RECUPERATIVE ENERGY POTENTIAL FROM A TYPICAL LANDFILL IN MALAYSIA

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ABSTRACT

The study looks into availability of recuperative energy potential from a typical landfill in Malaysia. Due to the rapid urbanization, rising population and lifestyle changes, the amount of municipal solid wastes (MSW) in Malaysia is increasing year by year. The average amount of MSW generated in Malaysia ranges from 0.5 kg/person/day in rural areas to 1.7 kg/person/day in urban areas. There are huge amounts of waste generated and they need a lot of landfill space according to current practices. Once a landfill is full, another landfill area will be needed to dump the ever increasing wastes. This study focused on the landfill potential as a solid feed for a recuperative energy incinerator. Landfill energy potential from solid consists mainly of organic materials such as paper, food wastes, biomass and the soil. Since the potential energy from MSW materials were well known, the study delved mostly into the soil energy potential from the landfill in the form of its calorific values (CV). The CVs obtained from soil at various locations were in the range of 1.1 MJ/kg to 14.89 MJ/kg at a typical landfill in Malaysia. The CV values could be enhanced for incineration by mixing with MSW as well as co-firing with gaseous fuels.

Keywords: municipal solid waste; incinerator; landfill; recuperative energy

INTRODUCTION

Over these few decades, Malaysia has experience rising population and industry development. This has led to increase in garbage or municipal solid waste (MSW). This trash can be recycled or reused, or simply burned, but usually buried in the landfill. There are two ways of garbage disposal, which are:

a) Dump- It is an open hole in the ground where trash or garbage is buried and it carries pests such as mosquitoes and rats. It can cause disease such as contamination to ground water supplies and release of poisonous gases.

b) Landfill- It is a carefully designed structure, located on the ground to bury the garbage with isolation from the surrounding such as ground water. Normallly it has liner at the bottom of the landfill. Sanitary landfill uses clay liner but municipal solid waste landfill uses synthetic (plastic) liner to isolate the garbage from environment. The purpose of the landfill is to bury the garbage in such a way that it will be isolated from surrounding environment. Garbage will not decompose much or quickly.

For a long time, landfill is used only to dispose waste, but now landfill becomes a new energy source where MSW incinerator and landfill gases are used as alternative energy. Incineration plants are able to generate electricity and heat that can substitute other power plants which are powered by other fuel sources. For example in United States, the first full-scale waste to energy facility was the Arnold O. Chantland Resource Recovery Plant, built in 1975 and is still in operation. It produces refuse-derived fuel that is sent to local power plants.

There have been many publications regarding MSW composition and its potential as new energy; however, present literature does not highlight the characteristic of calorific value from typical landfill. Therefore, this study will focus mainly on this characteristic.
Currently in Malaysia, because of massive waste production rate, many of the landfills are closed and new landfills are opened in order to fill the increasing waste. The closed landfill cannot be reused and must be monitored to prevent pollutions especially leachate (underwater pollution). The numbers of closed landfills also keep increasing from year to year and sooner or later shortage of land for disposal of waste will be occurring. Therefore, there is a need to study the landfill potential and determine its suitability for incineration.

OBJECTIVES

The aims of this study are:

a) Obtain calorific value of the soil from typical landfill.

b) To investigate potential energy content of landfill soil and its suitability for incineration.

METHODOLOGY

For this study, the main task was to collect the soil samples from Pulau Burong Sanitary Landfill and determine its calorific value. This process was subdivided into three steps or tasks, which were area survey, collection of landfill soil samples and bomb calorimeter experiments.

1) Random spots in landfill area

In order to investigate the variation of calorific value between different areas, four random spots had been selected in the landfill area with some representative criteria.

2) Landfill soil samples

Random soil samples were collected from Pulau Burong Sanitary Landfill in order to determine the calorific value of the typical landfill. Before entry to landfill, permission was obtained from the management of the sanitary landfill. This was because inside landfill, there were many trucks and machinery that unloaded the MSW and dumped the waste. The random samples were taken at four different spots. For each spot, random samples collected ranging from 4-8 samples. These spots were located at places where few or no trucks or machinery were working nearby. It was a safety precaution to prevent accidents from occuring. Each sample was taken around 200-500 grams. Before taking each soil sample, all rubbish or visible particles were separated from the samples. It was used to determine the net calorific value of soil only.

3) Bomb calorimeter

After the collected soil samples were brought to the lab, the next step was to conduct the bomb calorimeter experiment. Total number of samples for the four spots was 22. Before carrying out the experiment, each sample was put into oven to dry. It removed all moisture content inside the soil samples to make it easier to be combusted inside bomb calorimeter. In this project, only dry samples were used to determine their calorific values. In other words, it neglected the effect of moisture content to the actual calorific value of landfill soil.
After the bomb calorimeter experiment was completed, the percentage of ash and the calorific value for each sample were determined. For the overall calorific value, other particles such as plastic, metal, food waste, etc were also taken into account. The calorific value for each particle and composition of MSW were taken from publication.

RESULTS AND DISCUSSION

Calorific value variation: Figure above shows the calorific value variation for the Nibong Tebal Sanitary Landfill. For spot 1, the calorific value ranges from 1.5 to 13 MJ/kg. Average calorific value of Malaysian municipal solid waste (MSW) is between 1540 – 2640 kcal/kg [1] or about 6.4 – 11.0 MJ/kg. Relatively, this spot of landfill has high calorific value but with large variation. This spot was a new landfill area. Compared with other matured landfill, it was still undergoing dumping process. Municipal solid waste such as food, papers, plastics, wood and other organics materials were dumped in this area and decomposition process occured. The organic compound mixed with landfill soil. This organic compound contributes to the calorific value of the landfill soil.

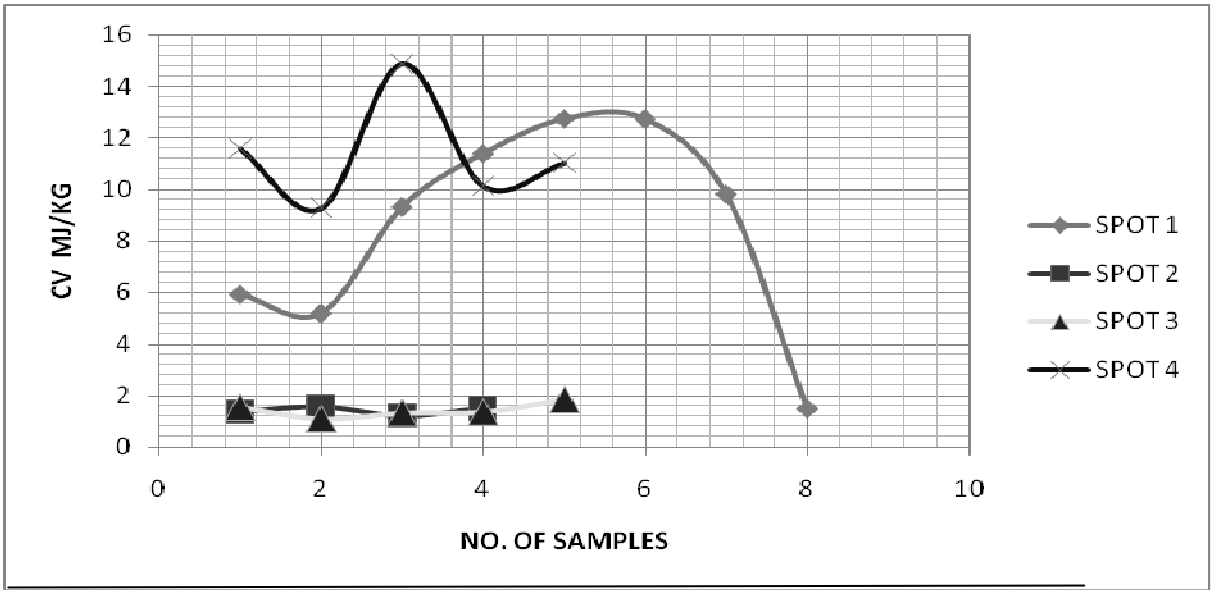

Figure 1: CV variations among the different spots

For spot 2 and 3, calorific values for these two areas are relatively low, ranging from 1-2 MJ/kg. Compared with average value, it is very low. This is because spot 2 and 3 are matured landfill. In matured landfill, trash or MSW had been in there for very long period. Underneath the landfill is an environment which has little oxygen and moisture compare with open-air area. In this condition, MSW does not break down rapidly. Actually, landfill is not designed to break down the trash, rather merely to bury it. Since it has slow degradation rate, the amount of organic compound inside the soil is also low. It may affect the calorific value for particular soil samples. Besides that, no new MSW was dumped at the closed landfill. Therefore organic compound inside the landfill soil is also relatively less than the other areas.
For spot 4, calorific value for this area is relatively high compared with other areas in the landfill, ranging from 9-12 MJ/kg. There is no concrete reason for this but it is suggested that there were more MSW in this area. As a result, more organic compound existed inside landfill soil and it increased the calorific value of the soil samples.
Short conclusion for this, average calorific value for soil samples in Nibong Tebal Sanitary Landfill are 5.41 MJ/kg.

Wet Analysis. Table below shows the calorific values for landfill soil with moisture content. They range from 0.98MJ/kg to 8.69MJ/kg. The average calorific value was obtained from the dry landfill soil. It means that average calorific value without the moisture content. From the table above, calorific value (wet) has lower value than average calorific value. This is because moisture content that existed inside landfill soil affected the calorific value. It makes the landfill soil harder to combust.

Table 1: CV for each sample and their average dry and wet CVs

SPOT	SAMPLE	CALORIFIC VALUE M J/kg	AVERAGE CALORIFIC VALUE M J/kg	CALORIFIC VALUE (WET) M J/kg
1	1	5.91	8.56	7.19
	2	5.17		
	3	9.3		
	4	11.37		
	5	12.73		
	6	12.72		
	7	9.8		
	8	1.47		
2	1	1.37	1.41	1.24
	2	1.55		
	3	1.22		
	4	1.497		
3	1	1.56	1.17	0.98
	2	1.1		
	3	1.33		
	4	1.37		
	5	1.86		
4	1	11.59	11.38	8.69
	2	9.27		
	3	14.89		
	4	10.14		
	5	11.033		

Estimated Calorific Value For typical Landfill. Landfill soil actually is in heterogeneous form that consists of soil and solid waste that are dumped in landfill. In order to determine the rough estimated calorific value for Pulau Burong Sanitary Landfill, it needs to combine landfill soil calorific value with MSW calorific value. The composition of MSW and its heating value is shown in Ttable 2 below [2]:

From Table 3, it shows that rough estimated calorific values for Pulau Burong Sanitary Landfill ranged between 4.92 – 13.42 MJ/kg. Spot 2 and 3 had lowest calorific values because they contained less organic component. There had been more solid waste dumped in spot 1 and 4. As a result, those solid wastes contributed for higher estimated calorific value in a typical landfill.

From the Table 3, the heating value ranges from 1500 – 2500 kcal/kg or about 6.3 – 10.45 MJ/kg. For landfill soil of Pulau Burong Sanitary Landfill, its average calorific value ranged from 1.1 – 11.38 MJ/kg. The upper value was comparatively close with the heating value from literature. Conclusion for this is that the landfill soil is generally suitable to burn in incinerator. However, the heating value of landfill soil was still relatively low where lowest value was 1.1 MJ/kg. It is suggested that if the landfill soil is mixed with solid waste and burned in incinerator, it can improve the overall calorific value.

Table 2: Typical composition of MSW [2]

COMPOSITION	AVERAGE PERCENTAGES %	HEATING VALUE M J/kg
FOOD WASTE	42.94	19.23
PAPER	18.4	17.53
PLASTIC	15.85	15
RUBBER	1.38	26.23
WOOD	1.03	19.94
YARD/LEAVES	4.49	20.54

Table 3: Estimated CV for landfill

		SPOT 1	SPOT 2	SPOT 3	SPOT 4
SOIL	PERCENTAGE %	50	75	75	50
	CALORIFIC VALUE MJ/kg	8.56	1.41	1.17	11.38
	ACTUAL CALORIFIC VALUE MJ/KG	4.28	1.06	0.88	5.69
MSW	PERCENTAGE %	50	25	25	50
	CALORIFIC VALUE MJ/kg	15.45	15.45	15.45	15.45
	ACTUAL CALORIFIC VALUE MJ/KG	7.73	3.86	3.86	7.73
ESTIMATED CALORIFIC VALUE FOR LANDFILL (MJ/kg)		12.01	4.92	5.03	13.42

Table 4: Heating value and capacity of 10 incinerator plants in Taiwan [3]

Plant scale factors of 10 incinerator plants

Scale factor	Plant area (PA) (ha)	Design capacity (DC) (ton/day)	Electrical power (EP) (kW)	Heat value (HV) (kcal/kg)
BT	10.6	1800	45000	2400
LZ	10	600	14700	1500
BL	6	1350	38000	2305
LT	10	900	25000	2500
RW	12.4	1350	31000	2400
PT	7	900	25000	2200
SJ	8.4	900	21000	2300
HC	5.5	900	23700	2300
GS	7	1350	38000	2500
YK	4.58	900	23000	2400

Table 5 shows the system parameters for the modern incinerator. From those parameters, minimum MSW calorific value is at 3.1 MJ/kg. The MSW is not self-sustaining due to low heating value. The landfill soil, which has a mean calorific value of 5.4 MJ/kg, is pretty close to that heating value. It means that it needs supplement fuel to burn. Short conclusion to this is that the landfill soil is not suitable to use as a fully alternative fuel source but is suitable to burn in incinerator with MSW.

Table 5: Typical parameters of a modern incinerator with power generation [4]

Key Parameters of Grate-CFB Incinerators and Power Generation System

item	value
incinerator capacity	2260 ton MSW/day
steam output	218 ton/h
steam parameters	3.82 MPa, 450 °C
boiler efficiency	≥79%
auxiliary fuel (coal) consumption	≤20% of total fuel mass
residence time of flue gas in combustion chamber	≥2 s
moisture content in original MSW	≤55%
MSW calorific value	≥3100 kJ/kg
condensing steam turbine	16 MW, 3000 rpm, 3.43 MPa, 435 °C
electric generator	16 MW, 6300 V, 3000 rpm

CONCLUSION

From the results, a conclusion can be made that the calorific value of soil for typical landfill at Pulau Burong Sanitary Landfill ranges from 1.17 – 11.38 MJ/kg. In addition, rough estimated calorific value for landfill soil, which indicates moisture content, ranges from 1 – 8.69 MJ/kg with a mean of 5.4 MJ/kg. This value is comparable with the typical heating value for incinerators in Taiwan [3]. As a conclusion, landfill soil is suitable to burn in incinerator especially when mixed with MSW.

Landfill soil at Pulau Burong Sanitary Landfill has low calorific value and it is not a good choice as a fully alternative fuel source for incineration. This is because the calorific value is low, moisture content is high and it is not self-sustaining in combustion process. However, the calorific value can be improved if burned together with municipal solid waste.

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