App. Envi. Res. 37 (2): 85-91

Applied Environmental Research

Journal homepage : http://www.tci-thaijo.org/index.php/aer

Potential of Producing Refuse Derived Fuel (RDF) from Municipal Solid Waste at Rajamangala University of Technology Isan Surin Campus

Tiammanee Weerasak [1,4], Sompop Sanongraj [2,3*]

[1] PhD student in Environmental Engineering

[2] Department of Chemical Engineering, Faculty of Engineering, Ubon Ratchathani University, Ubon Ratchathani 34190, Thailand

[3] National Center of Excellence for Environmental and Hazardous Waste Management, Ubon Ratchathani University, Ubon Ratchathani 34190, Thailand

[4] Department of Science and Mathematics, Faculty of Agriculture and Technology, Rajamangala University of Technology Isan Surin Campus, Surin 32000, Thailand

[*] Corresponding author: Email: sompopsanongraj@yahoo.com

Article History

Submitted: 9 February 2015/ Accepted: 29 April 2015/ Published online: 15 June 2015

Abstract

The objective of this study is to explore the potential of producing energy from open-dump solid waste from Rajamangala University of Technology Isan Surin Campus. Heating value as well as the physical and chemical compositions were analyzed. The composition and heating value were compared to refuse-derived fuel quality standard. All waste samples were separated into combustible and non-combustible matter. Paper, plastic, food residue, textiles, rubber and leather were classified as combustible. In excess of ninety-nine (99%) of open dump waste consisted of combustible matter as follows: mixed plastic (45%), textile (19%), food residue (18%), paper (14%), and leather and rubber (3%). Non-combustible composted inert material consisted of only 1% of the open-dump solid waste. Moisture and total solid contents of open-dump solid waste were 51.6% and 48.4% (wet basis) respectively. Volatile matter and ash contents of those were 95.14% and 4.37% (dry basis) respectively. The heating value of the open-dump solid waste was 29 MJ/kg, which is higher than the refuse derived fuel quality standard and results reported in earlier studies [8,10,14]. This indicated the potential of open-dump solid waste to produce refuse-derived fuel (RDF). Therefore, it is possible that energy recovery through RDF production can be an effective waste management option for Rajamangala University of Technology Isan, Surin Campus. Further study should focus on production of RDF in terms of moisture content removal and compositions of RDF. Furthermore, characteristics of RDF should be determined to explore alternative sources of renewable energy.

Keywords: Municipal solid waste; waste composition; open dump site; heating value; waste management; combustible

Introduction

Currently, solid waste disposal is one of Thailand's most pressing concerns. Waste from daily life leads to environmental pollutions of soil, water, and air, and these problems become more severe each year. Municipal solid waste (MSW), in particular, is one of the biggest challenges that requires proper management. Thailand continues to face problems associated with improper waste disposal. According to the Thailand State of Pollution Report 2013, of the country's 2,490 municipal solid waste sites, only 499 sites (19%) provided for proper disposal: i.e. sanitary/engineer landfill, controlled dumping (smaller than 50 tons/day) and incineration with air pollution-controlled system. In contrast, up to 2,024 sites (81%) disposed improperly of waste, i.e. controlled dumps with capacity larger than 50 tons/day (1%), open dumps (78%) and incineration without air pollution controlled system (2%) [1].

At seventy-eight percent (78%) open dumping is the most widely used waste disposal method. This improper method is generally found in areas governed by local administrative organizations where waste collection systems do not service the entire area governed by the administrative organization [2]. Open dumping results in accumulation of solid waste, causing release of toxic substances and creating unsanitary conditions that are highly detrimental to human well-being. The practice of open dumping is a critical environmental issue that needs more and better management.

Energy recovery from solid waste is one of the most attractive options in waste management. Numerous research works have focused on producing energy from solid waste, especially municipal solid waste due to its huge volume and ready availability. Several forms of energy recovery, such as electricity, liquid fuel and gas fuel have been reported in the literature [3, 4, 5, 6, 7]. In Thailand only 2% (by weight) of all municipal waste is used to produce refuse derived fuel [1]. Determination of physical and chemical composition of solid waste and its heating value was necessary to analyze its potential as an energy source [8, 9, 10].

From April to June 2013, 3.2 tons of municipal solid waste were generated at Rajamangala University of Technology Isan, Surin Campus, Thailand. After collection, the waste was sorted by its recyclability. Only 39% of municipal solid waste was recovered as recycling material, including metal, glass and plastic containers, while 61% was discarded to an open dump site (Figure 1).

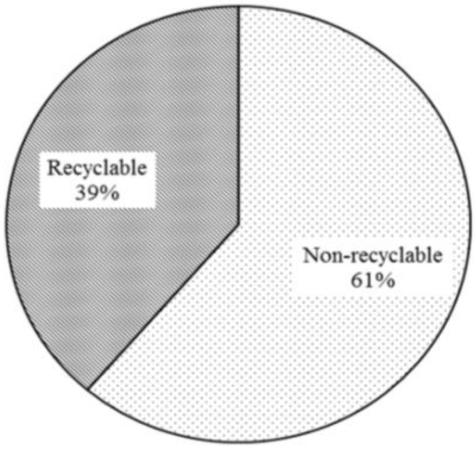

Figure 1 Main components of municipal solid waste in this study (% by weight, on wet basis)

Figure 2 shows a canal used as an open dump site at Rajamangala University of Technology Isan, Surin Campus. This open dump site area measures about 400 square meters and is 2 meters deep. Municipal solid waste is allowed to accumulate to a certain level before being burnt. After burning, additional waste is dumped at the site and the process is repeated, generating major local air pollution. Waste-to-energy was thus considered as a possible solution.

Figure 3 shows the waste products that constitute the recyclable and non-recyclable components of solid waste. This study focused on the non-recyclables. Non-recyclable waste consists of highly combustible solids which can be reformed to produce energy. This research aims to determine the physical and chemical composition as well as the heating value of municipal solid waste from the open dump site at Rajamangala University of Technology Isan, Surin Campus.

Material and Methods

This study was conducted by taking samples of municipal solid waste on five occasions during April and June 2013. The waste was collected from an open dump site at Rajamangala University of Tech-nology Isan, Surin Campus, Thailand (see Figure 2). The samples were obtained from the top layer of trash, avoiding the burnt waste below the deeper level of the canal. Samples were collected from the five sampling points shown in Figure 2, approximately 10 meters apart. Each sample consisted of about 200 liters of waste. The five waste samples were combined then followed the conning and quartering method, sample sizes of 250 liters (~30 kg.) were created. These waste samples were then manually separated into combustible and non-combustible materials, using the classification in Figure 3. Moisture content and total solids were determined by drying in an electric oven at 105°C until completely dry, based on procedures defined in ASTM D3172 [10]. Volatile matter and ash content were determined by heating in a furnace at 750 and 950°C according to standard procedures provided in ASTM D3175 and ASTM D3174, respectively. The heating value of the waste was then determined by bomb calorimeter based on ASTM D286-96 [10]. Three replications were conducted.

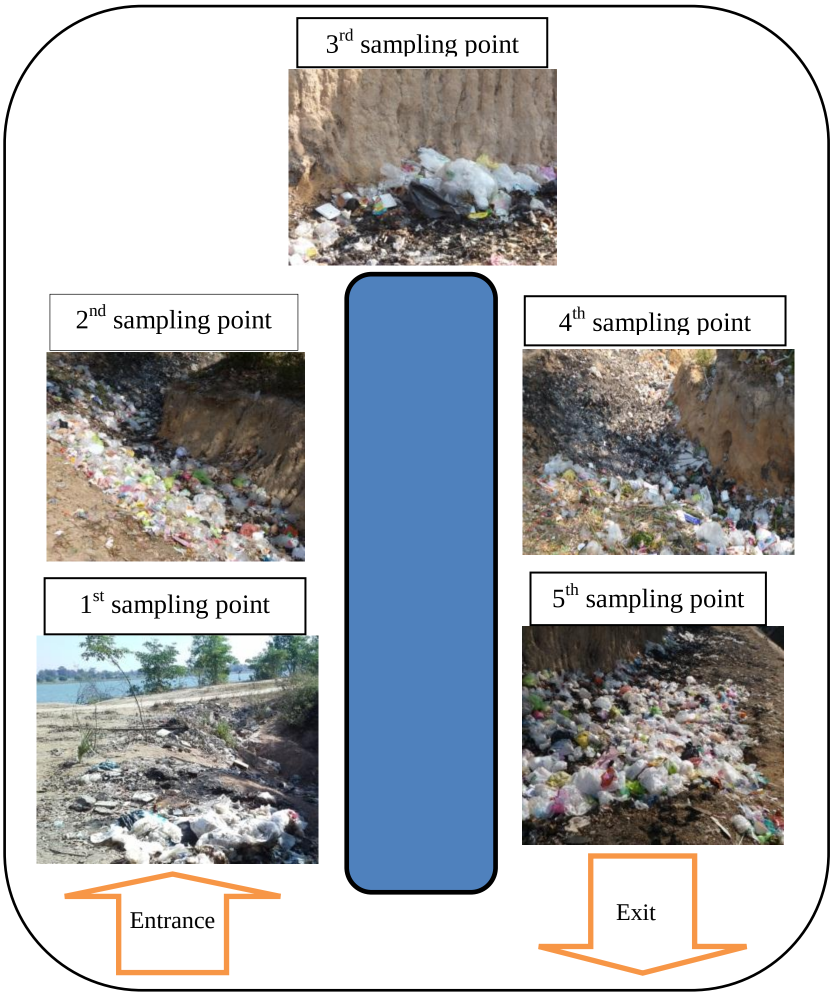

Figure 2 Open dump site and solid waste sampling points in Rajamangala University of Technology Isan, Surin Campus

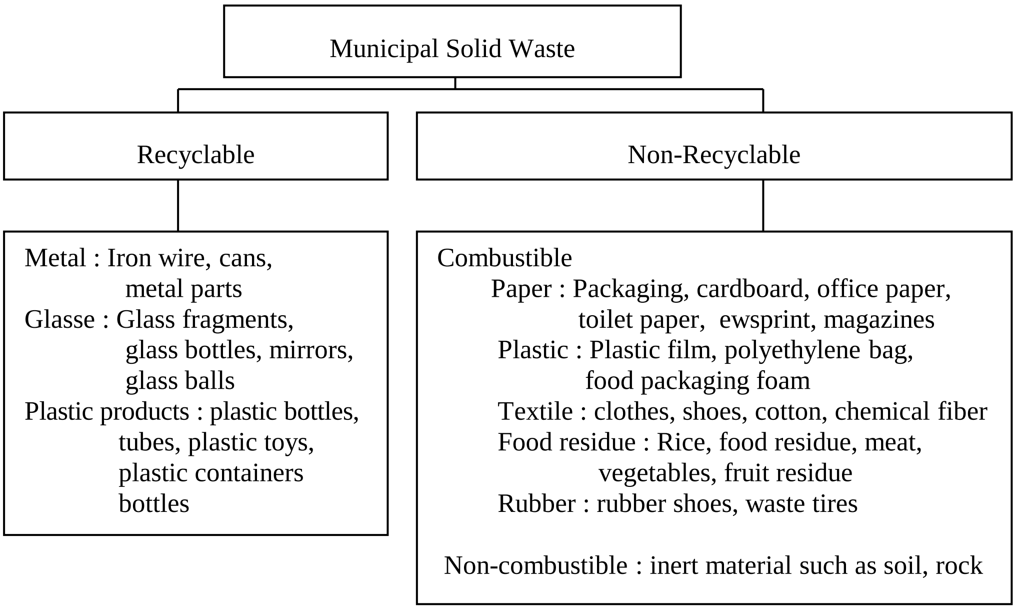

Figure 3 Classification of municipal solid waste at Rajamangala University of Technology Isan, Surin Campus, Thailand

Results and discussion

1) Physical composition of open dump solid waste

Figure 4 shows the physical composition of open-dump solid waste at Rajamangala University of Technology Isan, Surin Campus. Ninety-nine percent (99%) of the waste was combustible and one percent (1%) was non-combustible. By weight the combustible waste was 45% mixed plastic, 19% textile, 18% food residue, 14% paper and 3% rubber. Inert material made up only 1% of the total waste.

The percentage of combustible material in the open-dump solid waste obtained and analyzed in this study was high compared with that reported in several other studies [8, 9, 10, 11, 12] which ranged from 72% to 93% of open-dump solid waste.

Figure 5 shows the percentages of combustible and non-combustible material in municipal solid waste analyzed in the current study, compared with those found in other studies. A higher percentage of combustible material indicated that open-dump solid waste has a higher potential for energy generation via incineration, during which the organic component of the waste is converted to CO_2, water vapor and heat, which can be recovered as renewable energy [11]. The results indicate that the typical open dump-solid waste in this study shows high potential for RDF production.

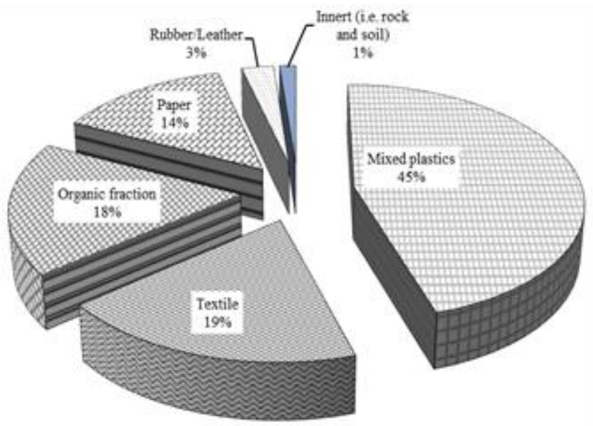

Figure 4 Composition of non-recyclable solid waste from open dump solid waste in this study.

2) Thermochemical characteristics of open-dump solid waste

The thermochemical characteristics of open-dump solid waste are presented in Table 1. The percentage of moisture and ash content were 51.60% (wet basis) and 4.37% (dry basis), respecttively. Moisture and ash content both influence the heating value (HV) of solid waste. Since the moisture content measured in this study exceeded the maximum permitted value for the RDF standard (20%, wet basis), pretreatment of open-dump solid waste is recommended to remove excess moisture content before RDF production. The ash content was found to be below the allowable level RDF quality standard (Italy) (20%, dry basis). The sorting of non-combustible components such as glass, metals and ceramic improved the thermo-chemical characteristics of the open-dump solid waste. Volatile matter content also affects ignition of solid waste during incineration. The higher the volatile matter content, the more easily solid waste can be ignited. In pyrolysis and gasification, volatile matter influences both composition and yields of the gaseous products [8]. The volatile matter of open dump solid waste in this study was 95.14% (dry basis).

Table 2 shows the comparison of heating value obtained from this study and those reported in other studies. The heating values of combustible waste material analyzed in this study was up to 29 MJ/kg, which exceeded the RDF quality standard [14], and was higher than the values reported earlier [8, 10, 14]. Moreover, the heating value of the combustible waste analyzed in this study was comparable to that originating from Nonthaburi dumpsite, Thailand [15]. This indicates high potential for using open-dump solid waste as raw material for RDF production. However, before transferring the open-dump solid waste to RDF production process, moisture must first be removed as noted above.

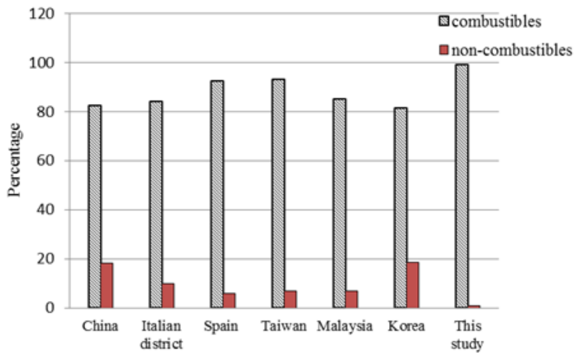

Figure 5 Comparison of combustibles and non-combustibles in municipal solid waste from the current study and recent studies. [8, 9, 11, 12]

Table 1 Characteristics of non-recyclable solid waste in this study

Chemical composition	Unit	Open dump site	Refused derived fuel quality standard (Italy)
Moisture	%wt, wet basis	51.60±4.56	25.0
Total solid	%wt, wet basis	48.40±4.56	-
Volatile matter	%wt, dry basis	95.14±0.85	-
Ash	%wt dry basis	4.37±0.74	20.0
Heating value	MJ/kg, dry basis	29±1.62	15.0

Conclusion

The main component of municipal solid waste from open dump in this study was the combustible material, representing 99% of the total volume. This component comprised mixed plastic, textile, food residue, paper, leather and rubber as well as inert material in proportions of 45%, 19%, 18%, 12%, 3% and 1% respectively (wet basis). The percentages of chemical compositions including moisture content, total solid, volatile matter and ash content were 51.6, 48.4, 95.14 and 4.37, respectively. The heating value of 29 MJ/kg exceeded that allowable by the refuse derived fuel quality standard (Italy), and higher than some published data previously reported in studies conducted in China and Korea. It also was consistent with results from the study of Nonthaburi dumpsite, Thailand. According to the results of this study, it can be concluded that municipal solid wastes from the open dump site at Rajamangala University of Technology Isan, Surin, Thailand is suitable as a raw material for RDF production. However, further studies should focus on production of RDF, especially in terms of moisture removal and composition of RDF. Furthermore, characteristics of RDF should be determined to explore alternative sources of renewable energy.

Table 2 Comparison of the combustion properties of this study with other reports

Studies	composition of combustibles (%wt (wet basis))	Heat value (MJ/kg)
H. Zhou et al., 2014., China [8]	Wood waste 2.94, food residue 55.86, paper 8.52, textiles 3.16, plastics 11.15, rubber 0.84, non-combustible 18.36	5.3
Y.-M. Chang et al., 2008., Taiwan [10]	Paper 13.38, plastics 17.90, cloth and textiles 14.76, leather and rubber 4, food waste 30.54, wood and garden trimmings 7.15, other organics 5.34, metals 2.17, glass 1.34, ceramic 1.20, sand/stone and inert 2.53	14.4
C. Dong et al., 2003., China [13]	Plastic 30.53, paper 43.51, textile 4.83, food residue 7.38, grass 1.02, metal 7.63, glass 5.09	17.4
Tawach Prehthai et al., 2006, Thailand [15]	Plastic and foam 42.5, wood 9.0, textile 10.0, rubber 1.0, paper 0.7, stone 0.9, glass 1.8, soil 30.9, metal 3.0	29.5
The current study	Paper 14, mixed plastic 45, textile 19, leather and rubber 3, food residue 18, inert part 1	29.0

References

[1] Pollution Control Department. 2013. Thailand State of Pollution Report 2013. Ministry of Natural Resources and Environment.

[2] Pollution Control Department. 2012. Thailand State of Pollution Report 2012. Ministry of Natural Resources and Environment.

[3] Chunguang Zhou, Qinglin Zhang, Leonie Arnold, Weihong Yang, Wlodzimierz Blasiak. 2013. A study of the pyrolysis behaviors of pelletized recovered municipal solid waste fuels. Applied Energy 107:173–182

[4] Christian Bidart, Magnus Fröhling, Frank Schultmann. 2013. Municipal solid waste and production of substitute natural gas and electricity as energy alternatives. Applied Thermal Engineering 51:1107-1115.

[5] Phillip N. Pressley, Tarek N. Aziz, Joseph F. DeCarolis, Morton A. Barlaz, Feng He, Fanxing Li, Anders Damgaard. 2014. Municipal solid waste conversion to transportation fuels: a life-cycle estimation of global warming potential and energy consumption. Journal of Cleaner Production 70(1): 145-153.

[6] Sandra Teixeira, Eliseu Monteiro, Valter Silva, Abel Rouboa. 2014. Prospective application of municipal solid wastes for energy production in Portugal. Energy Policy. http://dx.doi.org/1010 16/j.enpol. 2014.04.002.

[7] Monojit Chakraborty, Chhemendra Sharma, Jitendra Pandey, Prabhat K. Gupta. 2013. Assessment of energy generation potentials of MSW in Delhi under different technological options. Energy Conversion and Management 75:249–255.

[8] Hui Zhou, AiHong Meng, YanQiu Long, Qing-Hai Li, YanGuo Zhang. 2014. An overview of characteristics of municipal solid waste fuel in China:Physical, chemical composition and heating value. Renewable and Sustainable Energy Reviews 36:107–122.

[9] M. Horttanainen, N. Teirasvuo, V. Kapustina, M. Hupponen, M. Luoranen. 2013. The composition, heating value and renewable share of the energy content of mixed municipal solid waste in Finland. Waste Management 33:2680–2686.

[10] Yu-Min Chang, Chien-Chung Liu, Chao-Yang Hung, Allen Hu, Shiao-Shing Chen. 2008. Change in MSW characteristics under recent management strategies in Taiwan. Waste Management 28: 2433-2455.

[11] Sharifah Aishah Syed Abd Kadir, ChunYang Yin, Muhamad Rosli Sulaiman, Xi Chen, Mohanad El-Harbawi. 2013. Incineration of municipal solid waste in Malaysia: Salient issues, policies and waste-to-energy initia-

tives. Renewable and Sustainable Energy. Reviews 24. 181–186.

[12] Trang T.T. Dong, Byeong-Kyu Lee. 2009. Analysis of potential RDF resources from solid waste and their energy values in the largest industrial city of Korea. Waste Management 29:1725–1731.

[13] Changqing Dong, Baosheng Jin, Daji Li. 2003. Predicting the heating value of MSW with a feed forward neural network. Waste Management 23:103–106.

[14] Gendebien, A., Leavens, A., Blackmore, K., Godley, A., Lewin, K., Whiting, K.J. et al. 2003. Refuse derived fuel, current practice and perspective: B4-3040/2003/306517/ MA R/E3, July 2003. European Commission-Directorate General Envi- ronment.

[15] Tawach Prechthai, Chettiyappan Visvanathan 2006. RDF Production Potential of Municipal Solid Waste. The 2nd Joint International Conference on “Sustainable Energy and Environment (SEE 2006)” 21-23 November 2006, Bangkok, Thailand.