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A review on technological options of waste to energy for effective management of municipal solid waste

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ABSTRACT

Approximately one-fourth population across the world rely on traditional fuels (kerosene, natural gas, biomass residue, firewood, coal, animal dung, etc.) for domestic use despite significant socioeconomic and technological development. Fossil fuel reserves are being exploited at a very fast rate to meet the increasing energy demands, so there is a need to find alternative sources of energy before all the fossil fuel reserves are depleted. Waste to energy (WTE) can be considered as a potential alternative source of energy, which is economically viable and environmentally sustainable. The present study reviewed the current global scenario of WTE technological options (incineration, pyrolysis, gasification, anaerobic digestion, and landfilling with gas recovery) for effective energy recovery and the challenges faced by developed and developing countries. This review will provide a framework for evaluating WTE technological options based on case studies of developed and developing countries. Unsanitary landfilling is the most commonly practiced waste disposal option in the developing countries. However, developed countries have realised the potential of WTE technologies for effective municipal solid waste management (MSWM). This review will help the policy makers and the implementing authorities involved in MSWM to understand the current status, challenges and barriers for effective management of municipal solid waste. This review concluded WTE as a potential renewable source of energy, which will partly meet the energy demand and ensure effective MSWM.

Contents

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1. Introduction

Currently fossil fuels are the most reliable sources of energy, meeting almost 84% of the global energy demand (Shafiee and Topal, 2009). It is the time to realise the potential of waste to energy (WTE) as an option for sustainable solid waste management and as one of the most significant future renewable energy sources, which is economically viable and environmentally sustainable (Bajić et al., 2015; Kalyani and Pandey, 2014; Stehlik, 2009). Ali et al. (2012) concluded that WTE is not only sustainable waste management solution, but also an economically feasible, especially for developed countries. Baran et al. (2016) reported that energy recovery from waste incineration (one of the WTE technologies) is an integral part of environmentally sustainable waste management strategy. However, Yay (2015) did not find incineration as always economically sustainable due to its high operational and maintenance cost. WTE is a way to recover the energy from waste materials in the form of useable heat, electricity (by passing gas or steam through turbine), or fuel (Zhao et al., 2016). WTE technologies are now considered as the most suitable options for solving the waste related problems.

This paper aims to investigate municipal solid waste (MSW) as a potential renewable energy source. The present paper reviewed the available literatures on current global scenario of WTE technologies, necessary requirements for effective energy recovery and environmental impacts of different waste disposal techniques. The WTE technologies adopted in developed countries have been assessed to identify the challenges and barriers for effective implementation of WTE technologies in developing countries. In this review, 155 articles published in reputed journals, technical reports, and books related to WTE technologies (from year 1995 to 2017) were selected. More than 70% of the selected references were from year 2010 to 2017. For performing the review, a systematic approach was followed in which different aspects of WTE were identified. The identified aspects are: (i) the present status of WTE at global level, (ii) need of WTE, (iii) generation, characteristics and compositional requirements for effective energy recovery, (iv) WTE technological options and challenges associated with them in developed and developing countries, and (v) environmental and health impacts of WTE facilities. The previously published literatures and reports were selected and categorised based on these identified aspects. This study will provide a source of scientific information and analysed gap in the field of WTE to the scientific audience and waste management planners.

Global urban population is increasing at a fast rate (1.5%) than that of the total population (Ouda et al., 2016). At present, more than half of the world population live in urban areas, so the global escalation of MSW generation is mainly due to the population growth, urbanisation and economic development (Kumar and Samadder (2017)). Presently, the per capita MSW generation rate in developed countries is more than that of the developing countries, because generation rate depends on economic and social prosperity of a country. It was estimated that in coming decades the developing countries of Asia and other parts of the world will match the MSW generation rate of developed countries (Fazeli et al., 2016). Slowly, the people of developing countries are adapting lifestyle of developed nations due to globalisation, resulting in generation of large quantities of wastes. Thus, the escalation in MSW generation rate is mainly due to changing food habits, consumption pattern and living standards of the urban population (Khan et al., 2016).

Many researchers have reported that recycling is more preferred option than energy recovery (Tan et al., 2014; Ouda et al., 2016). It was observed from previous findings that the countries, which exercised high rate of energy recovery from wastes had appreciable rates of recycling, whereas, for the developing countries where landfilling is the most prevalent waste management option, recycling rates were low (Achillas et al., 2011). Arafat et al. (2015) reported the average recoverable energy contents (in terms of electrical energy efficiency) for different components of MSW using different WTE technologies (Fig. 1). From Fig. 1, it is evident that, anaerobic digestion is the best suited WTE option for food and yard wastes, whereas, gasification is the best WTE option for treating plastic wastes. Incineration remains an attractive option amongst all the waste streams (as specified by Arafat et al., 2015), as it can be used for energy recovery from all the

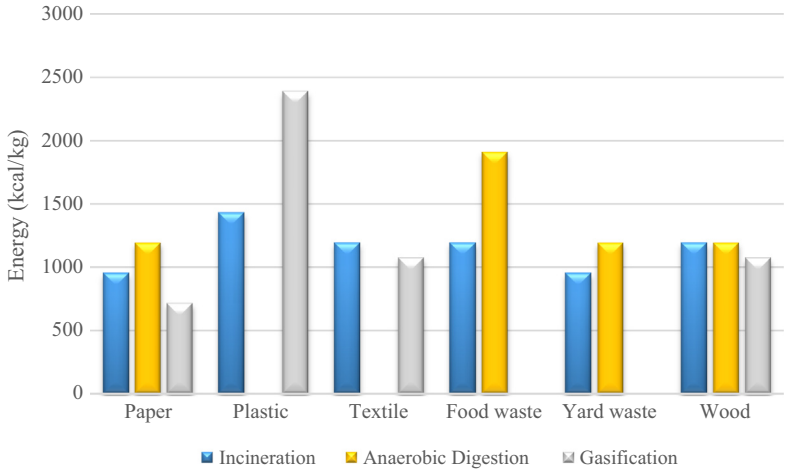

Fig. 1. Energy recovery potential of different WTE technologies for different MSW stream.