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Life cycle assessment-based environmental impact comparative analysis of composting and electricity generation from solid waste

Ahmed Elwan[a], Yanuar Z Arief[a,]*, Zuraimy Adzis[a], Nor Asiah Muhamad[a]

[a]*Institute of High Voltage & High Current (IVAT), Faculty of Electrical Egineering, Universiti Teknologi Malaysia (UTM), 81310 Johor Bahru, Malaysia*

Abstract

Managing waste is becoming more challenging than ever with the rate of increase of the global population and industrialization. The need for an optimal waste management system, offering added value to the population and industrial growth, is of utmost importance with the increase in energy and food demand, particularly that for organically grown food. In this study, waste generated by *Universiti Teknologi Malaysia* (UTM) was taken as a case study. The waste was converted to electricity and compost for use on farmland and the environmental effect of both processes was determined by Life Cycle Assessment (LCA) approach using GaBi™ software. The impacts analyzed were based on the level of emissions from each process. During the comparison, it was found that, if the waste generated by the UTM were used to generate electricity, the outcome would be a reduced emissions profile throughout the cycle as compared to using the waste as compost. However, the saving in emissions from indirect inputs was not considered for the purpose of this study.

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Keywords: life cycle assessment; solid waste; emisions; composting; electricity generation; municipal solid waste; waste to energy

1. Introduction

Solid waste generation is related to industrialization and population growth, and in 2010 global waste generation increased much more than in the previous ten years alongside the population increase. A study in 2010 estimated an increase of about 3 billion residents, generating 1.3 billion tons of municipal solid waste (MSW) per year at a per

* Corresponding author. Tel.: +607-5535342; fax: +607-5578150
E-mail address: yanuar@utm.my

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capita rate of about 1.2 kg per person per day. The report also forecast an increase in the total number of residents and the amount of solid waste generated by 2025 to 4.3 billion urban residents at a per capita waste of 1.42 kg/day of MSW [1].

MSW comprises various constituents in different proportions and compositions, which makes it difficult to manage. This variability makes solid waste a global contributor to environmental emissions in terms of greenhouse gases (GHGs) on disposal. To reduce the production of GHG, safe and economical ways to dispose of MSW have to be in place. The waste hierarchy, as shown in Figure 1, is a guide to solid waste management from the least to the most preferred method of disposal [2]. From Fig. 1, the preferred method of waste management is to stop waste generation, which is impractical, and the least preferred is to dispose of the waste through landfill. Landfill is the oldest, most adopted and preferred method used in most countries to get rid of generated waste [3]. The waste when dumped in landfill is compacted and covered to properly conserve it from water ingression, therefore saving the life of the landfill and reducing the risk of leach ate formation from the landfill [4]. The most common products of emissions from waste in terms of GHGs are principally methane and carbon dioxide (CH_4 and CO_2) [5].

Recovery from solid waste, in term of energy or material recovery, is at the bottom of the waste management hierarchy [6]. Composting is a form of resource recovery from solid waste, the product of this recovery process (manure) is applied to agricultural soils. The process of composting solid waste is gaining support globally, especially with the recent rise in global demand for organically grown foods and growing opposition to electricity generation from solid waste. Despite the stiff opposition to energy recovery from solid waste due to the fear of environmental effects, the recent advances in technology have shown that it is a viable alternative to landfill. The aim of this paper is to compare two forms of resource recovery from waste, namely composting and energy recovery in terms of electricity. An LCA approach was used for this study and all LCA models and simulations were performed using GaBi™ 5 software. The results were based on the output of the LCA, and are presented in tables and figures and then discussed and analyzed based on the level of environmental emissions for each method of recovery.

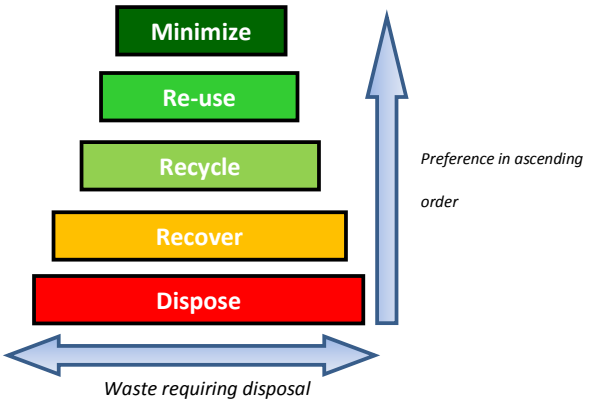

Fig. 1. Waste management hierarchy [2].

In terms of emissions to the environment, according to a study to identify the impacts of renewable energy [7], it was discovered that for every ton of MSW there is 1,100 Kg/kWh of CO_2 emissions while 1,833 g/kWh of CO_2 is released in any conventional generation system. Further analysis revealed that, in any waste to energy (WtE) conversion, only 20–40% of the carbon content is from fossil sources like plastics, which are considered non-renewable, while the rest comes from non-fossil sources, mostly organic considered to be renewable. The total CO_2 emissions from the non-renewable element per kWh are thus 367 g and this is just about 20% of the total emissions per kWh [7]. Figure 2 shows the comparison of solid waste and other non-renewable sources of energy in the production of 1 kWh of electricity.