Feasibility study of municipal solid waste for producing refuse-derived fuel (RDF): A case study of Bangkok, Thailand

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Abstract. The objective of this study was investigated the potential of municipal solid waste (MSW) to produce refuse-derived fuel from Bangkok municipality. The composition, heating value and proximately content were analyzed. The amount of MSW in Bangkok generated was approximately 4.86 million tons or 13,327 tons/day in 2017. About 79.5% was disposed by landfill and 20.5% was recycled. The compositions of MSW were biodegradable (49.58%), combustible (36.32%) and non-combustible (14.10%) wastes. Moisture content was 59.5±8.6% (as received), volatile matter, fixed carbon and ash were 72.4±3.2%, 8.2±0.5% and 19.4±0.5% (as dry basis), respectively. Heating value was 20.03±0.52 MJ/kg. These results indicated that MSW from Bangkok municipality is potential to produce the refuse-derived fuel. To reduce the environmental impacts as well as energy recovery, the MSW might be alternative sources of renewable energy in the future.

1. Introduction

In last decade, solid waste is an important issue in various countries. The amount of solid waste is increasing with the number of population. Currently, Thailand is facing solid waste management crisis. Solid waste was increased because the traditional and life style has been changed. Most of waste comes from human activities. Municipal solid waste (MSW) generation in Thailand was 27.37 million tons in 2017 or 74,998 tons/day, generation rate of 1.13 kg/capita/day [1]. The proper disposed was approximately 43% and recycled of 31%. Although, most of MSW was properly disposed and recycled but the amount of 7.17 million tons (26%) or 19,656 tons/day was improperly disposed by open dumping, open burning and dumping into the rivers.

Bangkok is a capital of Thailand as well as one of the destination of tourists that made Bangkok became too high population density. Nowadays, MSW generation in Bangkok was 4.86 million tons or 13,327 tons/day. After segregation, the amount of 0.99 million tons of solid waste was recycled whereas the remaining of 3.87 million tons was disposed by landfilling and incineration methods. Although, the number of waste recycled was increased but the total waste generation was trend to increase. Lack of a good management of MSW, is possible effected on human health and environment such as odor, lose of aesthetics, source of vector diseases, water pollution, air pollution, etc. In addition, improper disposal method such as open burning, which is the rapidly method and low cost but enhance environmental problem such as smoke, shoot, particulate matter, CO₂ which contributed to greenhouse gases (GHGs) and cause of respiratory system. The MSW is a critical environmental and health issue that needs more and better management [2].
The majority (90%) of world’s energy comes from non-renewable energy sources such as coal, crude oil and natural gases which have limited availability [3]. Therefore, search for alternative energy resources as renewable energy is an important to solve the energy crisis. To increase the value of MSW and reduce environmental pollution as well as alternative energy resources, the concept of waste to energy (WTE) is one of the most attractive option in waste management [4]. WTE technology is the generation of energy as heat or power from waste by transformation of non-recyclable material through different procedures, including thermal and non-thermal technologies. Thermal technologies include incineration, pyrolysis, gasification, plasma arc and refuse derived fuel (RDF), and non-thermal technology includes anaerobic digestion. WTE technologies can usually reduce the volume of the original waste by 90%, depending on the composition and use of outputs.

The mixed solid waste without segregation and pre-treatment as a feedstock to power production is enhance the efficiency approach to WTE recovery. RDF is the mechanical processing to recovery recyclable materials to produce a combustible product. The main advantages of using RDF as a fuel are an important reduction in the volume of waste and the possibility of energy recovery. According to ASTM E-75, RDF can be classified into 7 types depending on process. RDF has high caloric value comparing with collected solid waste. RDF is simple for storage, transportation, operation. The aim of this research was investigated the potential of MSW in Bangkok municipality to produce RDF. Determination of composition, heating value and proximately content was necessary to analyze its potential as an energy sources.

2. Material and methods
This study was conducted by taking samples of MSW on six occasions during three months of research operation. The study site was transfer station at On-Nuch station that collected MSW from Bangkok areas. Samples were collected from dumping pit for two times per day (morning and afternoon). Each sample was collected about 200 liters of waste [2]. Waste composition and waste characterization were conducted through the established sampling techniques and lab analyses of physical and chemical parameters. Waste composition analysis was performed through established sampling techniques following ASTM standards D-5231-92 [5] and manual sorting of waste samples with standard protocols, followed by lab analyses of the representative samples for its physical and chemical parameters. The proximate analysis was accomplished by the analysis of the moisture content, volatile matter content, fixed carbon and ash content according to ASTM standards D7582-12 [5]. Heating value was determinate by bomb calorimeter [4].

3. Results and discussion

3.1 MSW composition analysis
The samples of MSW that obtained from On-Nuch transfer station in Bangkok was analyzed the composition following ASTM standards D-5231-92. The average percentage of MSW composition representative of Bangkok municipality is presented in table 1. The large fraction of MSW was found to be of food waste (42.68%), followed by plastic (14.88%) and paper (12.09%). Further, these individual waste components were classified into three categories: biodegradable (food waste and yard waste), combustibles (plastic, paper, rubber/leather and textile), and non-combustibles (glass, metal, ceramic and others), their composition are as shown in the figure 1. The per capita generation rate in Bangkok (1.54 kg/capita/day) was more than generation rate of Thailand (1.13 kg/capita/day). This is definitely due to the high influx of commercial activities in Bangkok [6].

Table 1. MSW composition of Bangkok municipality.

| Content     | Waste composition (%) |
|-------------|-----------------------|
| Food waste  | 42.68                 |
| Paper       | 12.09                 |

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Plastic 14.88
Glass 6.63
Metal 3.54
Rubber/Leather 2.57
Yard waste 6.9
Ceramic 3.93
Textile 4.68
Others 2.10
Total 100

Figure 1. Classification of MSW in Bangkok municipality.

3.2 Chemical characteristics of MSW analysis
The proximate analysis was conducted according to the ASTM standards D7582-12 including determination the percentage of moisture content, volatile matter, fixed carbon and ash content. The percentage of moisture content, volatile matter, fixed carbon and ash was 59.5±8.6 % as received, 72.4±3.2 %, 8.2±0.5 and 19.4±0.5 % as dry basis, respectively. Moisture content and ash both related to the heating value of MSW. Since the moisture content measured in this study exceeded the maximum value for the RDF standard (25%, wet basis), so the pre-treatment of MSW of Bangkok is recommended to remove excess moisture content prior to produce the RDF. Whereas, the ash content in this study was found to be below the RDF standard of 20% as dry basis [2]. The result of calorific value or heating value of MSW was found to be of 4,785±125 kcal/kg as dry basis or 20.03±0.52 MJ/kg, which is higher than the RDF standard [7]. This result could be recommended the MSW of Bangkok municipality is appropriated to produce RDF. Table 2 shows the comparison of heating value that obtained from this study and previous study. The moisture content was a key factor affected the heating value of municipal solid wastes in variety sources.
Table 2. The comparison of heating value of this study and previous study.

| RDF material                                | Heating value (MJ/kg) | References |
|---------------------------------------------|-----------------------|------------|
| Solid waste from open dump site             | 29±1.62               | [2]        |
| Municipal solid waste                       | 21.28-27.10           | [8]        |
| Municipal solid waste                       | 13.51                 | [9]        |
| Wastewater sludge                           | 17.97                 | [10]       |
| Municipal solid waste                       | 14.40                 | [11]       |
| Municipal solid waste                       | 17.40                 | [12]       |
| Mechanical-biological treatment             | 15.53                 | [4]        |
| Compost rejected                            | 22.88                 | [4]        |
| Municipal solid waste                       | 20.03±0.52            | This study |

4. Conclusion
Results obtained in the present study show that the characteristics of MSW in Bangkok municipality are expected to produce a high energy content of RDF. It is also important to extend the landfill lifetime as well as reduction of CO₂ and other greenhouse gases emissions from landfill site. In addition, MSW is one of an alternative energy source for the future.

5. References
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