Assessment for Sustainable Solid Waste Management in Nakhon Ratchasima City Municipality, Thailand

Siriporn Boonpa, Alice Sharp

Sirindhorn International Institute of Technology Thammasat University, Thailand

0333

The Asian Conference on Sustainability, Energy & the Environment 2013

Official Conference Proceedings 2013

Abstract

Rapid increase in volume and types of solid waste generation due to economic growth, urbanization, and industrialization has become a problem in developing countries including Thailand. Urban cities in Thailand such as Nakhon Ratchasima City Municipality (NRCM) have put sustainable waste management among their top priorities. One way to solve this problem is to convert waste to energy. Municipal Solid Waste (MSW), as a source of fuel, decreases need for landfill volume, thus freeing sites for other more useful purposes; it also contributes to a decrease in fuel demand, thereby protecting the environment. Despite the fact that integrated waste management has been used widely in the country, there is room for improvement of the system being used to increase effectiveness of the system. At the NRCM, mixed MSW is being converted to renewable energy such as Refuse Derived Fuel (RDF) and biogas production. However, a large amount of MSW is still being disposed of in landfill. This study focuses on an assessment of waste management process at NRCM to determine its efficiency, environmental impacts, and impact mitigation measures in all the stages of waste management system. Data compiled for analysis include waste generation and separation at source, characterization of waste feedstock, and material flow through the integrated system being employed at the NRCM. Problems encountered in each step were identified. In addition, this study proposes improvement measures for waste management services to maximize resource recovery and resource utilization.

Keywords: Municipal Solid Waste, Integrated solid waste management system, system efficiency, waste to energy

1. Introduction

Environmental concerns on municipal solid waste management (MSWM) have become a global challenge because of increasing population, which results in increasing amounts of MSW.

Siriporn Boonpa is with the Department of Common and Graduate Studies, Sirindhorn International Institute of Technology, Thammasat University, PO Box 22 TU-Rangsit Post Office, Pathum Thani, 12121, Thailand. e-mail: boonpa.srp@gmail.com
Alice Sharp is with the School of Bio-Chemical Engineering and Technology, Sirindhorn International Institute of Technology, Thammasat University, PO Box 22 TU-Rangsit Post Office, Pathum Thani, 12121, Thailand. (Corresponding author phone: 66-2-986-9009 Ext. 1805; Fax:66-2-986-9112~3; e-mail: alice@siit.tu.ac.th)

In developing Asian countries including Thailand, this factor is further exacerbated by inadequate financial resources, and inadequate management and technical skills within municipalities and government authorities. Thailand is a country located at the center of the Indochina peninsula in Southeast Asia. The country is divided into 78 provinces, in 5 regions. Total land area is 513,120 square kilometers. Thailand has gross domestic product (GDP) growth of 6.4% [1] and a population of 67 million people [2]. The country has relied on agricultural and industrial exports and tourism. The average amount of waste generation per capita is 0.63 kg/capita/day with slight differences among localities: 1.5 kg/capita/day in Bangkok, 1.0 kg/capita/day in municipalities and Pattaya city, and 0.4 kg/capita/day outside municipality areas [3]. Waste generation per capita is the highest in the Asia Pacific Region [4]. Wastes normally contain a high organic fraction. This has potential for energy production. However, these wastes are being dumped into landfills and they release pollutants and greenhouse gases into the environment.

In addition to MSW problem, the country is also experiencing rapid economic growth which leads to increasing demand for energy. This may result in the energy insecurity that has become an emerging issue in Thailand. MSW can be used as a source of renewable energy. In MSWM, there are several technological methods to manage solid waste before final dispose into landfill. These methods manage solid waste in a sustainable way and can recover energy from waste materials. For example, incineration produces energy; composting of organic wastes produces fertilizer; anaerobic digestion produces energy (biogas); recyclable materials are recovered through recycling activities. The above methods together reduce the final quantity of waste into a manageable amount of environmental friendly product.

Technologies that can convert waste to energy in Thailand consist of 5 main types: incineration, refuse derived fuel (RDF), anaerobic digestion, pyrolysis, and landfill gas recovery. For this study, NRCM integrated waste management facilities are selected to study the waste management process. The efficiency, environmental impacts, and impact mitigation measures in all stages of waste management system are determined.

2. MSW characteristics and composition in NRCM

Nakhon Ratchasima City Municipality (NRCM) is located at Muang district, Nakhon Ratchasima province in the northeastern region of Thailand that is 250 km away from Bangkok. The area of jurisdiction is 37.50 square kilometers and located at 150 – 300 meters above sea level.

This section describes the results of the MSW characterization study carried out by the standard method [5-9]. Initially, MSW properties such as density, moisture content, dry matter, volatile solid, ash/non-volatile solid, and heating value are described, for Nakhon Ratchasima City Municipality.

Density of MSW

The density of MSW was 0.384 Kg/L or ton/m^3 on average. The density of MSW result will be used to predict the environmental problems due to limited landfill space and odor.

Characterization of MSW

The composition of MSW is shown in Fig.1. According to the result, organic waste was the largest portion of MSW, which contributes to 40% of total waste generated. The second and third largest components were soft plastics (23%) and paper (14%).

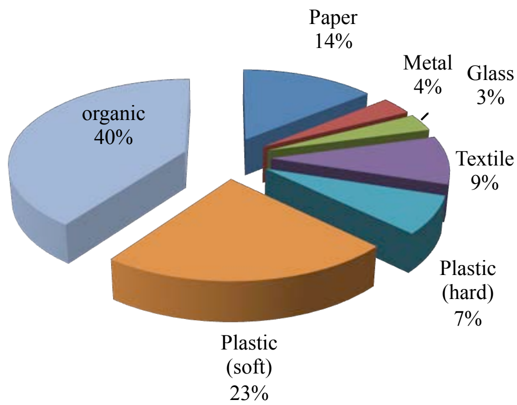

Fig. 1 Characterization of MSW at NRCM, Thailand.

Moisture content and dry matter of MSW

Moisture content and dry matter of MSW results are given in Table 1. The highest moisture content was observed for organic waste at 70.93%, while paper at 20.69% and plastic (soft) at 6.84% waste were the second and third levels of moisture. The compositions of metal and plastic (hard) waste had almost equal levels of moisture. The above information indicates the benefit of RDF product from plastic (hard) and plastic (soft) in managing waste at NRCM due to their moisture content low level. Furthermore, paper can be used for RDF production after decreasing its moisture content.

Volatile and ash/non-volatile solid of MSW

Volatile solids in most samples were found to vary from 87 to 99% of the total solid. Glass and metal waste contributed volatile solids of 0.8 and 11%, respectively, as shown in Table 1. According to the German fuel standard, volatile matter is approximately 50-80% by weight [10]. From these results, plastic (hard), plastic (soft), textile, paper, and organic wastes can be used as raw material for production of RDF and RDF can be used as energy source.

Heating value of MSW

Heating values of oven dried components of MSW were obtained the tests carried out according to the Bomb calories methods [7] and the results are given in Table 1. The highest heating value was observed for plastic (soft), while paper waste recorded the lowest levels of heating value due to it containing high moisture content.

Table 1 Compositions and characteristics of MSW in NRCM (2013).

Compositions	Contribution (%)	Moisture content (%)	Dry matter (%)	Volatile solid (%)	Ash/non-volatile solid (%)	Heating value (GJ/ton)
Paper	14	20.69	79.31	89.90	10.10	13.99
Metal	4	5.84	94.16	11.62	88.38	-
Glass	3	1.59	98.41	0.83	99.17	-
Textile	9	2.53	97.47	92.47	7.53	15.79
Plastic (soft)	23	6.84	93.16	99.96	0.04	36.86
Plastic (hard)	7	5.72	94.28	99.56	0.44	22.01
Organic	40	70.93	29.07	87.64	12.36	18.96
Hazardous	0	-	-	-	-	-
Other	0	-	-	-	-	-

3. Review and discussion of MSW management process in NRCM

Mass balance

The mass balance of the SW management process at NRCM is shown in Fig.2. Waste coming to the NRCM dumping site was estimated from the data obtained from the Development of Environment and Energy Foundation (DEE) [11]. The total solid waste generation integrated waste treatment facility of 392 ton is sent to NRCM on a daily basis: 48.98% of MSW was sent to landfill, while 51.02% was sent to a waste treatment facility. The estimated amounts of waste coming to the waste treatment facility are 87.61% as MSW, 1.54% as organic waste separated at source, 8.81% as market waste, and 2.04% as night soil. The majority of MSW was large size material that include recyclable waste (0.32%, 2,000 baht/ton), RDF1 (12.62%, 900 baht/ton), and others (87.06%) while small size material were mixture of organic and fiber waste. Only the organic portion was sent to be mixed with organic waste, market waste, and night soil in order to produce biogas by anaerobic digestion. Another material of MSW was metal waste which accounted for less than 1% with a sale price of 5,000 baht/ton.

Analysis of process

The analysis of MSW management process in NRCM is described in Table 2 in terms of strength, weakness, and solution of each process: collection, landfill, and waste treatment facility. The NRCM waste management process is shown in Fig.3.

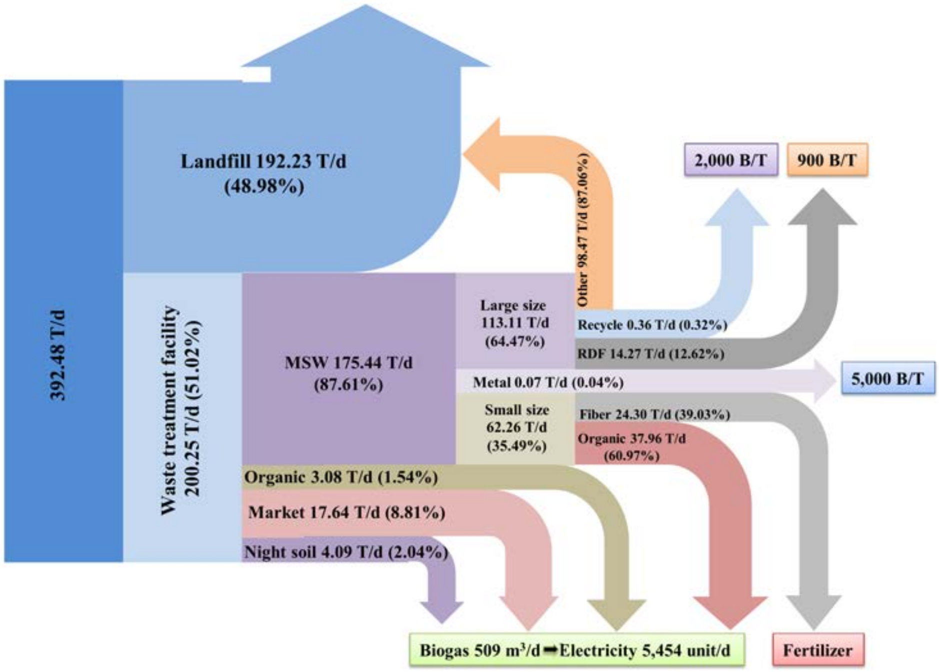

Fig. 2 Total waste flow within NRCM based on data from DEE foundation.

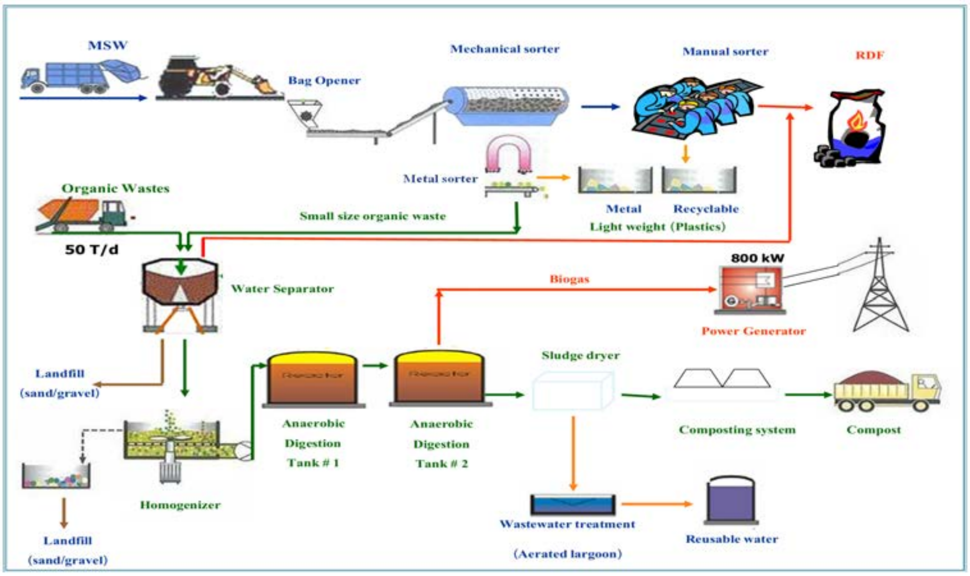

Fig. 3 NRCM waste treatment facility system [11].

Table 2 Analysis of MSW management process in NRCM.

Process	Strength	Weakness	Solution

Collection	• Solid waste can be collected daily
	  • Door to Door Collection
	  • Curb-side collection
	  • Waste Station
	• Collection rate is 72%.
		• Collection rate is less than 100%
		• Wastes are disposed as mixed MSW
		  • Difficult to manage
			• Introduced a public participation program in
			  • Solid waste management
			  • Source separation

Sorting			
- bag opening - mechanical sorting - metal sorting	• For effective waste separation • Constant material flow • Increase the values of waste • Use for alternative energy source (RDF)	• Cost of waste management is increased • Maintenance of equipment is frequently required • Effectiveness is low/large amount of waste to landfill	• Machine required skillful personnel in operation and maintenance • Always cleaning, inspecting and maintaining the machine
- manual sorting		• Collecting and sorting by labor at the facilities • It can be seen that the methods are not only ineffective but also not sanitory	• Annual health check for labor • Labor should be trained to sort waste • Incentive system
Treatment technologies			
- Refuse derived fuel (RDF)	• Can divert most combustible waste from landfill • Alternative energy source	• Waste separation system must be required • No trading market • Electricity cost • Maintenance of equipment is frequently required	• Encourage the use of RDF as alternative energy source in industry • Machine required skillful personnel in operation and maintenance • Produce RDF1, RDF2, RDF3
- Anaerobic Digestion (AD)	• Can divert most organic and biodegradable waste from landfill • Biogas recovery • Useable compost	• High-tech system that requires skilled technical operators • Methane gas that is explosive • Disease generated from solid wastes fermentation and odor • Annual system shut down needed for discharging	• Odor control at the organic waste separation plant prior to composting • Install automatic scum discharging part with peristaltic pump

Final disposal	• The landfill is located within a military area
	  • It can be extended
	• No public opposition
		• Lack of control of environmental impact
		  • No collection of emitted gases
		  • Landfill GHG gas and odor
			• Construction of gas collection and ventilation
			• Leachate treatment system

4. Conclusion

It can be seen clearly that appropriate management of solid waste in NRCM is required in order to reduce the quantity of waste in an environmentally and economically sustainable way. With increasing environmental concerns, the NRCM integrated MSW management system has the potential to maximize the utilization of waste materials (metals and recyclable plastic) and alternative energy sources (RDF and biogas).

In NRCM, the compositions of waste are mainly organic waste, plastic (soft), paper, textile, plastic (hard), metal, and glass. As a result, the waste in NRCM is very suitable for an integrated MSW management with suitable technologies for reducing the disposal cost. For NRCM waste, most combustible waste will be RDF, while most organic and biodegradable products contribute biogas by anaerobic digestion.

However, the current situation in NRCM is that wastes are disposed of as mixed MSW. Contamination of each component makes it difficult to use valuable materials within. Communities that effectively separate waste can reduce the quantity of waste to be disposed of drastically. Effective separation of waste starts with education programs for local citizens with well-designed waste containers provided. Information gathered from all sources show that in order to have successful implementation of MSW management, there are weakness and solution that NRCM should consider. If these weaknesses are not solved, the NRCM integrated MSW management system is unlikely to succeed.

5. Acknowledgment

The authors would like to thank the Development of Environment and Energy Foundation (DEE) for raw data provided in Fig. 2 of this paper. We would like to express thanks to The Bangchak Graduate Scholarship Program for their scholarship which has enabled us to carry out this research.

6. References

1. Wikipedia, t.f.e. *Economy of Thailand*. 2012; Available from: http://en.wikipedia.org/wiki/Economy_of_ Thailand.
2. Indexmundi. *Thailand Demographics Profile 2012*. 2012; Available from: http://www.indexmundi.com/thailand/ demographics_profile.html.
3. Sharp, A., and Sang-Arun, J. , *A Guide for Sustainable Urban Organic Waste Management in Thailand: Combining Food, Energy, and Climate Co-Benefits*, 2012.
4. Troschinetz, A.M. and J.R. Mihelcic, *Sustainable recycling of municipal solid waste in developing countries.* Waste Management, 2009. **29**(2): p. 915-923.
5. E830-87, A., *Standard Test Method for Ash in the Analysis Sample of Refuse Derived Fuel* 2004.
6. D5231-92, A., *Standard Test Method for Determination of the Composition of Unprocessed Municipal Solid Waste*, 2003.
7. E711-87, A., *Standard Test Method for Gross Calorific Value of Refuse Derived Fuel by the Bomb Calorimeter* 2004.
8. E790-87, A., *Standard Test Method for Residual Moisture in a Refuse Derived Fuel Analysis Sample*,

2004.

9. E897-88, A., *Standard Test Method for Volatile Matter in the Analysis Sample of Refuse Derived Fuel* 2004.
10. Kara, M., *Environmental and economic advantages associated with the use of RDF in cement kilns.* Resources, Conservation and Recycling, 2012. **68**(0): p. 21-28.
11. DEE, *Feasibility Study of Municipal Solid Wastes for Electricity Generation*, 2007. p. 13-15.