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A Life Cycle Assessment for Garden Waste Management in Northern Region of Malaysia

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Abstract: ***recently, the production of garden waste shows an increasing pattern throughout the year in Malaysia. Garden waste consists of grass clippings, tree cuttings, small branches, leaves, and woody debris. This paper studied the garden waste management in Kedah and focused on the environmental impact. The life cycle assessment comprises a collection of garden waste, transportation to a collection center, and transportation to a landfill. The aim of the study was to analyze emissions of garden waste generated in 2015, which is 6,240 tonnes. The result indicated the environmental impact of current garden waste management practice in Kedah. It denoted that this impact could be reduced by using garden waste for power generation. Hopefully, this paper could help stakeholders to consider the potential of garden waste in cutting down the environmental impact through utilizing it for power generation.***

Index Terms: ***Life cycle assessment, Garden waste, Northern region, Malaysia.***

I. INTRODUCTION

Garden waste is a biodegradable waste containing a variety of organics such as grass cuttings, bush cuttings, tree trimmings, small branches, leaves, and wood remains in a low density and heterogeneous waste fraction produced during the care of public areas and private gardens (Boldrin, 2009). The management of garden waste is a significant element for the country in achieving the standard of a developed country corresponding to The World Bank (2014c). In developing countries, the endowment of these amenities accounts for 20%–50% of local governments' expenditures, of which 80%–95% are spent in the collection and transportation processes of waste (Guerrero, Maas, & Hogland, 2013). According to Aleluia and Ferrão (2016), nearly most Asian government authorities in their countries spend up to 50% of their financial plan in the establishment of waste management services. The typical process of waste collection includes vehicles that start from the depot and travel in fixed paths to collect waste by visiting all locations, which consumes a large expanse of the allocation. While collecting waste, the vehicles keep their engines running, even during the loading-unloading of waste bins, which results in huge consumption of fuel and greater emissions (Akhtar, Hannan, Begum, Basri, & Scavino, 2017). Life cycle assessment is an important tool to determine the environmental impact of the project. The study of the life cycle assessment of garden waste has already been conducted in several countries such as India and England. It is important to monitor and obtain the accurate measurement of waste emission and then develop a scheme to become net GHG emissions reducers.

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II. LITERATURE REVIEW

Garden waste management is needed in such a way to avoid contamination. The world is taking care of its garden waste as concern as municipal solid waste. This is because, the amount of organic waste is still the highest production (Kathirvale, Yunus, Sopian, & Samsuddin, 2004) among of other wastes. In developing countries, the implementation of waste policies and regulation can be strong national drivers to reduce greenhouse gas (GHG) emissions. In Denmark, 99% of its garden waste is collected and turned into compost (Andersen, Boldrin, Samuelsson, Christensen, & Scheutz, 2010). In Thailand, their garden waste in each area is collected, for example, leaves are used for fuel, and wood is used to make furniture. The appropriate rule and policy towards garden or organic waste could provide a more sustainability environment. In UK there is special guideline and policy toward garden waste management routine. Nonetheless, solid waste management guidelines have only been legally implemented in Malaysia during the recent ten years and hence have yet to establish and produce the targeted consequences. The strategy to the successful development of waste management systems is the need to adapt to local conditions, rather than duplicate other technologies from one country or region to another country.

2.1 Current practice for Malaysia's garden waste

A research conducted in 2012, which involved a case study at Bukit Bakri Landfill, Muar, showed that the production of garden waste is about 15.15% of 330 tonnes per day at the area of study (Kalanatarifard & Yang, 2012). According to Kathirvale et al. (2004) , a conclusion can be made that the amount of organic waste is still the highest production among other wastes. There is no specific policy or guideline directly focusing on garden waste management in Malaysia. Table 1 indicates Malaysia's solid waste management timeline. In Malaysia, garden wastes are potentially used in electricity generation since 98% of garden wastes are being dumped in the landfills.

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The typical process of waste collection involves vehicles that start from the depot and travel in fixed routes to collect waste by visiting all locations, which consumes a large amount of the budget. While collecting waste, the vehicles are still running their engines, even during the loading and unloading of waste bins, which affects in huge consumption of fuel and greater emissions (Akhtar et al., 2017).

Table 1. Malaysia's solid waste management timeline

Year	Policy	Objectives
1988	ABC (Action Plan for a Beautiful and Clean Malaysia)	To produce a national uniform municipal solid waste system that is productive, environmentally sound, and socially acceptable in Malaysia by the year 2010.
2005	National Strategic Plan for Solid Waste Management (NSP)	Six strategies To guide solid waste legislative, institutional, and infrastructural planning and management in Malaysia including an action plan to act as a road map for the implementation of the NSP.
2006	National Waste Minimization (MWM)	To provide vision, strategies, and roles of stakeholders to minimize the amount of solid waste disposed in Malaysia.
2007	Solid Waste and Public Cleansing Management Act (SWMA)	The term 'controlled solid waste' denotes the source of the waste and defines solid waste as scrap material or other unwanted surplus substance or rejected product arising from the application of any process, but excludes scheduled waste, sewage, and radioactive waste.
2009-2013	Solid Waste Corporation Strategic Plan	Identified seven focus areas that include public awareness programmes, monitoring of solid waste management (SWM) services, environmentally sustainable SWM, human resource sustainability, strong financial management, utilisation of a comprehensive information and communications technology (ICT), and requirements to meet customer needs.
2011-2015	Tenth Malaysian Plan	The Ministry of Natural Resources and Environment is to develop an environmental performance index (EPI) to measure the environmental management performance of each state.

III. METHODOLOGY

In Malaysia, there are several companies that handle the collection of waste; for instance, the waste collection in the southern region (Johor, Melaka, and Negeri Sembilan) is managed by SWM Enviro, the northern region (Kedah and Perlis) by E-Idaman, and the central and eastern regions (Kuala Lumpur, Putrajaya, and Pahang) by Alam Flora. This study involved the overall garden waste in Kedah. It included 12 districts in Kedah. E-Idaman Sdn Bhd was incorporated as a joint venture (JV) company between Metacorp Berhad and Cenviro Sdn Bhd, undertaking the waste management business for the northern states of Malaysia, namely Perlis, Kedah, Penang, and Perak. Subsequently, E-Idaman formed Environment Idaman Sdn Bhd (ENVI) on 12 January 2004 as a wholly-owned subsidiary of E-Idaman Sdn Bhd that will hold the solid waste and public cleansing concession award from the Malaysian government and the Solid Waste and Public Cleansing Management Corporation, respectively. Each district has an E-Idaman service unit centre. A structured interview has been carried out for each district.

3.1 Goal and scope definition

The aims of this paper are: (1) to identify the production of garden waste in Kedah; (2) to ascertain the potential of electricity generation based on garden waste; and (3) to identify the life cycle assessment of garden waste throughout the current practice applied in the northern region of Malaysia. The functional unit used is the mass (depends on the location of production) of garden waste dumped into landfills. 3.2 System boundary and data sources

The system boundary used in this study is shown in Figure 1. The main processes in this study are garden waste collection, transportation, and landfill. Table 2 shows the data source in this study. The coefficient value that is used for the fuel consumption of garbage trucks is 0.591 litre/kilometer (Billa, Pradhan, & Yakuup, 2014).

Table 2. Process and data sources

Process	Data source
Garden waste collection	Involves 10 E-Idaman service units in Kedah
Transportation	
Landfill	Involves 11 district councils in Kedah

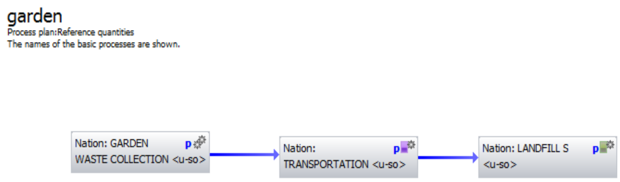

Figure 1. Flow diagram process for garden waste cycle in Kedah

IV. RESULTS AND DISCUSSIONS

In Kedah, garden waste from households is handled by E-Idaman, while street trees are managed by the District Council. The garden management process is carried out by E-Idaman as shown in Figure 2 in managing the rest of the gardens. The process has four steps that are used for garden waste management, namely generation, collection, transport, and disposal. Currently, almost 98% of the garden waste production in Kedah is being dumped into landfills. The rest are recycled and will be processed into compost (Zakareta & Shafie, 2016).

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Figure 3 shows the production of garden waste in Kedah from 2012 to 2015. It shows an increasing pattern for the near future. The top three garden waste productions come from Sungai Petani, Alor Setar, and Kubang Pasu districts. These district locations are near each other and potentially create an energy hub. The data started from 2012 due to the fact that this company took over the management of garden waste in the northern region of Malaysia since the middle of 2011. To synchronise the result, this study began with the data in 2012. Figure 4 show the pattern of potential electricity generation and garden waste production in 2015. Garden waste production showed an increasing pattern since 2012. It was forecasted that by 2020, garden wastes in Kedah will reach up to 0.25 million tonnes, which is more than 1.5% from the total waste generated in 2020. This will create another waste management problem due to landfill capacity constraint. A majority of landfills in Kedah have already expired, so their capacity is overloaded that can harm the community. Figure 5 displays the GHG emission for each district in Kedah. Alor Setar has the highest CO_2 emission contribution in Kedah. This is due to the distance of landfill that is far enough as compared to other districts. Since the GHG emission is lower in that particular area, it is potentially chosen as a base area for power generation. There are two districts that have minimum GHG emission per garden waste production, which are Padang Terap and Pendang. Global warming potential was found as the widely used environmental impact category (Yadav & Samadder, 2018). Figure 6 presents the garden waste production forecast up to 2020. Since the production of garden waste is forecasted to increase, the same goes for GHG emissions. Annually, about 180 tonnes of CO_{2eq} are emitted due to the current garden waste management schedule. Recently, it has shown an increasing pattern towards GHG emissions. Hence, Figure 7 show the GHG emissions up to 2020.

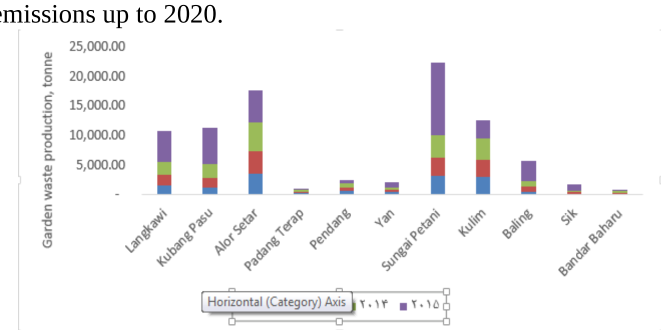

Figure 3. Garden waste production, 2012 to 2015

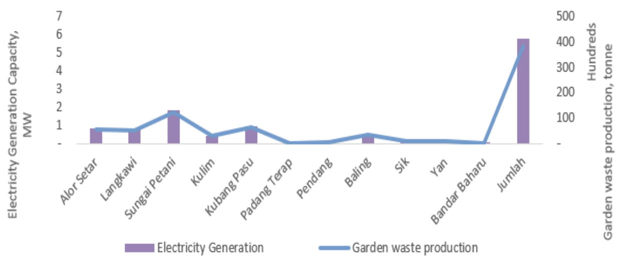

Figure 4. Pattern of potential electricity generation and garden waste production in 2015

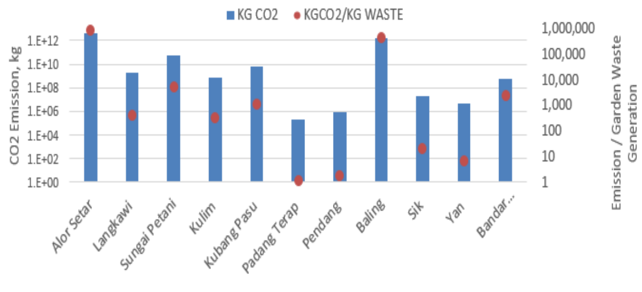

Figure 5. GHG emissions for each district in Kedah

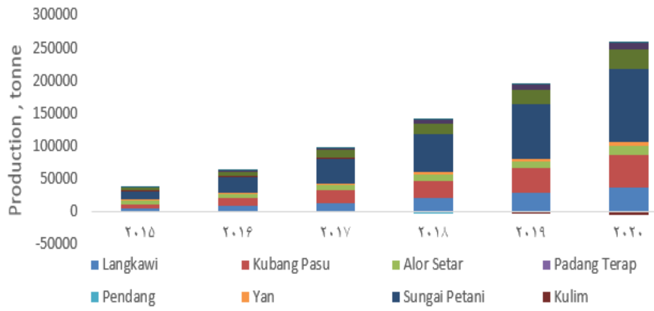

Figure 6. Forecasting of garden waste production

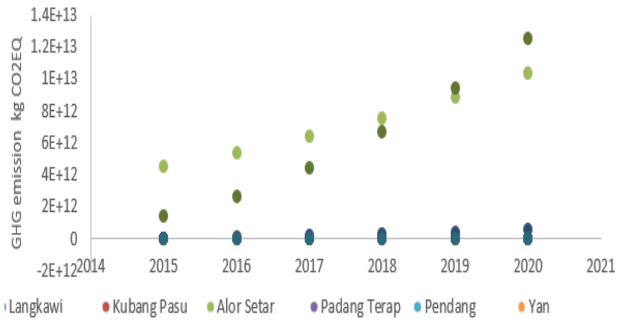

Figure 7. GHG Emissions up to 2020

Transportation is the main contributor towards GHG emissions. About 90% of life cycle GHG emissions come from the transportation process. This occurs due to the non-strategic location of existing landfills. Another factor is due to the capacity payload in this study, which is 4t, whereas some researchers used a higher payload up to 32t (Oldfield, White, & Holden, 2018). A lower payload capacity can increase the transportation trip and hence increase GHG emissions. It means that the optimum location design is needed to overcome this problem.

Recently, the result pattern indicates an increasing pattern of GHG emissions in garden waste management. All the landfills in Kedah are controlled by district councils. According to the persons in charge, they are currently facing the problem with expired and overload landfills. Their hope is that researchers can propose the best ways of managing garden waste without dumping them into landfills. Composting garden waste can actually divert the process from dumping at landfills and ultimately avoid the production of methane and leachate formulation in the landfills (Sanaz Saheri, Masoud Aghajani Mir, Noor Ezlin Ahmad Basri, Rawsan Ara Begum, & Noor Zalina Mahmood, 2009).

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Hence, the cooperation of every waste management practitioners involved is needed with a suitable method or technology to be used. The current management has caused double increments in GHG emissions. Certain countries have started to fully utilise their garden waste for energy production (Pradhan, Arora, & Mahajani, 2018, Liu, Kong, & Gonzalez, 2017).

V. CONCLUSION

Currently, the garden waste management system contributes to a huge GHG emission due to the conventional dumping process. The transportation process has the highest potential of GHG emissions among other processes. However, using garden waste in electricity generation helps to reduce the emission for six locations or districts in Kedah. It means that electricity energy can be generated with a reduction of GHG emission.

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