


Municipal Solid Waste - Management Cost and Opportunities

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INTRODUCTION

Waste, regardless of its kind (either in solid or liquid form) is produced since the dawn of human existence and it is not excessive to say, waste was the first thing generated before people were able to contribute to the betterment of life styles. Indifferent to the various definitions, the problems regarding the disposal and management of waste have never been out of the issues of open discussion. This controversial subject has become more severe when the growth of waste has reached its critical condition due to the increasing demands on the consumption of natural resources and raw materials in the creation of products to enrich people's lives [1,2]. Due to the continual increase of waste generation and its ever-changing composition, people are constantly exposed to all kinds of risks in their daily lives, such as underground water pollution, methane gas emission, opening of new landfill sites, air pollution and many other hazardous problems affecting human health. Unfortunately as society becomes more advanced, simple expedient solutions are no longer sufficient to solve the ever-growing disposal problems. The solution for these problems is the continual improvement towards an Integrated Waste Management (IWM) system, which includes the reclamation of useful material.

These recovery possibilities open a new era in converting waste to wealth. This would call for waste to be recycled and then converted to energy and finally reduce the dependency of landfills. Further, as energy cost rises, landfills become more difficult and costly to obtain suitable sites. Also more stringent regulations make landfill disposal more expensive. The popularity of resource recovery is certain to grow, in line with the growth rate in generation of waste.

WASTE GENERATION AND MANAGEMENT COST

Municipal Solid Waste (MSW) could be considered to be produced in proportion with the economic productivity and the consumption rate of the population of the countries resources. Countries with higher incomes produce more waste per capita and per employee, and their waste generally contains more packaging materials and recyclable items.

Table 1: Respective Management Costs [3]

	Units	Low Income	Middle Income	High Income
Mixed Urban Waste – Large City	kg / cap / day	0.50 to 0.75	0.55 to 1.10	0.75 to 2.20
Mixed Urban Waste – Medium City	kg / cap / day	0.35 to 0.65	0.45 to 0.75	0.65 to 1.50
Residential Waste Only	kg / cap / day	0.25 to 0.45	0.35 to 0.65	0.55 to 1.00
Average Income from GNP	USD / cap / yr	370	2,400	22,000
Collection Cost	USD / ton	10 to 30	30 to 70	70 to 120
Transfer Cost	USD / ton	3 to 8	5 to 15	15 to 20
Open Dumping Cost	USD / ton	0.5 to 2	1 to 3	5 to 10
Sanitary Landfill Cost	USD / ton	3 to 10	8 to 15	20 to 50
Tidal Land Reclamation Cost	USD / ton	3 to 15	10 to 40	30 to 100
Composting Cost	USD / ton	5 to 20	10 to 40	20 to 60
Incineration Cost	USD / ton	40 to 60	30 to 80	70 to 100
Total cost without Transfer	USD / ton	13 to 40	38 to 85	90 to 170
Total cost with Transfer	USD / ton	17 to 48	43 to 100	105 to 190
Cost as % of Income	%	0.7 to 2.6	0.5 to 1.3	0.2 to 0.5

** Income base on 1992 Gross National product data from the World Development Report, 1994*

In low-income countries, the commercial and industrial activity is limited; thus recycling activities are limited. Table 1 illustrates the generation rates with respect to the economic level and the management cost. It gives a good picture of the management cost that is involved in the different types of countries. However, managing the MSW generated has more significant impact on the environment. In most low–income countries, land availability, due to lack of economic value, makes it easier to operate open dumps as compared to developed countries where land cost is too high due to economic and residential demands and calls for more sophisticated management methods such as incineration, refuse derived fuel, composting, material recovery facilities and others. At the same time, the generation rate with the related disposal cost alone does not reflect the MSW management conditions in most countries. Many other factors, such as land availability, public opinion, political, economical and legal conditions too do govern over the decision made to tackle the MSW management problems in a country.

When waste generation is generally considered, many reflect on the quantity of the waste that is generated, forgetting the quality of the waste that is to be disposed off. Table 2 reflects some of the generation rates, the country's income and the composition of the MSW generated. Indications from Table 2 show that in the lower–income countries generation rates are lower. At the same time, the recyclable items such as plastics, paper and glass are low as compared to the higher income nations. This goes to show that the socio economic status of a country has adverse effect on the generation rates and also the recycling rates, not to mention the fact that the population does not get to enjoy the product of the modern world such as excessive packaging.

As for Malaysia, the capital city of Kuala Lumpur is usually the center of attention for waste management problems due to the congestion and over production of MSW. It was reported that on average, the daily collection is about 18,000 to 25,000 tons [6,7]. The average composition as shown on Figure 1 is that the organic content is around 40% with another 20% being inorganic. This high organic content translates to high moisture content of about 55% to 60%

Table 2: Socio-economic data, generation rates and major waste components in some countries [4,5]

City	Country	Socio-economic factors						Municipal Waste MW	Major waste components (% by weight)				
		W	T	PD	P/DW	GNP	POP		Paper	Plastic	Food	Metal	Glass
High Income													
New York	USA	1000	15	450	4.2	12 800	9.12	720	35	10	22	13	
Sydney	Australia	620	25	30	4.2	4 100	3.23	690	38	0.1	13	11	18
Tokyo	Japan	700	15	40 694	7.0	4 910	11.60	400	38	11	23	4	7
Paris	France	1250	10	4 000	2.5	18 400	2.18	590	30	1	30	4	4
Rome	Italy	580	14	700	4.9	7 000	2.88	460	18	4	50	3	4
Medium Income													
Madrid	Spain	410	14	290	4.2	5 000	3.19	390	21	-	45	3	4
Singapore	Singapore	440	29	26 427	3.9	4 000	2.44	-	43	6	5	3	1
Manila	Philipines	64	27	983	5.0	807	1.63	-	17	4	43	2	5
Taipei	Taiwan	220	22	1 250	4.2	-	2.50	-	8	2	25	1	3
Kano	Nigeria	70	30	200	4.5	2 000	1.00	-	17	4	43	5	2
Low Income													
Banglore	India	50	24	1 300	7.0	320	2.91	-	3	0.5	65	0.4	0.2
Dacca	Bangladesh	25	26	3 750	6.0	200	1.31	-	2	1	40	1	9
Karachi	Pakistan	340	29	1 300	5.5	1 890	5.10	-	0.5	0.5	56	0.5	0.5
Jakarta	Indonesia	45	24	700	8.0	474	6.50	-	2	3	82	4	0.5
Rangoon	Burma	32	26	200	6.0	120	2.60	-	1	4	80	3	6

W = monthly wages in US$ T = annual average temperature, ˚C POP = total population in millions PD = population density, persons/km² P/DW = persons/dwelling GNP = gross national product, US$ MW = kg/capital/yr

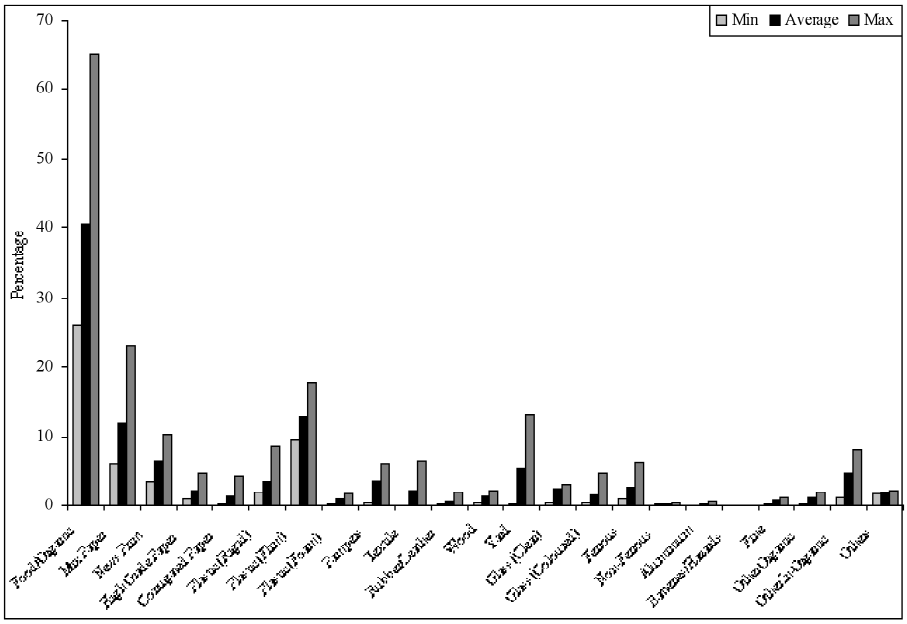

Figure 1: Composition of MSW generated in Kuala Lumpur [6,7]

and a low calorific value waste. However, the amount of plastic waste is around 25%, and the paper is about 15%. Malaysia is a country which is blessed with a tropical climate with a multi–racial community, which has an adverse effect on the quantity and quality of MSW that is generated. There might be some similarities in the generation and composition data as compared to Table 2. However, the causes for the similarities or the differences could not be put forward as there is a great deficiency in proving these arguments. Nevertheless, among the possible causes could be due to the change in lifestyle, increased or lowered income, difference in sampling method and so on.

WASTE MANAGEMENT TRENDS

To many residents in the world, generation of waste is considered a part of life which cannot be changed, but to some, the generation of waste is something that will eventually affect them if not managed properly. Having all the best waste management options available is good but a reflection of the current generation rates and the disposal methods is necessary in order to avoid overspending. This brings in the concept of BATNEEC (Best Available Technology, Not Entailing Excessive Cost) where the technology is suited to the problems and the situation in the country. However, there are some countries or rather counties / states that do not process their waste in their own state, but bring about the NIMBY (Not In My Back Yard) syndrome, which will entail excessive cost in just transporting the waste across the border [8].

As for Malaysia, until the year 2000, land filling of the waste generated has been the main option. However, the 120 odd landfills and open dumps scattered all over

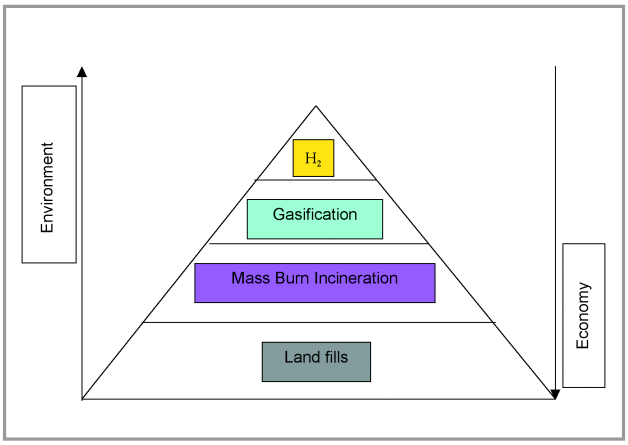

Figure 2: Waste management hierarchy [8]

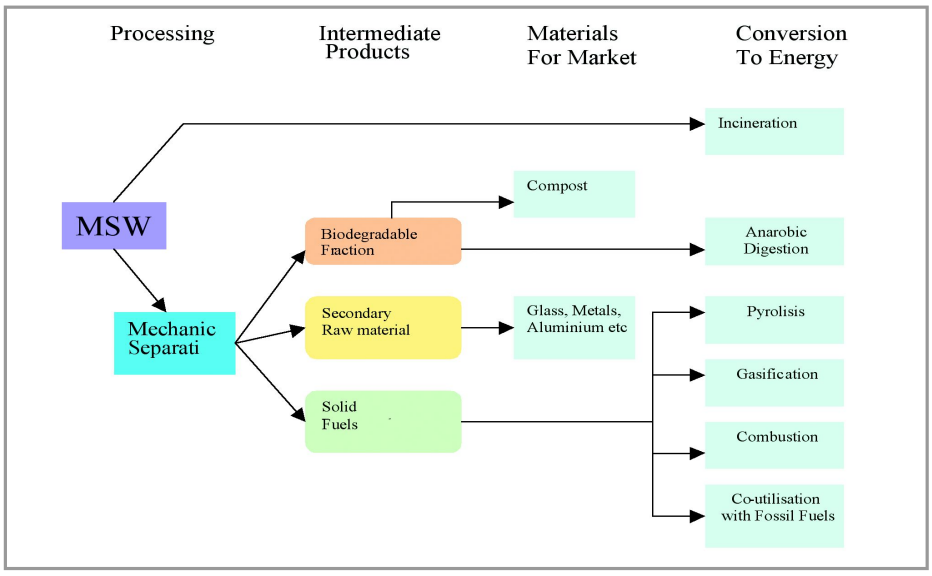

Figure 3: Pathways of processing of municipal solid waste [14]

the country are at a critical level of either at the end or beyond its lifespan. At the same time, Malaysia enjoys a high development rate and combined with the strict environmental regulations enforced, land for dumping of waste is scarce. Over the last 5 years, the management trends in major towns have changed from land filling to putting great pressure to recycle, recover and reuse. Kuala Lumpur has closed two landfills and has one landfill and has one transfer station and a Refuse Derived Fuel plant and Incineration plant in the pipeline. The same could be said about Penang and Johor Bahru. However, the management style in the lesser-populated states is still dependent on landfills. As for the central government, efforts are in the pipeline for the tabling of a national waste bill that will empower the local authorities to provide better management and allow for privatisation of the collection and disposal of the MSW. A master plan for the nation on wastes management policies and strategies has been prepared and earmarked for implementation by 2020 [8].

No matter what is the income or condition of the country, the environment needs protection. As such recycling and reuse is something that is essential in the current conditions. The general management concept in waste management can be described in Figure 2. Although the environment would prefer that the waste be converted to hydrogen fuel, the technology is scarce and still very expensive as indicated in Figure 2. Hence, striking a balance between recycling and the recovery of energy through incineration or composting for the production of gasses for combustion is preferred.

MANAGEMENT AND ENERGY CONVERSION OPPORTUNITIES

From the previous arguments, it is evident that the concept of recycle, reuse and recover is essential in minimising the amount of environmental damage that could have been done if the waste is disposed off indiscriminately. However, management of waste requires considerable funds and many countries do not have the economic resources for high technology management. On the other hand private companies are looking at the government for capital expenditure to reduce the financial burden on the company. Hence, the financial model becomes an important tool in making the final decision on the management method.

At this point, the concept of waste to wealth becomes apparent. The need to recovery maximum profits from the management method employed while ensuring environmental sustainability is the main objective. Figure 3 shows the pathways that are available right from the processing of the MSW to the final conversion. It is obvious that at every level of processing, there is money to be made if processed in a proper manner. Current technologies allow for even the inert ash material from the incinerators to be recycled into road pavement or for the manufacturing of tiles. This would not only save resources but allow for the extension of landfill lifespan while ensuring almost zero waste to the landfill.

In Malaysia, as mentioned earlier, the major cities have changed from land filling to incineration and even to Refuse Derived Fuel. The ideal about RDF production is that the plant allows for material recovery, which is an income to the plant, and then the organics are shred and either converted to RDF or fed into compost machines to generate biogases which instead are fed to a fuel cell to create Hydrogen fuel. This would allow for maximising the returns and it has been proven that by employing the recycling and conversion to RDF with power generation, the operation cost of the plant is almost equivalent to the operation cost of a landfill in Malaysia, estimated at about RM30 to RM 35. The amount of power that could be extracted

Table 3: Amount of Energy Recoverable from MSW by Various Treatment Technologies [15]

Material	Treatment Technology	Conversion Efficiency	Calorific Value of Fuel	Energy Recoverable / ton of Fuel	Total Energy Recovered (based on 1500 tons / day	Recoverable (Normalized to per ton of MSW Input)
MSW	Incineration	WTE - 25 %	2200 kcal / kg	639 kW.hr	960 MW.hr	639 kW.hr
MSW	Incineration	WTE - 25 %	1500 kcal / kg	436 kW.hr	655 MW.hr	436 kW.hr
MSW	Incineration	WTE - 25 %	800 kcal / kg	233 kW.hr	350 MW.hr	233 kWhr
RDF	Incineration	MSW to RDF - 30%, WTE - 25%	3500 kcal / kg	1017 Kw.hr	458 MW.hr	305 kW.hr
MSW	Anaerobic Digestion,	MSW to Digester – 60%, Biogas to energy – 25%	5000 kcal / m3	218 kW.hr	196 MW.hr	131 kW.hr
MSW	Anaerobic Digestion,	MSW to Digester – 60%, Biogas to energy with steam recovery – 80%	5000 kcal / m3	697 kW.hr	627 MW.hr	418 kW.hr
MSW	Anaerobic Digestion and Fuel Cell	MSW to Digester – 60%, Biogas to energy by Fuel Cell – 50%	241.83 kJ / mol H	585 kW.hr	526 MW.hr	351 kW.hr

form the various treatment technologies are shown on Table 3.

Apart from just waste treatment, landfill mining and recovery of material from closed landfills are another option. Most countries evolve from open dumps that receive all kinds of waste to sanitary landfills, which receive waste that has been recycled, thermally treated, and the inert only end up in landfills. By locating a material recovery facility or a RDF plant on a closed landfill or open dump, the plant could operate to recover some of the material that has been buried as fuel. On the other hand open dumps that have been closed could also be harvested for the landfill gasses that are emitted to be converted into electricity. This not only saves the environment but also generates electricity. Over a period of time, these landfills could also be converted into orchards, golf courses or even residential areas in years to come. The opportunity for this is enormous and waiting to be taken.

CONCLUSION

Waste generated and managed in a proper manner is essentially good for the environment. However, with the advancement of technology and in the pursuit for a modern and more comfortable lifestyle, many of the countries are endangering the environment to the point of no return. It has already been established that in some countries, the background level of dioxin in the air is higher than the allowable limit of 1 pica gram/Nm^3. The levels of greenhouse gasses have escalated to such high levels that global warming is being blamed solely on these gasses. Landfills emit these gasses throughout the world, which also add to the global warming.

Well instead of treating the waste produced, we should be thinking of not producing waste in the first place. This would take a long time to achieve but some actions need to be put in place to stop excessive manufacturing in the name of a comfortable lifestyle, while the same people are advocating that the world cannot take the burden that the population is inflicting on it. ■

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