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Low Carbon Solid Waste Collection and Transportation Route in University: A Case Study

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ABSTRACT

Solid waste management is an environmental problem in Thailand. Health of citizen and environmental sustainability can be improved by increasing the efficiency of solid waste collection and transportation. The appropriate solid waste management also involves control of the atmospheric emissions. This work aims to investigate the existing methods of solid waste collection and transportation within university, Mae Fah Luang University (MFU), Thailand by surveys and interviews. The GHG emission or carbon emission was calculated basing on flue oil used. Google Earth view was used to analyze the appropriate collection points and transportation route mainly base on low carbon emission and requirement standards. Improper collection and transportation designs were found in term of collection sites, pick-up rounds and transportation routes that effect to higher carbon emission. Two transportation routes were proposed on idea of collection point reduction (from 12 points to 6 points) and waste separation (general waste, recycle waste and food waste), it was found that carbon emission was significantly reduced from conventional route from 13.58 kg CO_2e/day to be 1.97 kg CO_2e/day and 3.36 kg CO_2e/day, respectively. However, burden of landfill and biogas generation for disposal of general waste and food waste were avoided, therefore waste minimization implementation was suggested to reach low carbon solid waste management.

Key words: Waste collection, waste transportation, university, carbon emission

INTRODUCTION

One of environmental problems in Thailand is huge generation of solid waste. Nearly 22 million tons of wastes are produced annually (PCD., 2003). Waste generation has declined slightly after 2002 because of the encouragement of recycling activities (Chiemchaisri *et al*., 2007). Then, waste generation was 15.16 million tons in year 2011. However, there's still bulk of solid waste that is out of collection (MPH., 2010). Solid waste collection and transportation is required to improve health of citizen, environmental sustainability, aesthetic and economic development. As mentioned, organic waste can be quickly degraded and produce leachate that attracts files, rats and order pests. The vectors can spread diseases such as typhoid and cholera and can also cause diarrhoea, eye problems, skin diseases etc. Water and air pollution from leachate and open burning, respectively are threats to environmental sustainability. Better waste collection supports environmental sustainability. Furthermore, solid waste management through improved waste collection enhances the scenic beauty and cleaner cities that will be able to attract private investments and tourists and thus create more jobs in the locality (MLGPC., 2008).

To achieve environmental sustainability institution, the effective and environmental friendly solid waste management programs are one of the greatest challenges (Smyth *et al*., 2010). The appropriate solid waste management does not only consist of waste collection, transportation, controlling leachate from landfills but involves control of the atmospheric emissions

(Tan *et al*., 2014). Atmospheric emission was calculated via an emission-model from the years 1989-2004, carbon emission was 1.37 Gg for the average transportation distance was 17 km. which indicated that collection and transportation is a very important factor for considering carbon emission (Zhou *et al*., 2014).

This work aims to investigate the existing condition of solid waste collection and transportation such as transportation route, collection point, collection vehicle, transportation time and carbon emission within Mae Fah Luang University (MFU), Thailand. An attempt has been made to propose an appropriate route of solid waste collection and transportation in MFU that is mainly base on low carbon emission.

MATERIALS AND METHODS

Site description: This study was carried out at Mae Fah Luang University (MFU), Chiang Rai Province, Thailand. The campus is located in a spectacular setting of mountains and trees with more than 800 ha.

MFU Environmental Policy, which is related to solid waste management has been subjected to some parts of management namely paper and plastic bag use reduction, growing trees to increase green space to offset the GHG emission.

Investigation of collection and transportation: Surveys, interviews and investigation were performed in a week to assess the current situation of MFU's solid waste collection and transportation system (Alam *et al*., 2008).

The investigation was subjected to collect the briefly important data of collection and transportation such as collection point, collection rounds, collection vehicle, collection loading, pick-up times, transportation route, transportation time and distance. The framework was considered the appropriate method of secondary collection and transportation of waste (Tchobanoglous *et al*., 1993).

Propose appropriate and low-carbon routes for waste collection and transportation: The proposed waste management plan was both mainly based on the appropriate method of secondary collection and transportation of waste and low carbon emission. Google maps/Earth based collection point and transportation was used to consider transportation route and collection points (Ghose *et al*., 2006; Luo *et al*., 2011). Whereas, carbon footprint was calculated as CO_2 equivalent emissions by use of fuel in transportation of waste to and from sites including collection (Muhle *et al*., 2010).

RESULTS AND DISCUSSIONS

Existing waste collection and transportation: There were both primary and secondary waste collections in MFU. Primary collection was own operation whereas secondary collection including transportation was operated by private sector with monthly bill payment. Subject to the secondary waste collection, from the surveys and interviews, it was found that MFU waste collection system was set-out with 12 collection points as shown in Google Earth view (Fig. 1) with total collection loading of 418 and 379 kg day^{-1} for weekday and weekend, respectively. However, unexpected collection points were set up everyday by housekeepers or gardeners which lead to over waste loading to truck, pick up time and transportation time. The collection system was manually loaded by one collector and serviced by three rounds a day; 6.30 am, 11.00 am and 2.30 pm. The

Fig. 1: Google Earth view of Mae Fah Luang University 12 existing waste collection points

Fig. 2(a-b): Mae Fah Luang University waste collection vehicle

collection pick up time was in the range of 34-365 sec/collection point which resulted in 17 min of total waste collection pick up time per round and totaling up to 41 min in a day.

As for MFU waste transportation, the waste in each collection point was manually transferred to a pickup truck of 6.40 m^3 collection loading capacities for transportation to the disposal site (Fig. 2). The transportation route involved driving from the disposal site to MFU and back to the disposal site within a distance of 24 km. The total time spent collecting waste within MFU is 36 min while, covering a distance of 13 km. The sum total of time spent driving from disposal site to MFU and back to disposal site is 50 min. The transportation route within the university had been designed by the private sector as shown in Fig. 3. However, it was not certain due to unexpected street-side collection points by housekeepers or gardeners.

From the investigation, it had been observed that MFU had no serious waste separation program due to the fact that only plastic bottles were separated from other wastes at the canteens. This resulted in three rounds of waste transfer in a day. Furthermore, due to not providing sign of collection point, there were unexpected street-side collection points which lead to collection overloading and changing transportation route resulting in time wasting. Moreover, it was found that the site and design of some collection points were not suitable. They were inconvenient for parking and collecting waste, which resulted in time wasting because the waste collectors had to

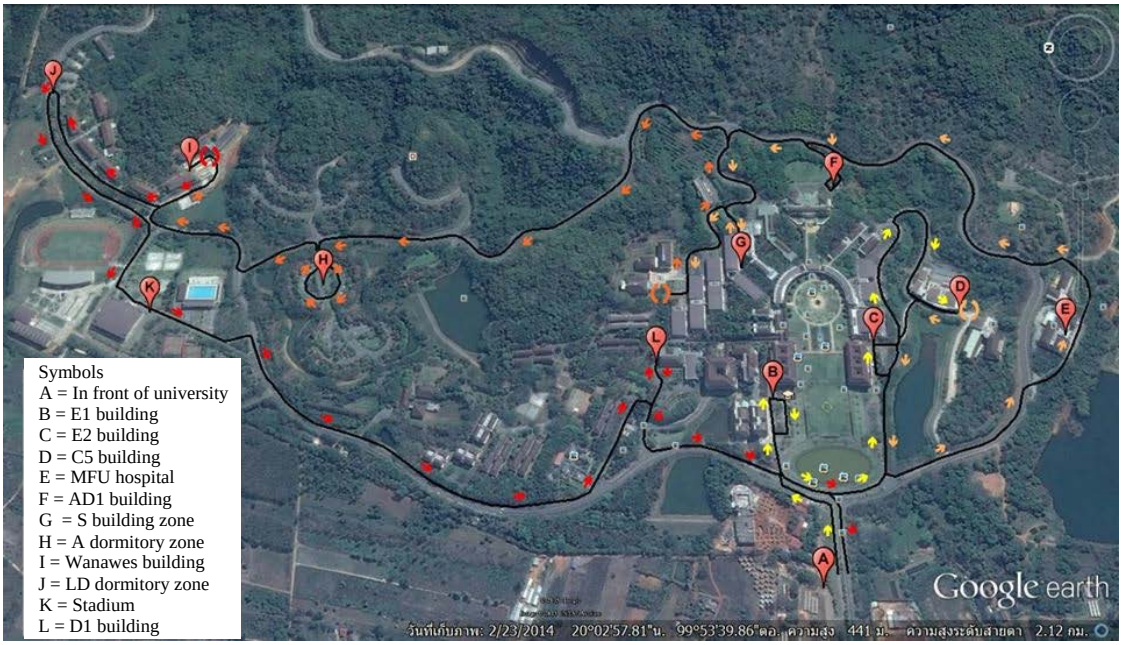

Fig. 3: Google Earth view of Mae Fah Luang University existing waste transportation route

walk some distance to the collection point from where their cars were parked. Some sites were near public areas with possibility of nuisance and loss of aesthetics. As for design, it was found that 60% of the waste collection points did not meet standards (Tchobanoglous *et al*., 1993) such as sign, no vector control, no roof and no fence etc.

On the other hand, waste transportation in MFU was inefficient due to not suitable route, transferring time and vehicle used. The transportation route was viewed by Google Earth view, which revealed the complexity and uncertainty. Drivers needed to drive around in order not to miss unexpected street-side collection points. Occasionally, the pickup truck had been driven with waste loading to high slope. Besides, waste transferring at 11.00 am and 2.30 pm were affected to people activities such as lunch and traffic. The pickup truck was not proper to transfer waste considering health concern such as eyesore and leachate released, also it was not designed to protect waste collector health and safety.

Suggestion of appropriate and low-carbon waste collection and transportation routes: The existing waste collection and transportation topic had described method of waste collection in MFU, then carbon emission of waste collection and transportation was calculated. In order to improve collection and transportation, there should be appropriate collection point and transportation route, efficient solid waste management and low carbon emission. Google Erath view had been used to consider distance and feasible routes. Route A and route B were proposed, new collection points were marked on Google Earth view as shown in Fig. 4. In route A, the improper collection was canceled remaining only 6 collection points namely MFU hospital, C5 building, canteen D1, officer dormitory, L7 dormitory, Chinese dormitory adding special collection point around stadium on Thursday due to Wednesday market fair. The waste transferring was reduced to be 2 rounds a day.

Whereas, route B was suggested base on possibility of efficiency MFU solid waste management in the future concerning waste separation at sources and waste to energy program such as biogas

Fig. 4: Google Earth view of Mae Fah Luang University proposed waste collection points and transportation route

Table 1: Evaluation on carbon emission of MFU solid waste collection and transportation system

Designs	Conditions	Flue oils consumption (L day^{-1})	Carbon emission (kg Co_2e/day)
Conventional	• 12 collection points • 3 rounds/day	4.89	13.58
Route A	• 6 collection points • 2 rounds/day (6.30 am and 5.30 pm) • Adding special route on thursday due to university market fair	0.7	1.9
Route B	General waste • 6 collection points • 1 round/day (6.30 am)	0.66	1.79
	Recycle waste • 1 collection point • 2 rounds/week (5 pm in Tuesday and Friday)	0.16	0.43
	Food waste (to biogas site) • 4 collection points • 1 round/day (5.30)	0.42	1.14
	Route B sum total	1.24	3.36

production from food waste. Previous work indicated that it is necessary to plan a new collection system that is appropriate for source separation waste (Nas and Bayram, 2008), therefore the idea about route B to separate waste into 3 types namely: General waste, recycle waste and food waste according to current MFU solid waste management plan on recycle wastes and biogas generation, will be advantageous (Mae Fah Luang University, 2014). The detail of route B collection points and waste transferring round shows in Table 1. In addition, Fig. 5a-b shows the route B design for recycle waste and food waste, respectively.

Considering carbon emission, 13.58 kg CO_2e/day was calculated for MFU conventional or existing waste collection and transportation by consuming 4.89 L a day of flue oils. While, it was clearly shown in Table 1 that route A and B can provide the lower fuel oils consumption and carbon emission when compare with the conventional waste collection and transportation. It can be noted that improving transportation route resulted in decreasing carbon emission because waste

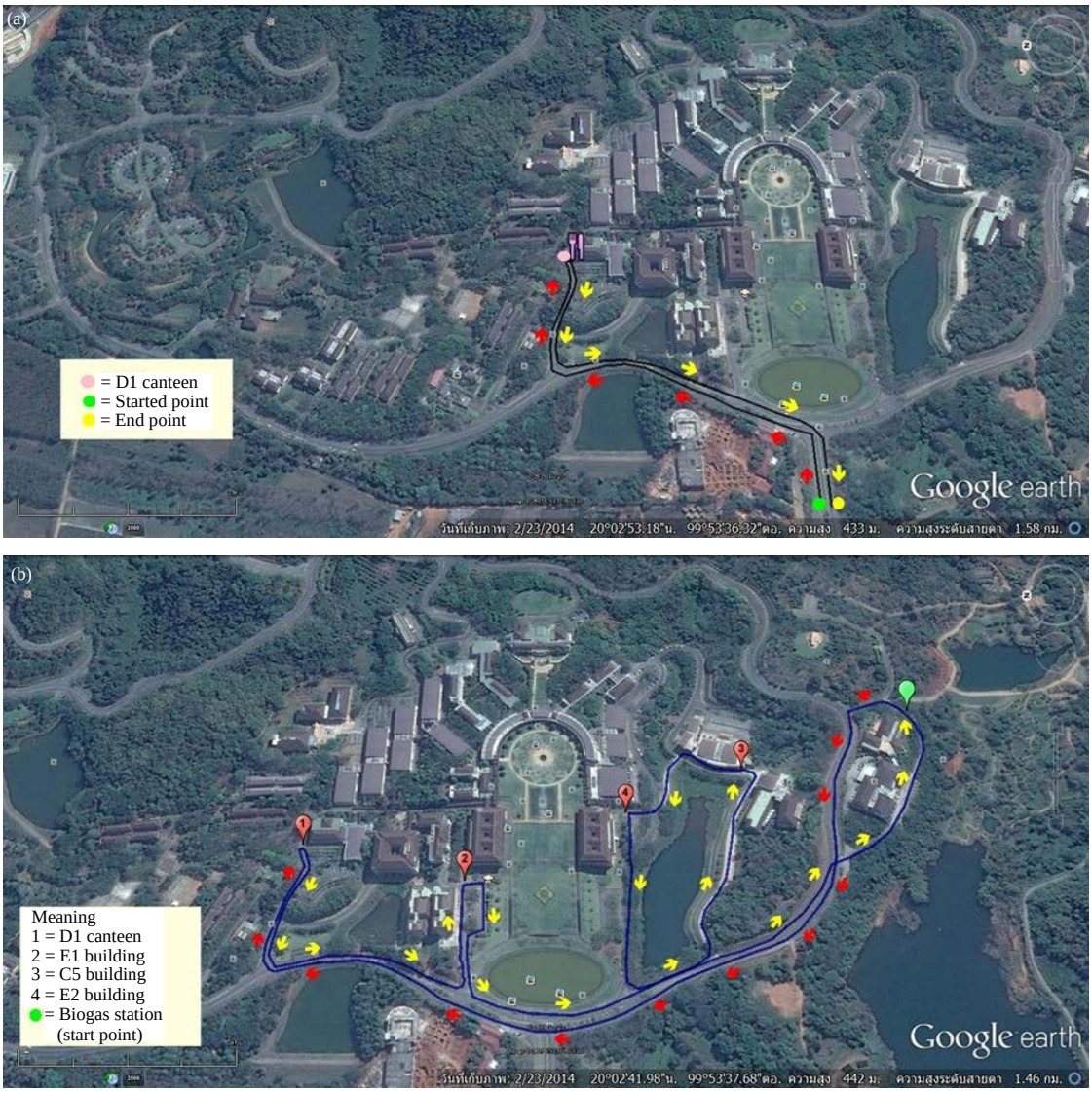

Fig. 5(a-b): Google Earth view of Mae Fah Luang University proposed collection points and transportation route (a) Route B for recycle wastes and (b) Route B for food wastes

transportation was reported to be the highest GHG emission process (Ting and Ren, 2011). Besides, it was found that in many reports that waste separation should be the first step to successful and efficient solid waste management (Dangi *et al*., 2011; Zhang *et al*., 2010a, b) and overall environmental impact can be reduced due to increasing waste separation rate (Yang *et al*., 2014).

Nevertheless, in order to reach low carbon or green solid waste management, the carbon emission from landfill (for general waste) and biogas generation should be calculated because avoiding the burdens for landfill, incineration and anaerobic digestion resulted in the difference of carbon footprint calculation (Muhle *et al*., 2010). Therefore, the strategy of waste minimization or 3Rs (Reduction, Reuse and Recycle) is considered (Pattnaik and Reddy, 2010), especially, reduction. The MFU systematic planning and implementation are needed for reduction of generation waste (plastic shopping bag, plastic cup, snack packaging and foam box) and food waste (food loss and food wastes).

CONCLUSION

The investigation of existing solid waste collection and transportation in Mae Fah Luang University, Thailand indicated that improper conditions were found such as collection sites, pick-up rounds and transportation routes. New transportation routes using Google Erath view were designed by idea of collection point reduction and solid waste separation. This clearly resulted in decrease GHG or carbon emission by calculation. Waste minimization was also suggested to implement on solid waste management plan to avoid GHG emission of waste disposal or waste to energy generation such as landfill, incineration and biogas plants.

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