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Managing Solid Wastes in Kandy City: A Cost Effectiveness Analysis

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ABSTRACT. Managing solid waste is one of the major problems in urban cities in developing countries. This paper evaluates the costs of managing solid waste in the Kandy municipal area using different alternatives. Solid waste can be disposed of with or without separating into wet and dry components. When it is disposed of without separation, direct dumping, sanitary land filling, or incineration can be carried out. When it is separated, dry component can be disposed of by direct dumping, incineration or by recycling and the wet component can be utilized to produce compost or bio-gas and bio-fertilizer. Cost effective analysis was conducted to evaluate the cost of different methods as suggested above using secondary data. Findings reveal that the least cost method is to produce compost from the wet part and to recycle the dry part.

INTRODUCTION

Background

Managing solid waste is one of the major problems in larger cities in developing countries. The rampant practice in disposing waste is open dumping in most of the developing countries including Sri Lanka. When solid waste is disposed in open dumps without any environmental safeguards, the leachate from these dumps can pollute surface and ground water. Water contamination is a serious problem, particularly since many households rely on these for their daily drinking and cooking requirements. In addition, these dump-sites could become common breeding grounds for flies, mosquitoes, rodents *etc.* They could become vectors of certain diseases leading to health hazards such as malaria and dengue fever. Apart from open dumping, disposal of waste typically consists of dumping in near by marshes and wetlands. Filling in wetlands worsens the flooding that occurs during heavy rains at monsoon periods. Such flooding disrupts sewer and waste water systems and impact on the sanitary condition of the residents around marshy areas. Consequently, dumping sites have very high economic and social cost to the public health services and have not yet been estimated by the government.

Aesthetic implications are another aspect of proper solid waste management when tourism is one of the main economic activities in a country. When waste is disposed at open dumps malodours and litter carried by wind could degrade the environment. Therefore, the main task of the local authorities in solid waste management should be safe, reliable and cost effective removal and disposal of the solid waste.

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Developed countries can afford cleaner technologies, for example incineration of solid waste. However land filling is known to be the common alternative adopted by developing countries in management of solid waste. Making compost, bio-gas, bio-fertilizer, and recycling are the other possible alternatives that can be used with a lower cost. A quantitative analysis has not been conducted so far in Sri Lanka to show the costs of alternative methods, even though a number of methods have been proposed. The objective of this paper is to propose a cost-effective alternative to manage solid waste in the Kandy municipal area in Sri Lanka.

The paper is organized as follows. The following section provides an insight to the experience in solid waste management in Sri Lanka. The next section is based on current solid waste management practice in Kandy. The following section discusses the alternative methods to manage solid waste. Method of analysis and data are presented next. Finally results and conclusions are presented.

Experience in solid waste management in Sri Lanka

Waste generation rate within the island of Sri Lanka is found to be around 2700 tons per day (Ministry of Forestry and Environment, 1999a). Around 54% of waste is found to be generated within the Western Province and a larger portion of that is from Colombo district. Apart from Colombo, the districts of Gampaha and Kandy show a comparatively higher amount in generation of waste (Ministry of Forestry and Environment, 1999b).

Most of the Municipal and Urban Councils where large quantities of waste is generated and appropriate disposal options are scarce, are faced with the challenge of managing their wastes. Though these local authorities have capacity to provide adequate collection of the waste, there is a significant problem with the disposal. Due to the current incidence of health disasters like dengue, a social unrest has developed towards waste disposal sites. Therefore, which is the usual open dumping rampant practice adopted by the local authorities in Sri Lanka, has become no more practicable. As an answer to the prevailing situation some of the Municipal and Urban councils have now turned towards alternative disposal methods (Allen, 2000). A waste in developing countries such as Sri Lanka contains as much as 70-80% of vegetable putrescible matter and as organic matter typically accounts for more than 80% of the waste stream, they have realized that composting offers a potential solution for the problem. Also, the recycling of the recyclable matter could follow the practice of composting.

Attempts were made by a few local authorities to manage solid wastes successfully. Horana, Rathnapura, Balangoda, Katana, Piliyandala and Maharagama are some examples. The waste generated within the Horana Divisional Council area was collected and directed for composting at *Saru Pohora* centre. Recycling follows the process of composting. Polythene, metal, paper and glass are the recyclable matters which are sold for recycling. Buyers come to the *Saru Pohora* centre and buy the recyclable matter. The buying price of the recyclable matter varies with the quality of the matter. The centre incurs a cost of around Rs. 8/- per kg of compost in producing compost and they are willing to buy waste at the rate of Rs. 200-500/- per ton depending on the waste quality.

The waste generated at the Rathnapura Municipal Council area is also directed for composting. Prior to composting, the non-biodegradable matter were separated and dumped. They incur a cost of production of Rs. 3 per kg and sell in bulk at the rate of Rs. 3.50 per kg.

Recently, the Balangoda Urban Council has started a composting program with their wastes. After collection of the waste, it is separated manually and the biodegradable part is directed for composting while the rest is further separated into polythene, paper, glass *etc.*, and planned to be recycled. However, this is a very recently started project and they have not yet calculated the cost of production.

Katana Divisional Council is about to start a fully mechanized composting project to compost the waste generated at Raddolugama housing scheme. They hope to sell compost in bulk to one of the leading compressed coir dust exporter, namely Christo Horticultural Products (Pvt) Ltd. at Negombo, and it has already agreed for regular buying at the rate of Rs. 4 per kg.

A non-government organization (NGO) has launched a composting program in Pliyandala. As improved market cleanliness attracts more customers, the Piliyandala market separates and supplies the separated voluntarily organic waste to the NGO which can then be directly used for composting. Prior to composting, carbon rich materials such as saw dust and paddy straw, along with high nitrogen material such as chicken dung are incorporated. The nutrient composition of the product is thus improved. Their cost of production is almost around Rs. 20 per kg and they sell compost at the same price with no profit.

Artharcharya Foundation has launched a community-based project at Galle, Negombo and Hikkaduwa aiming at poverty alleviation coupled with waste management. Due to the efforts of the foundation, the attitudes of the community have been changed first and as a result of that waste is now separated at the household level. Biodegradable matters of waste are composted on a small scale using a compost barrel. Recyclable matters are bought by the foundation and directed for recycling. The community gets an additional income from selling recyclable matter and compost. Compost is sold at the rate of Rs. 10-20 per kg. A similar project is to be launched at Dehiwala also.

The municipal council at Maharagama has started a project on solid waste management involving 2000 houses. Voluntary separation of the waste by the households is obtained by providing different coloured bags to collect recyclable matter. It collected by the Municipal Council and directed for recycling. The households using compost barrels compost the biodegradable matter in the waste.

Current practice of solid waste management in Kandy city

The per capita waste generation rate in Kandy is 0.7 kg indicating that 107 metric tons of wastes per day are generated in the Kandy city. The municipal council is responsible for solid waste management in Kandy. Currently, the municipal council collects around 84 metric tons in their daily collection and the rest is believed to be dumped illegally. Waste generators are requested to place their discards in black polythene bags

prior to collection. Street sweeping crews collect these discards along with street sweepings into their carts and unload their carts at a collection point located near the end of each route. There are 350 such collection points throughout the city. These collection points are 'constructed storage bins' which are enclosures of concrete hollow blocks on three sides and the open side of the bin act as the reception side for the waste. Out of 350 collection points 180 are such storage bins and the rest are open collection points that lack sufficient space for bins. The waste stored at those collection points are loaded into the tractor-trailers or compactor trucks and transported to the disposal site. The disposal site of the waste is located at Gohagoda. It is a place about 8 km away from the town centre. This disposal site has been in use since the early 1970's, and at the present rate of disposal, the remaining 3.5 acres of the site will be filled during the next 2-3 years. Already one ravine has been filled and closed. The transported waste is spread at the disposal site and covered by a thin layer of soil. No mechanical equipment is used for spreading of waste or compaction after spreading.

One zone of the Kandy Municipality area has already been privatized. The private company named *Care Kleen* is responsible only for waste collection and disposal at the open dumping site at Gohagoda.

Alternative methods of solid waste management

Solid waste can be disposed of with or without separating into wet and dry components. When it is disposed without separation, direct dumping, sanitary land filling, or incineration methods can be used. When it is separated, the dry component can be disposed of by direct dumping, incineration or by recycling whereas the wet component can be used to produce compost or bio-gas and bio-fertilizer. Fig. 1 shows the classification of the above mentioned alternative methods (Holmes, 1984; Datta, 1997; Choe and Fraser, 1998; Ministry of Forestry and Environment, 1999b).

Direct dumping of waste involves spreading of waste over an area. To minimize health risk a layer of soil is applied over the waste. Instead of this soil application, a solution of effective micro-organisms (EM) can be applied to prevent odour and health risks from the waste. EM mixture contains naturally occurring microbes and use of EM is known as a very useful and an easy method of managing the environment. It is believed that EM can eliminate the smell and the population of flies (Lee, 1998). EM is sold in the market. It has now been demonstrated that 100 times diluted EM solutions incorporated with molasses or *sakkara* can be used for application over the garbage. One of the problems of EM application is that it is still at experimental stage, and the impact of EM on the domestic microbial population is unknown. Land filling is a way of dumping waste in an environmentally sound manner (Rajakumara, 2000). The site should be constructed with impermeable liner materials and pipes to drain the leachate out and the spread waste should be compacted followed by a proper soil cover. As a method of disposal, waste can be incinerated. When a big bulk of waste (around 84 MT/day) is incinerated, the capacity of the incinerator should be very high. By incineration, waste can be totally disposed of as the left over ash (at the end of the process) is less than 1% and it is negligible. However incineration is not recommended for warm countries, as it generates heat and increases the environmental temperature of the area.

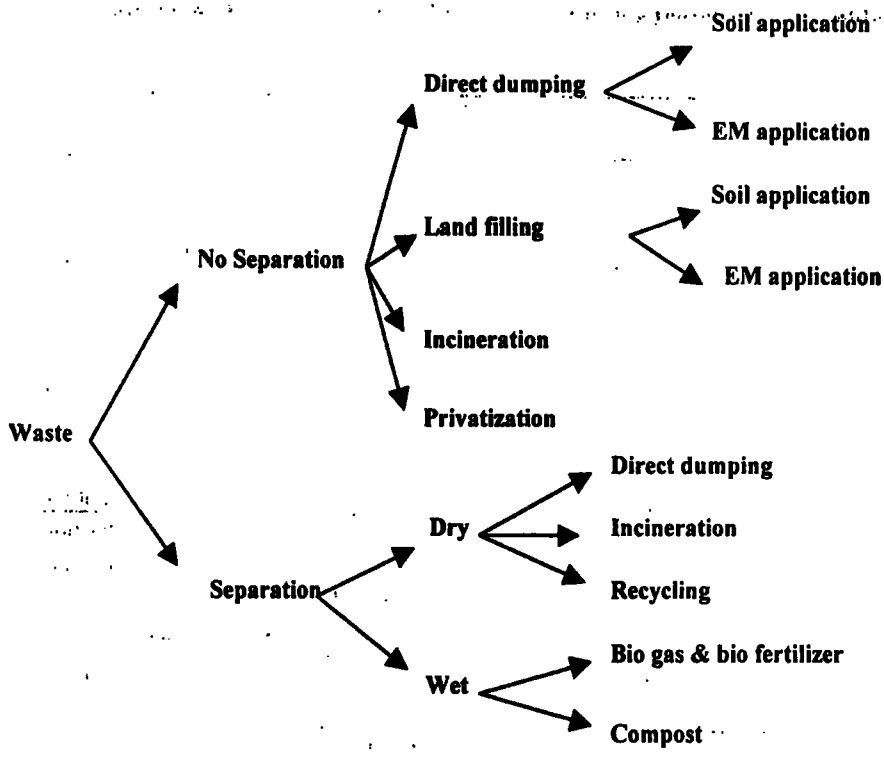

Fig. 1. Alternatives to manage solid waste.

If waste is separated as wet and dry, the dry part can be grouped into plastic, paper, metal, glass *etc.*, and the grouped matter can be recycled back to the original product or any other product of the same raw material. The wet part of the waste can be decomposed using a compost unit or a bio-gas unit (Bulathsinhala, 1998; NERD, 1998). The decomposed matter produced in the compost unit can be sold as compost. The bio-gas, produced during the process of digestion, can be utilized as a fuel to generate energy and at the end of every three or four months, the sludge of the bio-gas unit can be sold as an organic fertilizer.

MATERIALS AND METHODS

The above mentioned alternative practices consist of different activities and they are shown in Table 1. This study calculates the cost of solid waste disposal using various alternative methods as listed in Table 1. Cost of performing different activities cited in Table 1 was calculated, considering the cost of equipment, labour and other variable costs. It was assumed that all these methods result in similar benefits, *i.e.*, clean roads.

Table 1. Different activities to be performed by alternative practices.

Separation	Method		Activities
No	Direct dumping	With soil application (existing method)	Waste collection Waste dumping Soil application
		With EM application	Waste collection Waste dumping EM application
	Land filling	With soil application	Waste collection Waste dumping Soil application Site preparation
		With EM application	Waste collection Waste dumping EM application Site preparation
	Incineration		Waste collection Incineration
Yes	Composting	Wet: Composting Dry: Direct dumping	Waste collection Composting Dumping
		Wet: Composting Dry: Recycling	Waste collection Composting Recycling
		Wet: Composting Dry: Incineration	Waste collection Composting Incineration
	Bio-gas	Wet: Bio-gas Dry: Direct dumping	Waste collection Bio-gas Bio-fertilizer Dumping
		Wet: Bio-gas Dry: Recycling	Waste collection Bio-gas Bio-fertilizer Recycling
		Wet: Bio-gas Dry: Incineration	Waste collection Bio-gas Bio-fertilizer Incineration

Data were collected through a literature survey and personal communications with the relevant officials who are involved in managing solid waste at different institutions.

Using collected data the minimum and maximum costs for various activities were calculated. The following assumptions were made. Remains after composting the wet part and recycling the dry part of the waste are insignificant. Waste separation is done at source level with no cost. Land value for each practice and leachate treatment costs are excluded. The environmental costs and benefits are also excluded. The amount of the waste generated within the Kandy municipality area and amount of the recyclable matter and biodegradable matter included in the waste were calculated based on the information available at Forestry and Environment Ministry (Ministry of Forestry and Environment, 1999a). Data were collected from the Kandy Municipal Council for the existing method. In bio-gas utilization, data were from the National Engineering Research and Development Centre at Ekala, Ja-ela (NERD, 1998). Land filling data were obtained from the report of conceptual design at Alupotha sanitary landfill and from personal communication. Data on composting were collected mainly from the report of Basnayake (1998) and, the experience in composting at the Horana Pradeshiyasaba was incorporated in the calculation. Incineration data were gathered by the personal communication with the officers at NERD and Lanka Refectories Limited. Data on EM application was obtained through personal discussion with the experts at Sarvodaya Head Office, Moratuwa. The data collected on different methods were adjusted for the waste generated within the Kandy Municipal area and costs were recalculated. Unit cost to manage a ton of waste was obtained for each method. In scenario 1 the minimum values were considered while scenario 2 includes the reliable maximum values of the costs. Table 2 shows the assumptions made in costing the items in scenario 1 and 2.

Table 2. Assumptions.

Item	Units	Scenario 1	Scenario 2
Office work		No	Yes
Building depreciation	per annum	1%	2%
Equipment depreciation	per annum	5%	10%
Vehicle depreciation	per annum	5%	20%
Contingencies		0%	10%
Overhead		0%	10%
Compost bag	kg/bag	5	1
Bio-gas sludge		15% of waste	5% of waste
Bio-gas utilization		18%	50%
Labour consumption		Minimum	Reliable maximum
Fuel cost for incineration	Rs./ton	4680	6624
Storage costs		Excluded	Included
Bio-gas price	Rs./kg	4	8.5
Compost price	Rs./kg	3	5
Metal price	Rs./kg	4.5	3
Glass price	Rs./kg	2	1

All other items including labour wages were considered to be the same in scenario 1 and 2. Calculated costs and revenue of the activities of alternative practices are presented in Table 3.

Table 3. Costs and revenues of different activities.

Activity	Amount (Ton)	Scenario 1		Scenario 2	
		Total cost (Rs.)	Total revenue (Rs.)	Total cost (Rs.)	Total revenue (Rs)
Waste collection	2520	2,028,743		2,434,492	
Waste dumping					
Total waste	2520	36,315		43,578	
Dry part only	540	7,781		9,338	
Soil application					
2 cubes/day	2520	98,400		118,080	
5 cubes/day	2520	165,400		295,200	
EM application	2520	170,250		204,480	
Land filling (site preparation)	2520	494,943		656,932	
Incineration					
Total waste	2520	12,000,181		20,468,874	
Dry part only	540	2,545,600		4,319,432	
Composting	1980	1,044,570	1,188,000	2,635,750	1,980,000
Bio-gas	1980				
Bio-gas		627,296	276,480	2,978,488	1,615,680
Bio-fertilizer		151,083	270,000	670,000	500,000
Recycling	540	303,600	992,625	540,798	805,726

RESULTS AND DISCUSSION

Summary results of the cost effectiveness analysis are presented in Table 4. When the existing system is considered, the waste can be managed at a rate of Rs. 858 and 1030 per ton respectively in scenario 1 and 2, excluding the value of land. Availability of the disposal sites is the problem with the existing system. The present disposal site is to be filled up in the next 2-3 years and seeking the another disposal site is a big problem, due to unavailability of the land coupled with the social unrest towards dumping sites. Sanitary land filling also has the same problem of unavailability of land and social unrest, though it is more environmentally friendly.

Direct dumping with EM application involves a slightly higher cost than direct dumping with soil application. It however is more environmentally friendly. The problem with this method, other than the cost, is the unknown impact of EM.

Table 4. Summary of financial costs of the alternative practices.

Separation	Method	Scenario 1		Scenario 2	
		Total cost (Rs./month)	Unit cost (Rs./ton)	Total cost (Rs./month)	Unit cost (Rs./ton)
No	Direct dumping with soil application	2,163,458	858	2,596,150	1030
	Direct dumping with EM application	2,235,308	887	2,682,550	1065
	Land filling with soil application	2,725,401	1081	3,430,202	1361
	Land filling with EM application	2,730,251	1083	3,339,482	1325
	Incineration	14,028,924	5567	22,903,366	9089
Yes	Wet: Composting and selling Dry: Direct dumping	1,893,094	751	3,574,780	1419
	Wet: Composting and no selling Dry: Direct dumping	3,081,094	1222	5,554,780	2204
	Wet: Composting and selling Dry: Recycling	1,192,688	473	3,300,515	1310
	Wet: Composting and no selling Dry: Recycling	2,380,688	944	4,106,240	1629
	Wet: Composting and selling Dry: Incineration	4,430,913	1758	7,848,874	3129
	Wet: Composting and no selling Dry: Incineration	5,618,913	2229	9,864,873	3915
	Wet: Bio-gas - Selling Dry: Direct dumping	2,268,423	900	3,976,638	1578
	Wet: Bio-gas - No selling Dry: Direct dumping	2,814,903	1117	6,092,318	2418
	Wet: Bio-gas - Selling Dry: Recycling	1,517,617	623	3,702,373	1469
	Wet: Bio-gas - No selling Dry: Recycling	2,118,097	840	5,188,053	2309
	Wet: Bio-gas - Selling Dry: Incineration	4,806,242	1907	8,286,732	3288
	Wet: Bio-gas - No selling Dry: Incineration	5,353,722	2124	10,402,412	4128

Incineration is the most expensive alternative and cost may range from Rs. 5567 to Rs. 9089 per ton. It also suffers from the drawback that it generates heat during the process and cannot be recommended for Kandy.

The least cost alternative is source level waste separation followed by composting. When the wet matter is composted and the dry matter is further separated into different types (glass, paper *etc.*) and both are sold, the cost could range from Rs. 473 to Rs. 1310 per ton. This alternative however involves capitalizing on the available marketing channels

to sell compost and finding recycling centres. In a situation where compost cannot be sold and has to be disposed free of charge, the cost may range from Rs. 944 to Rs. 1629 per ton. If dry matter is disposed of by direct dumping, cost will be Rs. 751 per ton and Rs. 1222 per ton with and without selling compost respectively in the minimum calculation and Rs. 1419 per ton and Rs. 2204 per ton in the maximum calculation. Cost goes up significantly with the incineration option. It may range from Rs. 1758 per ton to Rs. 3129 per ton when compost is sold and from Rs. 2229 per ton to Rs. 3915 per ton when compost is distributed free of charge.

Selling bio-gas and bio-fertilizer is not as attractive as selling compost, as production of bio-gas and bio-fertilizer involves a higher cost. If the dry matter can be recycled the cost may range from Rs. 623 to Rs. 1469 per ton when bio-gas and bio-fertilizer are sold. When they are distributed free of charge, the cost may range from Rs. 840 to Rs. 2309 per ton. When dry matter is directly dumped, cost may range from Rs. 900 to 1578 per ton and Rs. 1117 to 2418 per ton when bio-gas and bio-fertilizer are sold and distributed free of charge respectively. With the option of incineration of dry matter the cost goes up and it may be as high as Rs. 1907 to 3288 per ton and 2124 to 4128 per ton when bio-gas and bio-fertilizer are sold and distributed free of charge respectively.

CONCLUSIONS

It is clear that the method involving recycling accompanied by composting is the least expensive, as it generates extra revenue. The alternative methods involving incineration are more expensive and bio-gas and bio-fertilizer generation lie in between. However, the latter may not be practical in the short run and marketing could be a problem. As the first step, the Kandy municipal council in improving waste collection, can start applying the EM solution to the dump site to minimize the environmental damage. It would involve a slightly higher cost, but the environmental benefits would cover the cost. If the municipal council can find a marketing channel to sell compost and recycling centres, the best alternative is to produce and sell compost while the dry part is used for recycling. Marketing of compost may not be a problem in the future as the current trend is towards producing organic products. Producing bio-gas and fertilizer would be the second best alternative. By practising one of these alternatives, the problems with land fill sites could also be minimized.

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