

A Review of Six Functional Elements Affect the Cost of Solid Waste Management in Malaysia

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Abstract— Cost is vital component in solid waste management. Every year government and private sector spend billions of money on it especially on the operational cost. As the growth of economics and population in the country, the burden in solid waste management for this country will become heavier and heavier if no way to minimize the cost. Six functional elements are the core of solid waste management. The six functional elements involve the whole process from the beginning of the waste being produced until how human being settle the waste. In this paper, we will discuss about how the six functional elements affect the cost of solid waste management.

Keywords- Cost; solid waste management; six elements in solid waste management

I. INTRODUCTION

Solid waste is defined as the unwanted of materials produced by residential, commercial or industrial activities. It is not necessary in solid form, it also can be in liquid or gaseous form [1]. In the other words, solid waste can be produce by most of the human activities including eating a meal. Integrated solid waste management (ISWM) is a complete waste prevention, recycling, composting, incineration, inert landfill, sanitary landfill and others. But in Malaysia, open dumping still is the first choice for the Malaysian. This is because open dumping is the easiest way. But this show the awareness of Malaysian towards the environment is still not enough [2].

Malaysia is a developing country. Nowadays the number of residents are increasing rapidly. It had increased from approximately 29 million of residents in year 2011 to 30 million of residents in year 2013. In 2012, Malaysian averagely generated 22,000 tonnes of solid waste per day. In 2013, Malaysian averagely generated 30,000 tonnes to 33,000 tonnes of solid waste per day. This showed a large increment from year 2012 to 2013, it increased about 8,000 tonnes to 11,000 tonnes within one year time [3]. As the population increase, the solid waste been produced also will be increase, as shown in table 1 which shown the trend expected by Ministry of Housing and Local Government (MOHLG) [4].

Year	Population (million)	Estimate Amount of Waste (Tons/ Year)
1991	17,567,000	4,488,369
1994	18,917,739	5,048,804
2015	31,773,889 (predict)	7,772,402 (predict)
2020	35,949,239(predict)	9,092,611 (predict)

Expenditure of government used in solid waste management is quite high every year. 40 to 80 percent of local

authority expenditure on solid waste management. The expenditure for capital expenditure (CAPEX) and operational expenditure (OPEX) is high. To buy a new landfill will cost about RM 30 million or above while for the operational expenditure averaged cost RM 28.90 to RM 49 per tonnes [5].

Every year, government state spend a lot of money in solid waste management. But does not have an effective way to reduce or minimize it. Through the information as above, we can conclude that expenses for operational is high. According to UNEP (2005), in solid waste management, there are six functional elements. The six elements are the operation for solid waste management. The six elements are waste generation, waste storage system, waste collection, transport, treatment and disposal. [6]

II. ELEMENTS IN SOLID WASTE MANAGEMENT

A. Waste Generation

According to IPCC Guidelines, solid waste generation is the first step or the first elements among the six functional elements. Rate for solid waste generation is different between country and country. The rate is depend on the situation of the country like the waste management regulations, industrial structure and so on. [7]

In the stage solid waste generation, composition of the waste can be determined. Normally, waste divided into different types of waste like organic, paper, plastic, glass, metal and others. Organic waste include food scraps, yard waste, wood and process residues. Paper include paper scraps, cardboard, newspaper, boxes, wrapping paper, bags, paper beverage cup and so on. Paper is not included as organic unless it is contaminated by food residues. Third type of waste is plastic. Bottles, packaging, containers, bags, lids and cups are included as plastic type of waste. Bottles, broken glassware, light bulbs and colour glass are included as glass type of waste. Cans, foil, tins, bicycles and so on are included in metal type of waste. Lastly, other types of waste include leather, textiles, ash, e-waste and so on.

According to the Hoornweg, Daniel; Bhada-Tata, Perinaz. (2012), the composition of these types of waste will be changed according to the income of the country. Normally, low and middle income country, organic type of waste is the highest. While the high income country, organic type and paper type of waste being generated are equally high. In Malaysia, the waste composition is shown as table below. Through the table, we can conclude that organic waste is the most dumping type of waste. This is because Malaysia is an agriculture country. Many district people are choosing farming as their way to survive. This will lead to many organic waste will be disposed. In the optimization model for treatment part, we can focus on the organic waste, paper waste and plastic waste. This is because, this 3 types of waste are higher than others. In the other words, it will spend more expenditure on it.[8].

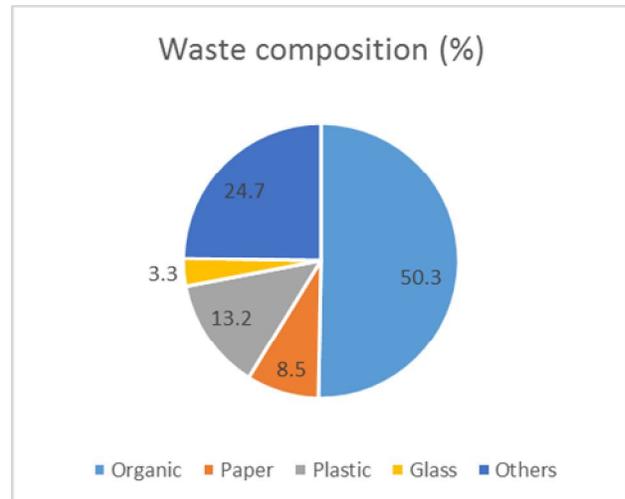


Figure 1: Waste composition in Malaysia 2012

B. Solid waste storage

According to Nur Syazwani, there are 4 factors we need to be considered in the onsite storage of solid waste. Four of them are the effects of storage on waste components, type of container to be used, location of the container, and the public health and aesthetics. The effect of storage include the microbial decomposition, absorption of fluid and so on. In the other words, the effect of the storage occurs when the waste mixed together. The effect is the bad odour due to the waste undergoes microbiological decomposition especially for the organic waste, the paper type of waste absorb the water due to the mix of waste. These are the effect of the waste. For the type of container factors, according to Nadzri (2012), new and standard garbage bins had been distributed to residents. In 2011, two federal territories and six state in Malaysia with total 1.3 million of household received new and standard bins that is 120 litter capacity bins. [9]. There are 3 locations for placing the container. They are side or rear of house, special enclosure (for department or condos), basement. This factor is very important due to the location of the container will affect the routing systems. If the location for the containers are not place at strategic places will affect the efficiency of the workers, the schedule and so on, the cost will be increased. For the fourth factor, public health and aesthetic is relate to the on-time collection of the waste to avoid spread out diseases like Cholera disease and so on.[10]

The waste storage system in residential housing area is the residents collect the garbage and put in a garbage bag and put in a garbage bin. The garbage bin will be place in front of their house and waiting the date had been setting by concessionaires to collect it. In public place, normally recycle bins and normal garbage bins are prepared especially at tourist hotspot. Because of the effect of 3R programs in Malaysia, recycle bins are prepared in public places like school, public playground and so on. Normally, 3 colours of recycle bins had been distributed. They are blue, brown and orange colour. Blue colour of recycle bin is for paper type of waste, brown for

glass type of waste and orange colour is for cans, aluminium tins, plastic type of waste. [11]

Other than that, small collection centre also has been prepared especially in small town. A garbage container will be placed at there. This collection centre are mainly prepared for the residents not living in residential housing area. They live at the edge of town. The garbage collectors will not pass through those area, so the residents need to collect their garbage or their household waste and bring them to the collection centre. This will easy for the collectors to collect the waste.

C. Solid waste collection

Collection element is the third functional element in solid waste management. In the other words, it is the third step or stage in solid waste management. In this stage, the waste will be collected. Here we will discuss about the collection systems. Every community need to define the collection system goal. Some issues should be considered like the level or the quality of service need, the roles, community's long term waste management and source reduction goals, constraints for funding mechanisms and lastly labour or service contract that affect decision making. [12]

Waste collection system is a vital elements in solid waste management especially in reducing the cost of solid waste management. This is because every year 60 to 80 percent of the budget are using in collecting waste. In the other words, waste collection system play a vital role in minimizing the cost of solid waste management. If a country has a well waste collection system, it will save a lot of money. There are various types of collection. Types of collection can be divided into 2 types. They are residential and commercial or industrial. In collection for residential area, curb side is the most common type of collection in Malaysia. Curb side collection involve 1 driver and 1 to 2 collectors. The container size is about 120 litters and the location of containers will be placed at roadside, alley or backyard. Second type of collection is set out and set back collection. In this type of collection, crew need to enter the property to take out the container and empty it. After that, need to put it back to the property. There are 2 types of waste collection system. They are hauled container system (HCS) and stationary container system (SCS).

Hauled container system (HCS) is a system that haul the container to disposal sites. After empty the container, it will be returned to original location or other location. This kind of system is suitable for areas with high waste generation. While stationary container system (SCS) is for residential or commercial sites. In SCS container will remain at the point of generation. Unless it is move to curb or other place to empty it. [10] There are some disadvantages for HCS and SCS. The disadvantage for HCS is the container may not fully utilize while disadvantage for SCS is the container size may be not enough.[13]

Equation to calculate number of trips were developed.

$$Y = a + b + c(d) + e + f + g$$

Where,

Y=total collection time

a=time need from garage to route

b=actual time for collecting waste

c=number of trips to disposal site

d=time to drive fully loaded truck to disposal facility, unload and return to collection area

e=time to drive to garage at the end of the trip

f+g=off route time, can express as fraction Y/day

Through this equation, we can clearly count the number of trips needed (c) base on the time needed as the equation. Through number of trips needed we can estimate the usage of fuel or gas per day and estimate the cost needed for fuel every day. Malaysia nowadays is implement the 2 + 1 collection systems, which means 2 days will be spent to collect the residual and 1 day is for recyclable waste include bulky waste and green waste. This collection need highly cooperation with the residents. [5]

According to the research by Stevens in 1978, an equation for collection cost is estimated.[14]

$$\ln C = \alpha_1 \ln Q + \alpha_2 \ln I + \alpha_3 \ln D + \alpha_4 F + \alpha_5 G + \alpha_6 P + \alpha_7 V + \alpha_8 E + \alpha_9$$

Where

C = Total collection cost in a municipal area.

Q = Number of pickup points

I = Number of residents in a pick-up point

D = Spending time from one pick-up point to another pick-up point

F = Frequency of collection per week

G = Percentage of glass

P = Percentage of paper

V = Percentage of vegetable, fruit and garden waste

E = Dummy for institutional form

This equation can help us estimated expenses for collection in solid waste management.

D. Solid waste transport

Solid waste transport system is a way to transfer the waste from residential area to the center to let the waste to accept treatment. In solid waste management, transportation is the process after collection. After the waste been collected, they will be transfer to the treatment station. Expenses for fuel is the most important component we need to concern. So, we need to have a good route planning to minimize the usage of fuel to reduce the cost. Geographical Information System is the most common use and the most traditional ways to plan the transportation routes[15]. Other than this, GIS also can be used to plan the best location for the landfills especially in the new

landfills. GIS require the spatial data. Through the planning by GIS, we can plan the route well and find the shortest routes. So, the usage of the fuel will be decreased. Types of trucks to collect waste and the maintenance fees also is the main concern in order to minimize the cost.[19]

E. Solid waste treatment

There are several solid waste treatment. For example, mechanical treatment, thermal treatment and biological treatment. Mechanical treatment is for material recovery, thermal treatment include incineration, pyrolysis and gasification, biological treatment is undergo composting process. [16]

Material recovery treatment is a treatment with the function as recycle. The used products will be recycled. Paper, steel, aluminum, glass and plastics are the type of waste can be recycled. Organic type of waste can undergo the composting process, while most of the waste can undergo the incineration process.[16] According to the hierarchy of the solid waste management, composting and the recycle (mechanical) treatment is the preferable option, incineration treatment is least preferable as shown in the waste management hierarchy as below. [17] There are 6 methods or treatments for solid waste in Malaysia. They are recycling, composting, incineration, inert landfills, sanitary landfills and others. The table below shows the improvement of Malaysia in handle the solid waste. Through the way to handle the waste, we can conclude, Malaysian are trying to minimize the case of open dumping and target in year 2020, there will be no others dumping ways except the recycling, incineration, composting and dispose to landfill[18].

Method	2002 (%)	2006 (%)	2020 Target (%)
Recycling	5.0	5.5	22.0
Composting	0	1.0	8.0
Incineration	0	0	16.8
Inert landfill	0	3.2	9.1
Sanitary landfill	5.0	30.9	44.1
Others (ordinary dumping, etc)	90.0	59.4	0
Total	100	100	100



F. Solid waste disposal

Waste disposal to landfills is the last option for solid waste treatment. This is because after the waste dispose to landfills, the waste will become useless and bring some bad effect to our environment. There are 3 types of landfilling disposal. They are municipal solid waste (MSW) landfills, hazardous waste landfills and surface impoundments.

MSW landfills are mainly for the waste without contain harmful or hazardous wastes. Normally, it is for the waste from residential area, school, institutions and so on. Hazardous waste landfills is for hazardous chemicals or harmful products. So it must be well designed due to prevent or minimize the hazardous component leak into the environment. Thirdly, Surface impoundments are designed for liquid waste disposal.

In landfilling need cost for operation and maintenance to make sure the safety of the surrounding environments. First of all, the waste identification and restriction. The waste must be identified to prevent the hazardous waste throw into the MSW landfills and cause the hazardous component leak out and affect the environment surroundings. Secondly, the working face should be kept as small as possible and covered after operation. This is to prevent spread out of the diseases. Thirdly, run-on and run-off control. Run-on control is to prevent water flow in from outside while run-off control is to prevent the unclean water flow out from landfill area. Fourth, the protective equipment should be prepared for workers to minimize the risks that will hurt or threaten the health or safety of the workers.

Fifth, the way to control the landfill gas. This is because waste will be decomposed after a period of time. The gas produced might harmful to human and environment. So, equipment must be provided to prevent the gas leak out. Sixth, leachate management, Leachate is a type of liquid produced when the waste undergo degradation. Lastly, special waste. Waste like battery, hospital waste and others, normally people mix them in non-hazardous waste. But in fact, these waste must be handle in other ways.[20]

III. CURRENT PRACTICE IN MALAYSIA

At first, residents will generate the waste and put in a garbage and place in a refuse bins. With 2+1 collection system, one week garbage truck will come to each residential area for 3 times a week with 1 truck driver and 2 collectors. Waste will be collected and transport to accept the treatment. All the route of the truck is planned through GIS. After that, waste will be disposed to landfill if the waste cannot be handled by treatment.

Malaysia is a developing country. The cost expenses every year for solid waste management become the main concern by the government. In order to reduce the cost, we can focus on the operational cost before minimize the cost from other ways. This is due to Malaysia spend much in operational cost for solid waste management. To investigate through the operational cost for solid waste management, focus on the 6 functional elements in solid waste management. This is

because the 6 functional elements is the main core and the main process for solid waste management.

IV. CONCLUSION

In conclusion, the cost in solid waste management are mainly caused by the five out of six functional of elements. Except the solid waste generation, this elements, others will affect the cost especially collection and transportation part. Every year government spend most of the budget on the collection and transportation cost. Cost needed for storage is the bins prepared for residents, cost for collection and transportation is the fuel, the labour cost, the maintenance cost for the trucks and so on. Well planning is very important in this stage. Lastly, the cost spend on the treatment and disposal landfilling is high too. In this stage, the cost of maintenance and the labour cost need to be considerable.

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