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Minimizing the cost of Municipal solid waste management in Pasir Gudang Johor Malaysia

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Abstract

Malaysia like any fast developing country is facing a serious problem of the increase in solid waste generation in the urban areas such as Johor Bahru. Therefore, managing of solid waste with less cost is the current dilemma, which is facing the municipality of solid Waste Management in Pasir Gudang. The paper aim is to determine the cost of solid waste management in Pasir Gudang Johor Malaysia. In order to achieve this goal, the composition study was conducted in Tanjung langsat Landfill for one year. This study is to evaluate the current municipal solid Waste Management in order to estimate the cost of transportation from various locations in the municipality to Tanjung Langsat landfill. A model is proposed to minimize the cost of transportation to the landfill consisting recycling and reusing some portions of solid wastes. To conduct the assessment, data was collected through personal visits and interviews of stakeholders of the council, also questionnaire survey and review of literature were carried out. The assessment found that Pasir Gudang municipality generates 240,379 kg per day of solid waste. Based on the study also, the per-capita waste generation is 1.13 kg/person/day. The proposed model could reduce the cost of solid Waste Management expenditures from RM 7,130,884.00 to RM 6,093,872.00 that is a cost saving of RM 1,037,012.00 or 14.5% cost reduction every year. This could further prolong the life span of the landfill in the area under study.

Keywords: Municipal Solid Waste management, solid waste management.

1. Introduction

Solid waste is defined as the surplus products of human and animals in the solid state from the activities discarding by the society [1] The management of solid waste continues to be a big challenge in urban areas throughout the world, especially in the town, villages, where the solid waste increases at an alarming rate, particularly in the underdeveloped countries [2, 3]. According to [4], world population rose to six billion in 2001 with 46% of this population residing in urban areas. Global municipal solid waste generated in 1997 was about 0.49 billion tons with an estimated annual growth rate of 3.2–4.5% in developed nations and 2–3% in developing nations. Solid waste management in Pasir Gudang has a very serious problem associated with the increased waste in various locations of the Pasir Gudang area. This is also augmented the populations increase and the amount of waste per capita to 1.13 kg/day [5]. However, the real problem is how to manage the solid waste with less cost and impacts to the human and environment. The amounts of waste transferred to Tanjung langsat landfill was 350 ton/day [6]. Therefore, the Solid Waste Management system (SWM) needs to be upgraded to suit the present section of solid waste management. A characteristic of a solid waste management system in Pasir Gudang have posed an array of problems, including the low collections, coverage, irregular collection services, crude [7]. In Malaysia as in many underdeveloped countries there is poor in organization of solid waste management due to the lack of awareness and how to manage solid waste with less cost and effects. The lack of reliable database of mange solid waste management system in the underdeveloped countries this contributed to solid waste management to become a serious problem.

The negative effects of solid waste to the human and the environment have been considered as a serious problem. The other problems are caused by technical, financial, institutional, economic, and social factors, which constrain the development of effective solid waste management systems. This, therefore, necessitates the search for a way for the solid waste management with less cost and impacts. This study presents an overview of the current solid waste management practices in Pasir Gudang and also how best practices can be sustained towards the solid waste management in Malaysia. Therefore, the main focus of the study is to minimize the cost of solid waste in Pasir gudang Johor, Malaysia through the treatment of some portion of the solid waste.

2. Materials and methods

2.1 *Study area*

Pasir Gudang is an industrial town located in east of Johor Bahru, it 35 Km away from Johor Baharu town. According to Iskandar Malaysia [8] the population of Pasir Gudang Johor Malaysia is 211,900 people in the year 2010. Over time there has been an increase in the population in Johor generally and especially in Pasir Gudang "between 2000 to 2010". Consequently, the average municipal solid waste (MSW) generated is found to be 0.5 - 0.8 kg by day per capita [9]. As such the high number of the population in Pasir Gudang have resulted with a corresponding high increase in of solid waste in the area which makes (MSW) municipal solid waste management crucial. The traditional way for treatment of solid waste in Malaysia, especially in Johor Bahru to be the landfilling method, which has existed for many decades [6]. Landfills still cover 60 to 90% of the served areas, and are projected to cover more than 75% soon with 80 % of the waste-disposal sites having less than two years of remaining operating life [2]. This has necessitated the urgency for municipalities to secure new landfills is a priority before the existing ones get exhausted Landfilling and open dumping are practiced and this is likely going to continue [10].

2.2 *Classification of (MSW)*

Municipal solid waste depends on many factors: location, lifestyle, season, packaging, and local authorities. Therefore, detailed classification and quantification of MSW is desired to obtain accurate data concerning estimating the current and future trend in MSW in necessary. In addition, universal classification system is required to be applied by any municipality, irrespective of national or regional differences [10]. There are many sources where solid waste is produced every day. Some of these sources include the households, offices, schools, shops, hotels, and other enterprises. The proportions include paper, plastics, metals, rags and glass and other sources produced of solid waste [11]. Classifications are based on domestic institution, commercial industrial construction and sever based waste. Yet another classification is based on organic combustible inorganic, non-combustible, and putrescible, [12]. Furthermore, there exist other MSW such as those found on the roadside, sewage, dead animals and street sweeping. Above all, as outlined in Table 1 and more specifically, municipal solid waste is defined as any rubbish, or refuse, sludge from a waste treatment plant, including semisolid or contained gaseous material that is resulting from industrial, commercial, mining and agricultural operations and from any community activities [13].

Table 1: Waste sort analysis by type, content, and source (ISW1970)

Types	Contents	**Sources**
Industrial wastes	Food processing wastes , boiler house cinders , lumber scraps , metal scraps , shaving	Power plants ; Factories ; Companies
Street refuse	Leaves , dirt , catch basin dirt , sweepings , contents,	Alleys, vacant lots Street , Sidewalks
Sewage treatment Wastes	Solid from coarse screening and from grit chambers ; septic tank	Sewage treatment Plants , septic tanks
Demolition and construction waste	Lumber pipes, brick, masonry, scrap lumber and other construction materials from razed building.	Demolition sites to be used for new buildings ; Renewal, projects expressway, new construction.

Similarly, Table 2 also gives an outline of solid waste generation, Source activities and location associated with various source classifications.

Table 2: Typical solid waste generation, Source activities and location associate with various sources classifications (EPA)

Source	**Activities and location**	**Type of solid wastes**
Industrial	Construction , fabrication , light and heavy manufacturing , refineries , chemical plants , lumbering , mining , power plants , demolition .	Rubbish , food waste Ashes Special wastes
Open areas	Streets , Alleys , parks , vacant lots , , playgrounds, beaches , highway , recreational areas	Rubbish , dirt
Residential	Single – family and multi – family Dwellings , low , medium	Food waste , Rubbish , ashes , Special wastes
Treatment plant sites	Water , waste water and industrial treatment process	Treatment plant wastes Principally composed of residual sludge
Agriculture	Field and row crops , orchards , Vineyard , dairies , feedlots , farms	Alleys, vacant lots Street , Sidewalks
Commercial Municipal	Stores , restaurants , markets , offices , Buildings , hotels , print shops , medical facilities and enterprises	Food waste , rubbish , ashes ,demolition and construction Wastes.

2.3 *Solid waste generation in Malaysia*

Solid wastes are testified to be substances that are generated as no more useful or having no values than to be disposed. The increment of solid waste generated to step up to 7.0 t/y million tons in 2010 in Malaysia [15].15 to 39 % million tons of the total municipal solid waste of the year 2010 was expected to be combustion. The percentage of total municipal solid waste being disposed in landfills is decreasing; the actual tonnage was expected to increase from 118 million tons in the year of 1995 to 125 million tons by the year 2010. However, because of the economic boom, the tonnage already increased to 2.5 million tons in 1991 to 7.0 million tons by the year 2010. However, because of the economic boom, the tonnage already increased from 2.5 million tons in 1991to 17.0 million ton in the year 2010. It is expected that landfill disposal will continue to be the single most predominant municipal solid waste management methods in future years. Table 3 shows the increased of solid waste generated in the local authority of Malaysia "between 1991 to 2010".

Table 3: Estimated solid waste generation by local authority in Malaysia (Daskalopoulos, 1998).

Year	Increased population at 3%	Increased waste generation 2% Kg/capita day.	Total amount of solid waste Million Tons
1991	13.727	0.7	2.5
1995	15.450	0.8	3.0
1996	15.913	0.8	3.2
1997	16.931	0.8	3.4
1998	16.882	0.8	3.5
1999	17.389	0.8	3.7
2000	17.911	0.9	3.9
2005	20.598	1.0	5.9
2010	23.284	1.2	7.0

Abba 2013, reported that the solid waste generation in Johor Bahru in the year 2010 was 596,527 t/day and expected to step up to 1,423,957 t/y in the year 2025 [5]. In another major study Abba (2013) estimated the amount of solid waste generation in Pasir Gudang area, was 81,984 t/y in 2010 and expected to be 174,149 t/y in 2025 [5].

3. Waste Handling and Separation, Storage and Processing

The biggest problem faced by the Malaysian government is collecting the solid waste generated. The other problem is managing the waste with minimum cost. Furthermore, handling and, separating the waste involves sorting the waste in terms of organics and recyclables, some treatments involve processing the waste from sources such as compaction, and yard waste composting [16]

3.1 *Waste Collection*

Waste collection involves gathering of solid waste and its disposal, it also involves the collection of recyclable materials for recycling [17]. It is important in waste collection to choose the optimum collections process. The attainment of the optimum collection process involves the determination of the quantity and also the density of the waste generated. Furthermore, waste collection also includes the collection of recyclable materials that technically are not considered as waste [18].

3.2 *Waste separation and processing*

Separation, processing and transformation is the fourth stage of municipal solid waste management [19].There are two ways of separation of solid waste, drop off, and the buyback centuries. The drop of control system is such that the solid waste is separated as initio. The system requires placing containers in places such as restaurants where waste is separated based on their types such as organic, and recyclable. For effective collection and separation of waste, it is important to have dropped off containers placed in strategic places, especially in densely populated countries as well as heavy waste producing countries such as factories and restaurants [19].

3.3 *Transferring Solid waste*

In many cities around the world, the waste collection companies mainly collect MSW from the school, offices, households, hospitals, wholesale and markets. In the past solid waste has been transported to the landfill directly via transfer station by vehicles and trucks with different collection capacity. This later becomes not effective because in many cities around the world, the waste collection companies mainly collect MSW from the school, offices, households, hospitals, wholesale and markets. In the past solid waste has been transported to the landfill directly via transfer station by vehicles and trucks with different collection capacity. This later becomes not effective because the vast quantity grew and the distance increased because used vehicles covers only lower than three tons per load. Therefore, their best way to minimizing the cost is focused to improve transport efficiency and establish a new waste transfer station near the waste generation. This strategy was conceived to reduce the waste transport to the landfill. Transfer and transportation of waste is very important and the function has two steps:

i. Transfer the waste from the small collection vehicle to the largest vehicle equipment
ii. The distance is reduced by transferring the waste to transfer station instead of transporting from generating point to the disposal site; table 4 shows the consumed fuel of some vehicles litre /100 km of transferring solid waste.

4. Data Analysis

The data obtained was analyzed by using Microsoft excel and statistical Package for the social science (SPSS) to optimize the cost of municipal solid waste management in Pasir Gudang Johor Malaysia. Data was collected on the amount of waste generated from the authority through the use of questionnaire and interview survey. The data of solid waste were analyzed using SPSS. The nature of solid waste collected range from paper, food, plastic as well some other solid waste in Pasir Gudang municipality. The cost of handling solid waste informs of cost of trucks, RORO bins, salaries, wages to workers were also inputted and analyzed using Microsoft excel

Table 4: The fuel consumption for truck (litre per 100 km) (Emis_eng_10110_14001, Volvo trucks)

Typical fuel consumption in liters per 100Km				
Trucks type	Payload in tons	Total weight tons	Liter/100 km	Liter/100km full load
distribution traffic	8.5	14	20-25	25-30
regional traffic tuck	14	24	25-30	30-40
Tractor and semi-trailer , long-haul traffic	26	40	21-26	29-35
Truck with trailer ,long –Thaul	40	60	27-32	43-53

5. Municipal Solid Waste Generations in Pasir Gudang Johor Malaysia

Based on the Local authority in Majlis Perbandran Pasir Gudang (MPPG) Johor Malaysia solid waste generated was collected from seven areas before sending it to the landfill disposal in Tanjung langsat. According to statistics provided by the SWM in Pasir Gudang, the latest amount of waste loading at Tanjung Langsat Landfill for the year 2012 is about 350 ton/day or 350.000 kg /day. The percentage of compositions of solid waste weight was tabulated into nine categories as shown in Table 5 and Figure 1. Table 5 shows; Food waste has had the highest percentage with percentage of 50 %. The others wastes which have been reported as the lowest waste weight such as textile and other solid waste.

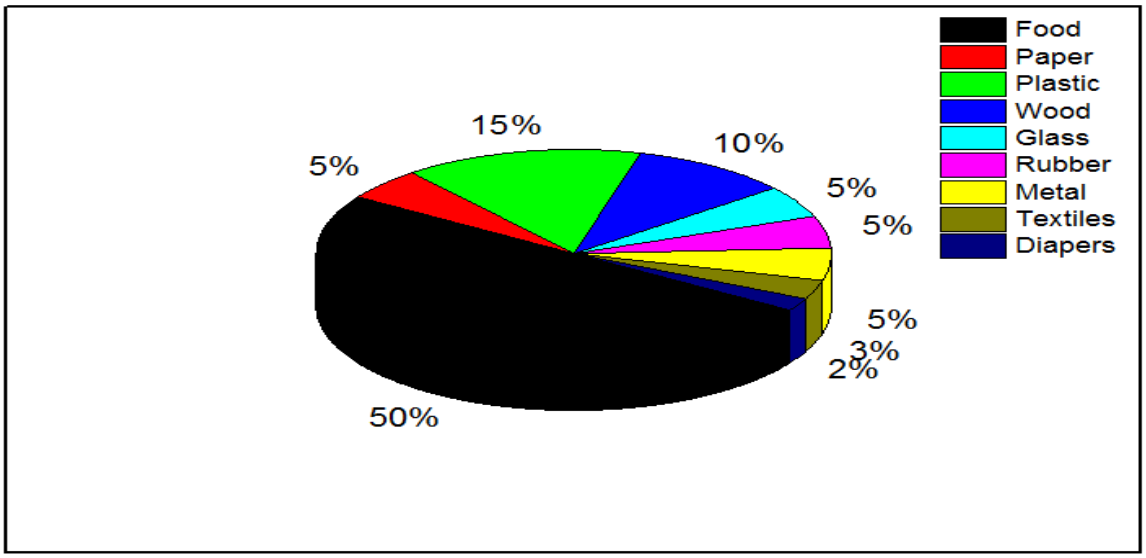

Figure 1: The weight percentage of solid waste compositions.

The food waste constitutes the highest percentage at 50 % while the plastic waste was 15%, the wood waste was 10 %, whereas all of the paper, glass, rubber and metal were 5%. The others wastes which has been reported as the lowest waste weight such as textile and other solid waste as shown in Figure 1.

The content analysis shows that for every 1 Kg of solid waste, it is made up of 0.7335Kg of organic waste and 0.2665 Kg of inorganic waste. Therefore, by applying this equation 1 to the data above, the amount of each type of waste from landfill can be identified and the actual amount of solid waste generated can be determined. As such, it is deduced as follows:

The amount of Organic waste (kg /day) = weight of organic waste per day × 0.7335 (solid waste made by kg of organic waste) ×amount loading of solid waste to landfill per day/kg (1)

The amount of inorganic waste (kg /day) = weight of inorganic waste per day × 0.2665 (solid waste made by kg of inorganic waste) × amount loading of solid waste to landfill per day/ kg (2)

The amount of waste generated in daily basis in Pasir Gudang Johor Malaysia as 240375 kg/day as shown in Table 6. This calculation is based on the total population mentioned above and the total amount of waste generated. Therefore, the total waste produced by each person in Pasir Gudang every day 1.13 kg/day.

Table 5: The different types of municipal solid waste composition loading to Tanjung Langsat landfill

Type of solid waste	Weight percentage (%)
Food waste	50
Paper	5
Plastic	15
Wood waste	10
Glass	5
Rubber and leather	5
Metal	5
Textiles	3
Others	2

Table 6: The daily waste generated of different types solid waste in Pasir Gudang

Type of wastes	Amount of wastes (Kg /day)
Organic waste	
Food waste	128,362
Paper products	12,836
Plastics	38,508
Wood waste	25,672
Rubber	12,836
Diapers	5,134
Textiles	7,701
Inorganic waste	
Glass	4,663
Metals	4,663
Total	**240,375**

5.1 *Waste disposed in Tanjung Langsat Landfill*

Waste disposal site (landfill) is situated in Tanjung Langsat Industrial Area with an overall area of 50 acres. The landfill receives 350 tons of domestic and industrial waste per day. Estimated industrial waste of 200 tons/day) is charged RM 45.00 per tons of waste dumped. The cost spent for maintenance of the landfill is RM 125, 000 per month (according to MPPG), which is RM 1,500,000 per year.

5.2 *The Solid Waste Estimation in Tanjung Langsat Landfill*

The estimation of solid waste in Tanjung landfill was obtained according to the composition of solid waste is obtained from the MPPG. The sorting of different type of solid waste was listed in Table 7. However, the variation of the quantity of different type of solid wastes sorted in Tanjung Langsat landfill during the survey period is shown in Figure 2.

Table 7: Estimation the different of solid waste sorted from the total solid waste composition

Days of operation	**Food waste%**	**Paper waste%**	**Plastic waste%**	**Wood waste%**	**Glass waste%**	**Rubber / lather%**
Monday	41	10	12	2	2	0.5
Tuesday	32	5.5	12	6	6	3
Wednesday	34	4	8	3	3	0.8
Thursday	24	5	17	0	2	1
Friday	33	4	15	0	1	1
Saturday	24	6	13	1	2	0.5
Days of operation	**Textiles waste%**	**Diapers waste%**	**Metal ferrous waste%**	**Fruit waste %**	**Textiles waste%**	**Diapers waste%**
Saturday	24	6	13	1	2	0.5
Monday	13	12	2	8	13	12
Tuesday	3	4	12	0.5	3	4
Wednesday	7	18	1	2	7	18
Thursday	4	11	0.5	18	4	11
Friday	5	11	1	8	5	11
Saturday	8	4	2	12	8	4

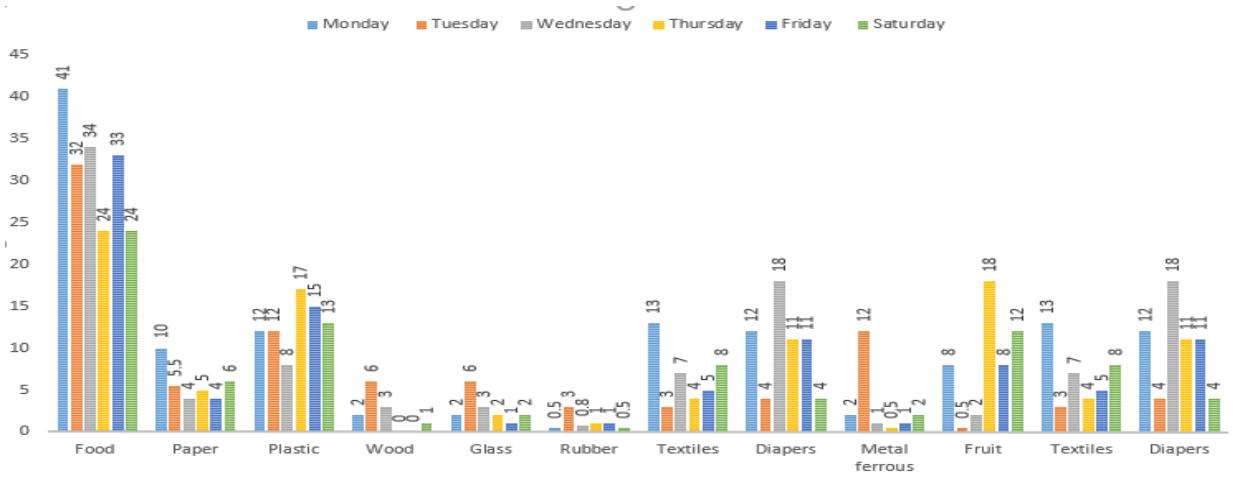

Fig. 2: The quantity of different types of waste categories during 1 week of solid waste monitoring in Tanjung langsat landfill

Figure 2 shows the highest food waste on Monday approximately 41%, which represented the main component in waste, due to the cumulative food waste from Sunday (Sunday was a holiday). By contrast, the lowest type of waste was on Saturday and Thursday. As well as, the season of duration harvest caused the increase of fruit waste so there was much fruit waste noticed during daily monitored. For each component, the figure shows the highest and the lowest composition of solid waste in one-week monitoring. The diaper was another important ingredient of domestic waste it was found to be of the large amount, on average, 12 % because the collected waste includes the hospital of Pasir Gudang and the babies care center. Another main component was the plastic and textile, which represented about 13% and 7 %. According to the result from sorting process, the amount of mixed paper that comes to this landfill was not much different during the monitoring period, with mean 6 % of total waste per day. This indicated that food waste, diapers, yard wastes followed by plastic were the largest fraction of domestic waste around Tanjung Langsat Landfill.

5.3 *The Cost of RORO Bins Purchase*

Rolled on Rolled off (RORO) is used to store the waste with range capacity of 6 to 8 cubic meters and weighed about 4 tons. According to MPPG there were 15 RORO bins in Pasir Gudang in different locations depending on space and service access condition. The price of purchase for each one was in RM 8,000 and the total expenditure for all in RM 120,000.

5.4 *The Drivers Expenditure*

According to the survey, there were thirty drivers in Tanjung langsat landfill working full time from the morning to 5 Pm. They have thirty trucks with different loading and engine capacity, Hicom trucks 2771 CC, Hicom trucks 4433 CC and Fuso 6557 CC .They have different type of salary depending on the time of employment. Table 8 presents the different type of salary for one month of the drivers in Tanjung Langsat landfill.

Table 8: Salary of the driver's expenditures on Tanjung longest landfill

Salary amount by RM	Frequency	Percent %	Cumulative Percent
1700	8	55%	30.0
1600	6	30 %	45.0
1800	16	15 %	100.0
Total	30	100 %	

The salary amounts are categorized into three categories as shown in Table 8. These categories adopted according to the time of service. However, there are varying salaries between the drivers. There are eight drivers with RM 1700 /month, six drivers with RM 1600 / month, and sixteen drivers with RM 1800 / month.

The maximum of driver salary were RM 1800, which represented 53 % of drivers whereas the minimum salary was RM 1600 month with percentage of 20 % of total drivers as shown in Figures 3. However, the analysis of the total cost of thirty drivers for one month as illustrated in Table 8.

Table 9 shows the total cost of drivers' salary was 52000/month. The cost of sixteen drivers was RM 28800/month represented 53% of the total cost. However, the cost of the second group (eight drivers with RM 1700) was RM 13,600/month and the cost of six drivers was 9600 RM. Therefore, the total cost of the driver salary every year is RM 624,000

The total cost of driver salary annually = Total salary of 30 driver's per month ×12

= RM 5,200 × 12 = RM 624,000/Year

Table 9: The Analysis of supervisor Salary Amount

Salary amount	Frequency	Percent	Valid Percent	Cumulative Percent
RM1700	2	20.0	20.0	20.0
RM1600	2	20.0	20.0	40.0
RM1800	4	40.0	40.0	80.0
Rm2000	2	20.0	20.0	100.0
Total	10	100.0	100.0	

5.5 *The Laborers Expenditure*

According to the survey conducted in MPPG, there were 200 workers as cleaners serving in various locations and with salary averaging RM1900 per month. This totaled the cost of R38, 000 per month and RM 4,560,000/year.

5.6 *The Supervisors Expenditure*

Ten supervisors were interviewed in the survey in Tanjung longest landfills that is they are responsible to for monitoring laborers and drivers inside and outside the landfill. According to the survey they have different salary depending on years of work. Table 10 illustrates the amount of supervisor's salary where two supervisors earn

RM 1700/month (20%), other two earn RM 1600 /month (20%) another set of two collect RM 2000/month with percent 20%. Finally, four supervisors has been reported with a salary of RM 1800/month (40%), see Table 10 & Figure 3.

Table 10: The total supervisor salary per month

Salary amount	Frequency	Salary cost of respondents
RM1700	2	RM 3,400
RM1600	2	RM 3,200
RM1800	4	RM 7,200
RM 2000	2	RM 4,000
Total	10	RM 17,800
Total cost annually	0	RM 213,600

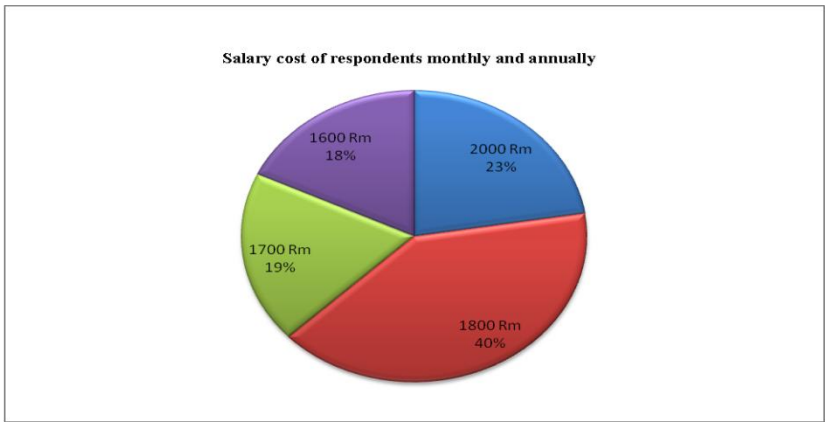

Figure 3: The total salary for supervisors monthly and annually

6. The Analysis of Transportation Costs

Fuel consumption estimated according to the quantity of fuel consumed per 100 km used by Hicom trucks with an engine capacity 2771 CC was 67% five liter , 10 % three liter and 7 % two liter. The second type of Hicom trucks with engine capacity 4433CC was 50% ten liters, 33% fifteen liter and 17% twenty. Whereas the percentage of fuel consumption used by Fuso trucks with engine capacity 6557 CC was 17% fifteen liter, 17% twenty liter and 67% 26 liter. Table 11 illustrates the average of fuel consumption for each truck depending on the engine capacity.

Table 11: The average of fuel consumption depending on the engine

Fuel consumption	Hicom truck engine capacity 2771CC	Hicom truck engine capacity 4433 CC	Fuso truck engine capacity 6557 CC
fuel consumption for trucks	7 L	13L	23L
Number of trucks	10	10	10
The total of fuel consumption/100 Km	67 L	133L	232L
The cost (RM) /100Km for each ten trucks	113	227	394

The analysis of fuel consumption for different trucks was obtained in one-way trip of each type of the trucks. The weekly cost of fuel consumption of Hicom small trucks with an engine capacity of 2771 CC was RM 53 and RM 1,271 per month as in Table 12. However, the Hicom trucks with an engine capacity of 4433CC consumed RM

121 per week and RM 2,900 per month as shown in Table 13. In addition, the cost of fuel consumed by Fuso trucks with an engine capacity 6557 CC was RM 220 per week and RM 5,270 per month as shown in Table 14. However, the total cost of fuel consumed annually by all different types of trucks was RM113284 as shown in Table 15.

Table 12: The different types of municipal solid waste composition loading to Tanjung Langsat landfill

Pick point to Tanjung Langsat	**Operational days/week**	**Frequency**	**Distance by KM**	**Engine capacity**	**Fuel Per 100 KM**	**Fuel per KM**	**Transfer cost/RM**
Kota Masai2	6	2	10.9 Km	6557CC	23.17	2.52	51
Pasir Putih	6	1	7.7 Km	6557CC	23.17	1.78	18
Nusa Damai	6	1	9.8Km	6557CC	23.17	2.27	23
Taman Sciente	6	2	10.2 Km	6557CC	23.17	2.36	48
Total cost per week							**RM 220**
Total cost per month							**RM2,900**

Table13: Analysis of the cost transferring of solid waste by using Hicom medium truck from different location to Lanjung langsat landfill weekly and monthly.

Pick point to Tanjung Langsat	**Operational days/week**	**Frequency**	**Distance by KM**	**Engine capacity**	**Fuel Per 100 Km**	**Fuel per KM**	**Transfer cost/RM**
Taman Mawar	6	3	5.8km	2771cc	6.67	0.33	10
Bukit Dahlia	6	1	7.8km	2771cc	6.67	0.47	5
Kota Masai 1	6	1	9.9 km	2771cc	6.67	0.66	6
Kota Masai 2	6	1	10.9km	2771cc	6.67	0.72	7
Pasir Putih	6	2	7.7km	2771cc	6.67	0.51	10
Nusa Damai	6	1	9.8km	2771cc	6.67	0.65	7
Taman Scientex	6	1	10.2 km	2771cc	6.67	0.68	7
Total cost per week							**53**
Total cost per month							**RM1,271**

$$\text{X Liter Consumed Per Km} = \frac{\text{Distance of travel by KM} \times \text{Fuel consumption per 100 KM}}{100} \quad (3)$$

According to the analysis in table 12, it was clear the cost of fuel consumed, used by Hicom small trucks with an engine capacity of 2771 CC was RM53 RM/ per week and RM 1271Per month.
The calculation was conducted by using the formula: below:

I. The cost of fuel consumption per week = amount of fuel consumption per km (actual distance) × Turks frequency × the price of one-liter diesel × 6 days
II. The cost of fuel consumption = amount of fuel consumption per km (actual distance) × Trucks frequency × the price of one-liter diesel.

The total cost of fuel consumed annually by all different types of trucks was Rm113, 284 as shown in table 15 and Figure 4.

Table14: The cost of transferring solid waste using Fuso big truck from different location to Lanjung langsat

Pick point to Tanjung Langsat	Operational days/week	Frequency	Distance by KM	Engine capacity	Fuel Per 100 KM	Fuel per KM	Transfer cost/RM
Taman Mawar	6	1	5.8km	4433 CC	13.33	0.77	8
Bukit Dahlia	6	1	7.8km	4433 CC	13.33	1	10
Kota Masai 1	6	1	9.9 km	4433 CC	13.33	1.31	13
Kota Masai 2	6	1	10.9km	4433 CC	13.33	1.45	15
Pasir Putih	6	2	7.7km	4433 CC	13.33	1	20
Nusa Damai	6	2	9.8km	4433 CC	13.33	1.30	27
Taman Scientex	6	2	10.2 km	4433 CC	13.33	1.36	28
Total cost per week							**RM121**
Total cost per month							**RM 2,900**

Table 15: The total cost of trucks fuel consumed per year

Type of trucks	The annual cost RM
Hicom Engine capacity 2771CC	15,244
Hicom Engine capacity 4332 CC	34,796
Fuso Engine capacity 6557 CC	63,244
Total cost	113,284

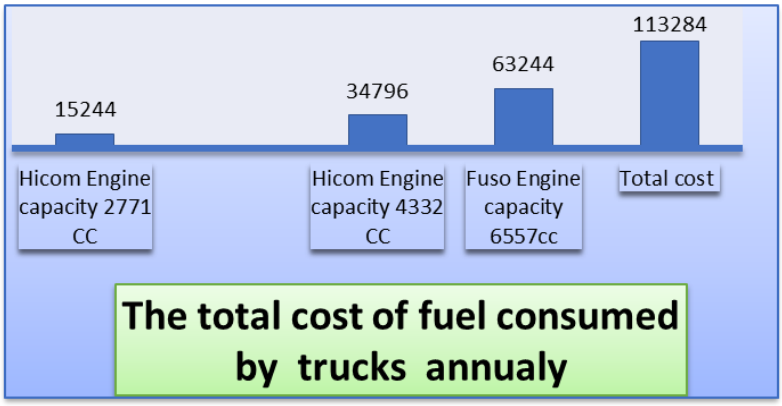

Figure 4: The total cost of fuel consumed annually for all trucks

Figure 4, represented the total cost of fuel consumed per year used ten Hicom trucks with engine capacity 2771 CC, which was equaled RM 152, 243. Whereas the ten Hicom trucks with engine, capacity 4332 CC is equal to RM34, 796 per year. In addition to the fuel consumed by ten Fuso trucks with engine capacity 6557CC is RM 63,244 per year. Therefore the total cost of fuel has been consumed using 30 trucks was RM113, 284 per year.

7. The Current Model Practice of Waste Disposal in MPPG in Pasir Gudang Municipal Council

The current municipal solid waste management in Pasir Gudang involved expenditure on RORO bins and trucks, salaries of drivers, supervisors and, the fuel consumed by all trucks per year. The cost of landfill maintenance has been involved with current expenditures in Pasir Gudang municipality. Table 16 illustrates the total expenditure of the current practice of waste disposal in Pasir Gudang municipal council.

Table 16: Illustrates the total expenditure of the current practice of waste disposal in Pasir Gudang municipal council

Cost Of the current practice	**The total cost per year by RM**
The spent of RORO (bins)	RM 120,0000
Laborers	RM 4,560,000
Drivers	RM 624,000
Supervisors	RM213,600
Fuel consumption	RM113,284
Landfill maintenance	RM 1500,000
Total cost	RM 7,130,884

7.1 *RORO Bins*
The cost spent on purchasing RORO bins was RM 120,000, whereas the cost spent as salary for the laborers per year is RM 4560,000, as shown in Table 16.
7.2 *Trucks*
The cost spent for truck drivers per year is RM 624000 while the cost spent for supervisor per year is Rm213, 600. As well as the cost of fuel, consumption per year is Rm113, 284, Table 16 illustrates the amount of trucks drivers spent per year.

7.3 *Maintaining the Landfill*
According to MPPG, the cost spent for maintenance the landfill per month was RM 125,000 and totally per year RM1, 500,000, Table 16 shows the cost of landfill maintenance annually.

8. The Proposed Model to Minimize the Cost expended on MPPG waste disposal

The suggested model involves reusing and recycling some portion of solid waste in Pasir Gudang area, aimed at minimizing the waste thus supporting MPPG budget. Because of recycling and reusing, some portion of solid waste was totally minimized and the expensive cost of trucks cuts down through reducing the numbers of trucks, the fuel consumed, drivers, and supervisors' salaries cut down.

8.1. *Suggestions for Reusing and Recycling Some Portions of the Waste*
Reuse and recycling of portions of solid waste are recent advanced methods to reduce the cost of solid waste management. In such approach, the use of different bins to sort the waste depending on the waste type is the first strategy to reduce the cost of separating waste. This is by using four bins, each for plastics, paper, metals and organic waste (food, fruit) respectively. Metals and coins should be categorized as other wastes which can be recycled to reduce the waste in order to prolong the landfill life span. The waste metals and cans have been indicated to reduce the cost of transportation and support the budget of solid waste management in Pasir Gudang.

Table 17: Illustrates the solid waste generation by kg per day n Pasir Gudang

Name the type of waste	**Waste by kg per day**	**Percentage %**
Glass	4663	5
Plastics	38508	15
Metals	4663	5
Papers	12836	5

Reusing some

portion of papers, plastics have many benefits such as reduced the waste, reduced the cost of waste transportation with the advantage of cleaning the environment. The wastes, which were sorted or separated at the source by the respondent is to be reused or recycled, hence reduced the numbers of RORO bins, the number of trucks, drivers, and supervisors costs. Therefore, less waste means less RORO bins and less cost, fewer trucks (less fuel consumed), less drivers, supervisor's salary, and less landfill maintenance.

Table 17 show the glass daily waste generated in Pasir Gudang of 4664 kg /day or 4.664 tons /day and, contained 5% of the total waste generated per day. However, the other type of solid waste generated by kg/ day and the price of recycling for each10 kg was illustrated in Table 18 "The price of recycling some type of solid waste for each 10 kg obtained from the personal survey from MPPG. The benefit of recycling solid waste is showing in Figure 5.

$$\text{The realized cost of recyclable} = \frac{\text{The cost per unit} \times \text{the waste generation per kg}}{10} \quad (4)$$

Table 18: The price of recycling some solid waste categories for each 10 kg

Name of waste categories	Waste by kg per day	Cost per unit for each 10 kg	The realized cost recyclable
Glass	4663	RM 0.55	RM 257
Plastics	38508	RM 0.50	RM 1,925
Metals	4663	RM 1.20	RM599
Papers	12836	RM 0.40	RM3,294
The total cost realized some portion of solid waste per day			RM 3,294

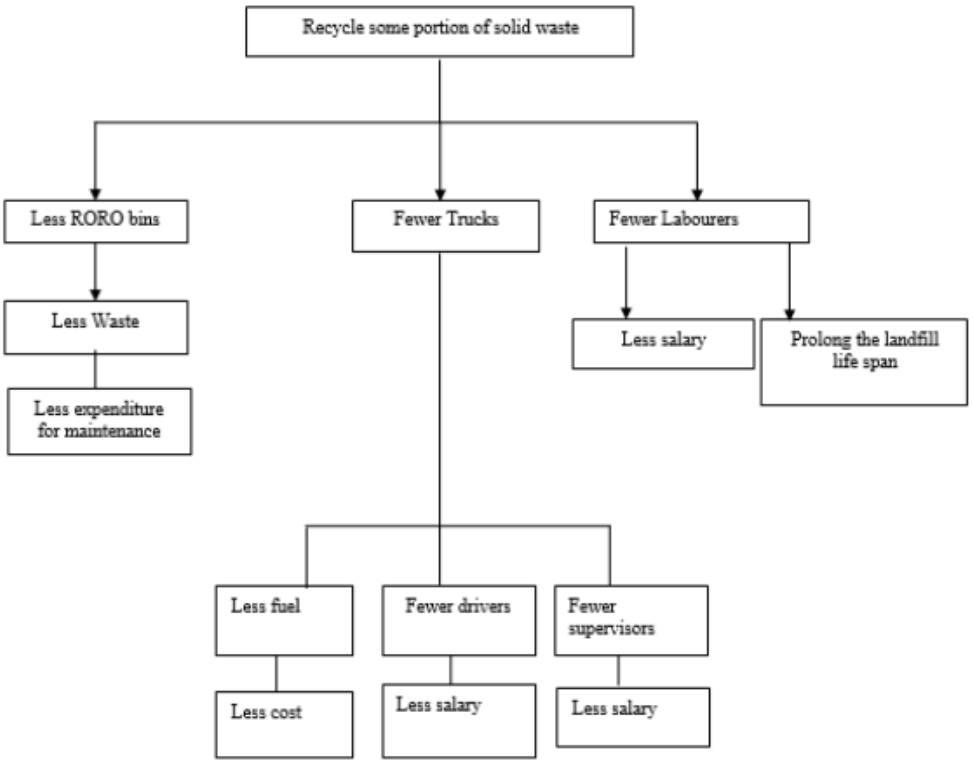

Figure 5: Illustrate the benefits of recycling to reduce the cost of solid waste

The calculation and analysis in Figure 6 shows the cost of solid waste management which reduced by recycling and reusing some portion of solid waste. According to the survey, there were 200 labourers, 30 drivers, 10 supervisors and 30 trucks transferring 350-tons waste to the landfill per day. Besides the cost of maintenance, the landfill was RM 125,000 (MPPG) per month, which is RM 1,500,000 per year reduced to RM 1260,000 per year. Table 18, illustrates the realized cost of recycling some portion of solid (RM3294) per day to recycle 56 tons per day. However, the cost of maintenance of 350 tons per day is RM4166. Therefore, the cost of maintenance of 56 tons (recycled) has been reduced to RM240, 000 per year. In addition, the number of trucks used to transfer waste was 30 trucks per day. The number has reduced to 5 trucks, (1 Fuso 6557 CC, 2 Hicom 4332 CC, 2 Hicom 2771), by the use of the current model. The numbers of the Hicom truck with engine capacity 2771 CC has also reduced to, 2. Hicom trucks with engine capacity 4332 CC is also 2 and 1 truck Fuso with engine capacity 6557 CC the fuel consumption per year illustrated in Table 19 for all trucks before and after minimizing. The cost of fuel consumed without using 5 (recycle and reuse some portion of solid waste has reduced the amount of waste, so the number of used trucks is reduced) trucks was reduced RM 26119 per year and the drivers salary reduced to RM 100,800. The numbers of supervisors has been minimized was 2 and the reduced cost is RM 39600 per year. However, the total cost of solid waste management that was minimized was RM1037, 011 per year and the total cost after optimized model has reduced from RM 7130,884 to RM 6,093,872 per year Table `19 illustrates the total cost before and after minimizing.

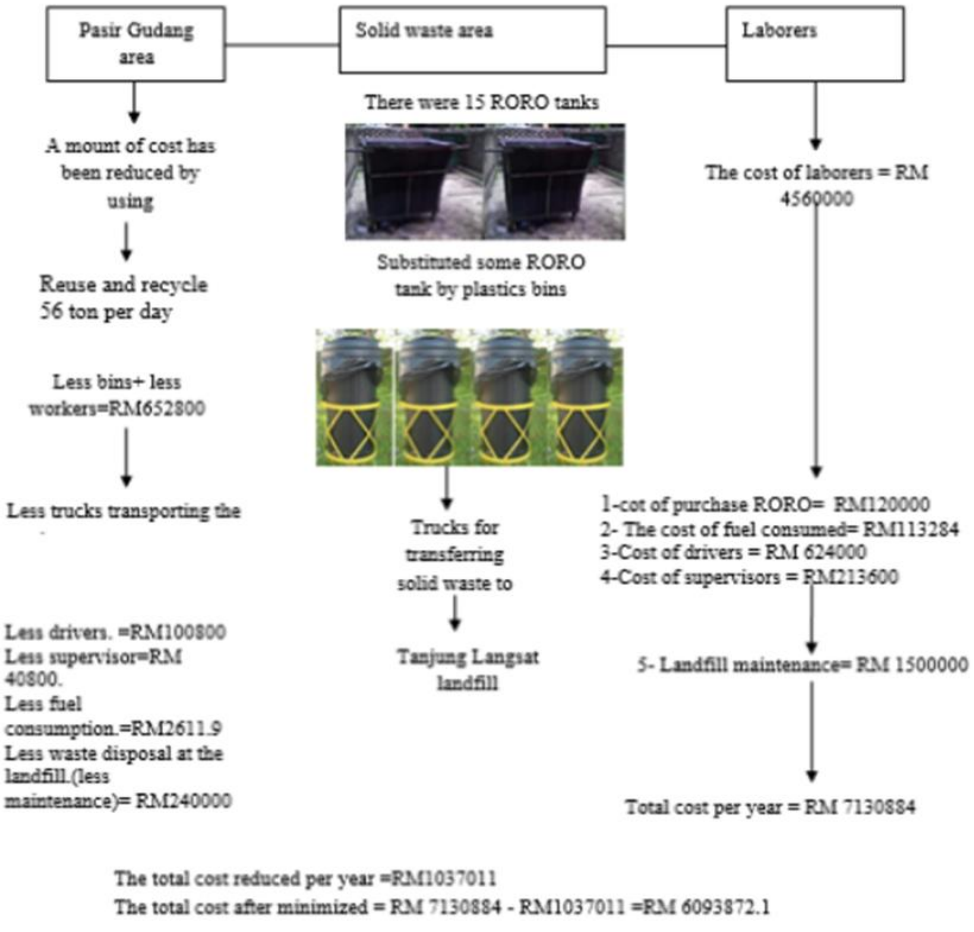

Figure 6: The total cost has been reduced using recycle and reuse some portion of solid waste

Table 19: The total cost of expenditure before and after minimizing

Expenditure on	The cost per year before minimizing	The cost per year after minimizing	Percentage Minimized expendtures%
Drivers	RM624,000	RM523,200	16
laborers	RM4,560,000	RM3,907,200	14.3
Landfill maintenance	RM1,500,000	RM1,260,000	16
Fuel consumed	RM113,284	RM 110,672	36
Total expenditure	RM 7,130,884	RM 6,093,872	14.54

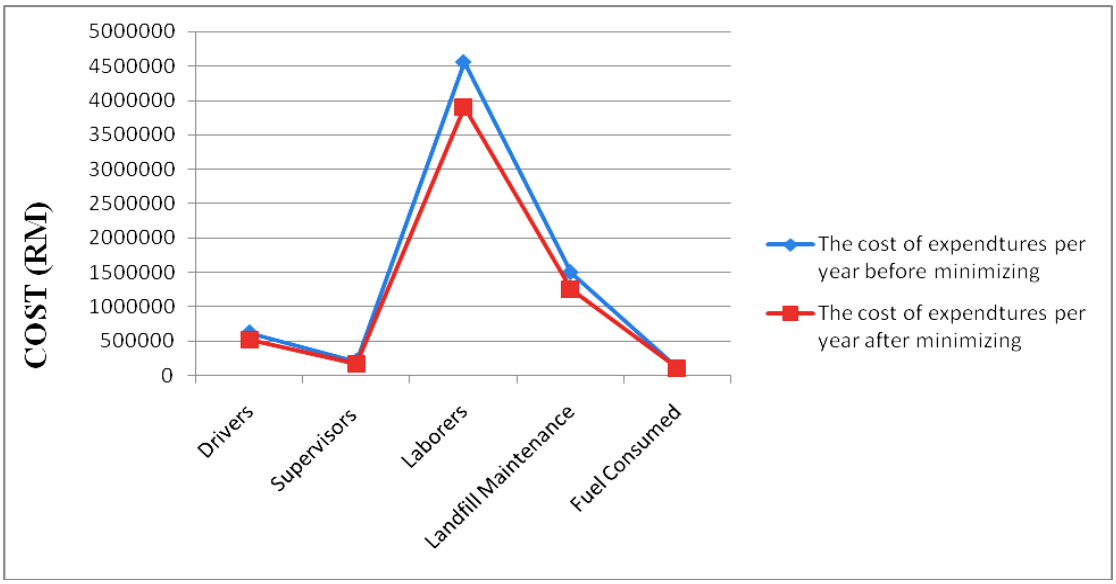

Figure 7: Illustrating the expenditure on Pasir Gudang solid waste before and after minimization

The current expenditure (in blue) of managing solid waste in Pasir Gudang municipality against the cost expenditure minimization (in red) using the proposed model was compared. The proposed model indicated a cut in expenditure by 14.54 % that is from RM 7,1308,84 to RM 6,093,872 per year as shown in Figure 7.

Conclusions

Result of this study reveals that Pasir Gudang has a population of 211,900 people in the year 2010 and generated 24,037,925kg waste per day on the average at 240-350 tons at maximum. The total waste generated per capita is 1.13 kg/day. The solid waste is reported to have been composed of 15% plastic, 10% wood ,5%, glass, rubber, paper and metal each, 3% textile, 2% others and the rest 50% organic waste . There are currently 15 RORO bins with different capacity and at different locations. The cost of the purchase of these bins amounts was RM120, 000 .There are two hundred laborers and employees to load and upload the bins into trucks at the cost of RM 4,560,000 per year. There are 30 trucks altogether for the transportation of the waste to Tanjung Langsat landfill at the cost of RM 113,284 per year and RM 624,000 for drivers salary. Tanjung langsat landfill is currently maintained at the cost of RM 1,500,000 per year. The cost of paying 10 supervisors salary is also reported to be RM213, 600 per year. The total expenditure for managing waste in the municipal council is RM 7,130,884.00 per year. Applying our model, the following cost of expenditure was cut down as follows:

Separation at source were proposed which resulted in less waste, less workers, hence the wages and salaries were reduced from RM4,560,000 to RM 3,907,200 per year. This led to less truck with few drivers. The five drivers' salaries were reduced from RM624000 to RM 523,200 per year. Finally, landfill maintenance cost also reduced

from RM1, 500,000 to RM 1,260,000 per year. Therefore, using the proposed model, the total cost saved as a result of the proposed solid waste management model in Pasir Gudang municipal council is RM 1,037,011.90 per year.

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