. Mei, "Characteristics and management of domestic solid wastes in rural areas of the Yunnan-Guizhou Plateau, China," *Journal of Agro Environment Science*, vol. 32, pp. 2495-2501, 2013.
4. Y. Chen and L.J. Xia, "Characteristics identification of rural solid wastes based on different types of farmers," *Journal of Agro-Environment Science*, vol. 29, pp. 773-778, 2010.
5. X.Z. Qu, "Study on life cycle assessment of urban solid waste processing systems in Qingdao," M.S. thesis, Qingdao Technological University, Qingdao, Shandong, 2011.
6. H. Chen and K.P. Lei, "Analysis on constituent and physical and chemical characteristics of MSW in Shihezi," *Journal of Anhui Agricultural Sciences*, vol. 38, pp. 1266-1268, 2010.
7. B. Tian, "A primary scheme for municipal solid waste treatment of Lanzhou City aiming at energy regeneration and resource recovery," *Journal of Gansu Agricultural University*, vol. 43, pp. 121-124, 2008.
8. J. Zhao and W.G. Sun, "Composition and characteristic analysis of municipal solid waste in Hohhot City," *Acta Scientiarum Naturalium Universitatis Neimongol*, vol. 36, pp. 100-103, 2005.
9. W.W. Zhao, "Survey and analysis of municipal domestic waste in centre area of Dalian City," *Environmental Sanitation Engineering*, vol. 14, pp. 29-31, 2006.
10. H.W. Shao and W.L. Xu, "Investigation and estimation of domestic waste in Urumqi," *Environmental Sanitation Engineering*, vol. 17, pp. 10-12, 2009.
11. M.X. Huang, "Characteristic and composition of municipal solid waste in Sichuan Province," *Environmental Monitoring in China*, vol. 28, pp. 121-123, 2012.
12. H.L. Zhang and X.P. Li, "Analysis of composition characteristics of municipal solid waste in south China," *Envrionmental Science*, vol. 36, pp. 325-332, 2015.
13. J.Q. Chen and D.H. Liu, "Heat value monitoring of Xiamen Domestic waste and analysis of its influencing factors," *Environmental Sanitation Engineering*, vol. 18, pp. 14-18, 2010.
14. X.J. Sun and D.M. Xu, "Analysis of composition and caloric value of municipal solid waste in Shanghai," *Journal of Tongji University (Natural Science)*, vol. 36, pp. 356-360, 378, 2008.
15. Y.X. Liu, "Fuzhou municipal solid waste source separation and resource utilization," M.S. thesis, Fujian Agriculture and Forestry University, Fuzhou, Fujian, 2012.
16. Y. Zhuang and S.W. Wu, "Source separation of household waste: a case study in China," *Waste Management*, vol. 28, pp. 2022-2030, 2008.
17. S. He and S.Y. Zhu, "Characteristics analysis and treatment countermeasures of domestic waste in Suzhou City," *Environmental Sanitation Engineering*, vol. 16, pp. 62-64, 2008.
18. C.F. Huang, "The statistical analysis of characteristics of municipal solid waste for Shenzhen," M.S. thesis, Huazhong University of Science&Technology, Wuhan, Hubei, 2012.
19. X.D. Li and S.Y. Lu, "Analysis on caloric value of Chinese cities' municipal solid waste," *China Environmental Science*, vol. 21, pp. 156-160, 2001.
20. Y.F. Qin and Y. Bai, "Distribution characters of municipal solid waste in Chaoyang District of Beijing," *Chinese Journal of Environmental Engineering*, vol. 3, pp. 1498-1502, 2009.
21. H.L. Yao and W. Wu, "On advantages and disadvantages of soild waste treatment technology," *Chinese Journal of Rock Mechanics & Engineering*, vol. 22, pp. 1756-1759, 2003.

22. T*echnological Policy for Treatment of Municipal Solid Wastes and Pollution Control*, Ministry of Environmental Protection of the People's Republic of China, Jiancheng[2000]120, China, 2000.

23. R.X. Bian and Y.J. Sun, "Study on Production characteristics and disposal countermeasures of rural solid wastes," *Environmental Engineering*, vol. 12, 2014.