

Development of an Integrated Solid Waste Management System for Three Local Authorities in Sri Lanka through Capacity Mobilization

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ABSTRACT. *Accumulation of urban solid waste (USW) is a rapidly emerging problem in many countries including Sri Lanka. Increasing quantities of solid waste impose pressure on individual local authorities that are responsible for management of solid waste. A waste composition study was conducted and secondary data on the existing system were obtained from three local government authorities (LAs) in proximity to the University of Peradeniya, namely Udunuwara, Yatinuwara and Gangawata korale. A workshop, meetings and awareness programmes were launched to introduce point source separation. A survey was conducted to check the effectiveness of the programme and to obtain data and views of the LAs.*

A significant quantity of wastes is generated in the three selected LAs. The collection amounts to 16.5 tons/day out of which approximately 4.6 tons/day is processed at the University of Peradeniya pilot composting plant at Meewathura. The remainder is dumped in different locations. There is no regular system of waste collection. A high component of biodegradable perishables (about 65%) is suitable for composting. The survey indicates that the point source separation program is not effective. The public expects incentives for point source separation and considers it as a burden. According to the responses from the surveyed members of the public, the local authorities are not performing well. These local authorities have limited resources to manage their solid wastes effectively and efficiently. Their existing databases are not adequate for a complete capacity mobilization study.

There is a market for recyclable polythene but it needs to be of clean stock for pelletizing. An additional composting plant and a landfill site are needed for managing the wastes. The economical and environmental study indicated that the two locations proposed by the LAs are not suitable for a common landfill site and an alternative location should be selected. Several suggestions have been made to introduce the concepts of capacity mobilization for effective use of the resources in the three LAs.

INTRODUCTION

Improved standards of living, growth of consumerism, population growth, and industrial activities in developing countries have led to exploitation of natural resources and generation of enormous quantities of urban solid waste (USW) and consequential

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environment degradation. Of the current population of 18.7 million in Sri Lanka 23% is urban and densely populated, and generate large quantities of waste containing a higher quantity of non-biodegradable components. The total amount of waste generated in Sri Lanka is around 6500 tons/day. The amounts of USW collected by the local government authorities are around 2500 tons/day (UNEP, 2001). Present waste generation rate in Sri Lanka is 2% (De Alwis, 1998). Therefore, it is estimated that the amount of waste collected by local government authorities (LAs) in 2010 will be 3000 metric tons/day. In Sri Lanka, waste management is the responsibility of LAs. They are divided into three categories depending on population and population densities, namely municipal councils (MC), urban councils (UC) and *pradeshhiya sabhas* (PS), where PS having the lowest population densities.

There are many options available for LAs in managing solid waste such as direct dumping on approved sites, sanitary land filling, dumping in sea, incineration and direct or indirect recycling. Direct dumping is the most common disposal method in Sri Lanka although it does not maximise the use of available space neither fulfil required sanitary conditions. At present, due to the higher rates of waste generation the available sites are insufficient to meet the requirement. Direct dumping causes problems like destroying natural habitats, alter the landform, polluting the ground water by releasing leachates, causing fly and mosquito problems, producing odour and toxic gases and leading to spread of diseases that are hazardous to human health.

The open dumpsites may be marshes, wetlands and sloping lands, a riverside, a forest margin or a plot of bare land. It is estimated that nearly 41 wetland sites are in the verge of destruction due to pollution (UNEP, 2001). Such ill disposal methods result in serious environmental problems. Therefore, dumping sites have very high economic and social costs to the public health and environment. Safe, reliable and cost effective removal and disposal of the solid waste is one of the major tasks of local authorities in solid waste management (SWM) (UNEP, 2001).

Capacity mobilization in SWM is defined as mobilization of potential and existing resources of communities (mainly human and available funds), organizations and institutions and local authorities effectively and efficiently for managing USW. Although many capacity mobilization studies have been done in many parts of the world for solid waste management, essentially very few in Sri Lanka and they are confined to efforts in participatory approach programmes (Lorna, 2000), hence true capacity mobilization studies have not been undertaken. Thus, this study was conducted to identify the present status of solid waste management and the waste composition within three PS (Udunuwara, Yatinuwara, Gangawata Korale) in proximity to the compost plant located at the University of Peradeniya. Although back-end sorting is done successfully (Dissanayake, 1999), reduction of non-biodegradable materials fed to the composting plant would increase the payload of the plant. This study was designed to formulate a research methodology in introducing capacity mobilization concepts in point source separation, and to identify and quantify the extent to which these developed methodologies are applicable, and to investigate the possibility of introducing an integrated solid waste management system for the three selected PS.

MATERIALS AND METHODS

Compost plant and study area

The compost plant is located at Meewathura Farm, University of Peradeniya, Sri Lanka and at present, the payload is 4 tons/day and nearly 1 ton of compost can be extracted as output (Basnayake, 1998). Only a part of the wastes that is collected from the Udunuwara, Yatinuwara and Gangawata Korale PS, is transported (ends up) to this composting unit at Meewathura. The study area was selected on the basis of locations where the wastes are collected for composting.

Gathering secondary data of the existing system within three *pradeshiya sabhas*

The following data were collected, namely number of waste collecting locations, specific quantities from different locations, types of storage and classification, disposal practices of generators, system of collection and efficiency, disposal practices of local authorities and availability of resources. Unfortunately, some data could not be gathered due to lack of proper databases in the PS. Secondary data were collected by interviewing the environmental officers of the three PS.

Identifying the waste composition within three *pradeshiya sabhas*

One waste load from each of the three PS was analysed by stratified sampling over a period of 10 days. The load was first divided into three equal parts and secondly, subdivided randomly into three parts. Then from each of these parts a volume of 0.125 m³ were separated individually to as many waste categories (components) as possible such as biodegradable (perishables), cardboard, polythene, and paper, and other waste materials such as used king coconut shells, hard waste, hair, glass, plastic, tin, clay, porcelain, clothes, coconut shells and metal. Lastly, each component was weighed and the moisture content of wastes was also determined.

Capacity mobilization activities

Three meetings were held to discuss point source separation programme with the local authorities. Discussions were centred on the type of information that should be included in the posters and information leaflets. The Hantana Conservation Society, a non-governmental organization, prepared 10 posters each for a PS, seven posters in Sinhala and three posters in Tamil languages illustrating clearly the message of the proposed programme on source separation. A total of 3000 leaflets were distributed among the LAs. A workshop was held in the Department of Agricultural Engineering of the University of Peradeniya, Sri Lanka with the participation of officials, tractor operators, waste collectors, environmental officers, public health inspectors, and medical officers to envisage shortcomings and problems that could arise in the proposed programme and new suggestions, particularly in relation to methods of collection and formulating explanations for the public. It was also necessary to gauge their commitment to continue the source separation programme smoothly.

The awareness programme was conducted in 14 specific locations of townships in the three LAs. Public health inspectors of the area, environmental officers, Hantana Conservation Society and members of the solid waste management research unit (SWMRU) of the University of Peradeniya assisted in this activity.

A survey was conducted through a prepared questionnaire (Priyangani, 2002), to identify the effectiveness of the introduced programme, the problems associated with point source separation and to assess the ground truth of the waste problem. The areas for the survey were randomly selected according to the availability of resources. The interviews were undertaken in 36 locations in Yatinuwera PS, 34 in Uduuwera PS and 45 in Gangawatta Korela PS. Results of the questionnaire were analysed using Minitab statistical computer software programme.

Each of the Secretaries of PS was made aware regarding the results of the questionnaire and discussions were held with them to seek possibilities of distributing bags or plastic bins. Their suggestions were also gathered. The commissioner of local government of the central province was invited to discuss the problems, which would arise during the leaflet distribution and questionnaire.

Several meetings were held with plastic recycling enterprises in Mawenella, and Kandy to identify the possibility of supplying the collected polythene and plastic for recycling and to determine the quantity of non-recyclable wastes for final disposal in a common landfill for the three LAs. In the meetings held with the LAs three landfill sites were identified namely Gurudeniya, Sindurankanda and Sinha Haragama so as to select the best landfill site and two of these sites were visited and tested for the social, economic and environment feasibility of developing a landfill.

RESULTS AND DISCUSSION

The status of the existing system within three *pradeshiya sabhas*

The status of the existing system in the three LAs is summarized in Table 1. The population sensors of 2001 reported a lower figure for Gangawata Korale and it seems that the earlier publications may not have been accurate. It has a higher population density with a higher generation rate than the other two local authorities. The predicted generation rate is based on the UNEP (2001), which indicates that the per capita generation could be 0.35 kg/person/day for these three LAs.

It was reported that in Yatinuwara PS, the waste collection takes place between 6–7 a.m. but in practice, entire morning is taken for this activity. Uduuwara PS has given fairly accurate data on collection and the collection efficiency is better. Unfortunately, none of the LAs have fixed routine system of waste collection. The number of locations used for disposing of wastes in dumpsites differs from one LA to another and from one day to the next. The highest number of disposal locations was observed in Yatinuwara PS. Whereas Gangawata Korale PS and Uduuwara PS have two sites each for disposal, one of which is the composting plant. Thus, not all wastes could be brought to the composting plant. The monthly waste handling costs for Gangawata Korale PS is approximately Rs. 87,000/- to 90,000/- and more than Rs. 50,000/- for Uduuwara PS.

Table 1. Summary of data on population, extent and waste generation, collection and disposal, for each local authority.

Description	Udunuwara	Yatinuwara	Gangawata Korale	Ref.
Population	92,677	92,338	225,000	1
	98,838	95,946	161,325	2
Area (sq. km)	66	70	75	3
Population density (person/sq. km)	1498	1385	2143	1 and 3
Waste generation (kg/day)				
Predicted generation	34,500	34,000	56,400	3
Published data on collection	6500	500	800	1
Disposal at compost plant	1377	1442	1877	3
Collection deduced from survey	5500	5000	6000	3
Waste collection				
Waste collection locations	24	5	4	1
Method of collective location	1-4T, 5-C	1-4T	1-4T, 1-2T, 2-C	3 and 4
Workers				
Permanent	3	8	6	1
	6	7	9	3
Casual	1	3	3	3
Collection efficiency (kg/worker)	787	500	667	3
Number of dumping sites	2	6	2	3

1. Ministry of Environment and Natural Resources (1999); 2. Department of Census and Statistics (2001); 3. Study; 4. UNEP (2001).

4T - Four wheel tractor trailer; 2T - Two wheel tractor trailer; C - Hand carts.

Unfortunately, none of the local authorities maintains databases on SWM. Therefore, the expected information such as extent covered for collection, total mileage of roads, number of days of collection from collecting points, total loads handled, population densities, updated maps of number of houses and shops, amount of industrial wastes and number of locations could not be obtained, since these LAs are unable to provide services to the entire extent of land under their jurisdiction and due to lack of management directives, know-how and skills. Therefore, improved integrated SWM systems such as the decisional model developed by d'Antonio *et al.* (2002) cannot be applied.

Analysis of waste within the three *pradeshya sabhas*

All three LAs have, on average, 65% biodegradable perishable wastes and moisture content of waste is in the range of 50-55% on dry days (Table 2). Therefore the three LAs supply suitable waste loads for making compost. Waste generated in Udunuwara PS has a significant difference in polythene, biodegradable, glass and paper percentages as

compared to the other two LAs. The polythene and paper percentages of waste obtained from Udunuwara PS are high because the waste collecting area is highly urbanized. Yatinuwara PS has a significant variation in biodegradables, wood, glass and paper percentages between loads from one day to the next.

Table 2. Average waste composition of the three local authorities Udunuwara (UN), Yatinuwara (YN), Gangawata Korale (GWK) *pradeshhiya sabhas*.

Waste components	Weight (kg)			Density (kg/m ³)			Weight percentage		
	UN	YN	GWK	UN	YN	GWK	UN	YN	GWK
Perishables	884	85.17	74.15	413.66	220.59	192.04	72.64	61.8	60.88
Cardboard	64	5.50	8.02	29.94	14.24	20.78	5.25	3.99	6.59
Polythene	114	7.45	7.12	53.34	19.30	18.45	9.37	5.4	5.85
Paper	72	12.45	13.55	33.69	32.24	35.09	5.92	9.03	11.12
Used coconut	30	10.95	2.65	14.04	28.36	6.86	2.47	7.94	2.18
Hard waste	30	3.95	4.35	14.04	10.23	11.266	2.47	2.86	3.57
Hair	7	-	0.005	3.28	-	0.388	0.0057	-	0.04
Glass	4	0.005	0.775	1.87	0.129	2.007	0.0033	0.036	0.64
Plastic	1	0.35	0.375	0.47	0.906	0.971	0.0008	0.253	0.31
Tin	3	0.25	1.05	1.40	0.647	2.719	0.0025	0.18	0.86
Soil	-	-	0.325	-	-	0.842	-	-	0.27
Porcelain	-	-	0.550	-	-	1.424	-	-	0.45
Cloths	8	1.8	2.675	3.74	4.661	6.928	0.0066	1.3	2.20
Coconut shell	-	1.475	0.150	-	3.820	0.830	-	1.07	0.12
Metal	-	0.15	0.005	-	0.388	0.129	-	0.10	0.04
Weight of sample (kg)	1217	137.8	121.8	-	-	-	-	-	-
Moisture (%)	55.95	54.85	50.2	-	-	-	-	-	-

The lower percentages of wood and glass found in this study are mainly due to the selective collection of waste that was brought to the unit. These selective as well as random collections from different parts of the LAs make predictions of waste composition for the entire LAs difficult and inaccurate.

Capacity mobilization activities

The meetings helped in getting the assistance and contribution from the members of the PS. Such activities have developed a good relationship between the SWMRU and PS Members. In the workshop that was held, it was suggested to place good-looking bins in town areas for biodegradable and non-degradable wastes. Waste collectors and tractor drivers informed that resources as well as labourers are lacking and assured to help as much

as possible for the programme. In addition, they also could make the public aware that this process would be a benefit.

Members of the trade association agreed to assist in the point source separation programme. However, they accused the PS for the poor waste management services, indicating lack of regular collection and not well equipped for collecting and final disposal of wastes. Furthermore, it was stated that sometimes PS takeaway the bins and baskets and do not return them and highlighted the fact that LA employees demand money to remove the waste.

Out of the 115 samples, there are only 13 commercial places that separate waste. Others continue to dispose mixed wastes as before. Seventy persons expressed their willingness to get bags to separate their waste. Some of the commercial places did not have a dustbin for themselves.

Problems associated with point source separation

At least nine notable problems were identified in point source separation. They are (i) irregular collection (by tractor) and wastes ending up in drains and rivers; (ii) lack of essential equipment to cleanup the waste; (iii) lack of supervision of waste management practices; (iv) waste collection only from the first half of the road due to inadequate capacity of tractors or the remaining half/other side of the road belongs to another PS; (v) lack of labour for waste collection; (vi) demanding remuneration to remove the waste; (vii) mixing of sorted wastes takes place when loading the tractors; (viii) lack of awareness on waste accumulation, and (ix) waste that is brought in vehicles and just thrown into waste collection common dustbins or on to either side of roads were identified as major problems associated with point source separation.

Efficiency of point source separation programme

Source separation practice did not depend on age or education levels. Between PS also show no significant differences (Table 3).

Table 3. Survey data and analysis on separation of wastes.

Activity and result	Age			Educational level			Local authority		
	< 35	35-50	50 <	below O/L	O/L	A/L	YN	UN	GWK
Separating	8	2	3	0	10	3	3	3	7
Not separating	42	42	18	20	50	32	33	31	38
Chi-square	3.290			4.530			1.337		
P-value	0.193			0.104			0.513		

YN - Yatinuwara; UN - Udunuwara; GWK - Gangawata Korale
O/L - Ordinary level, A/L - Advanced level

Comments from the local authorities

The local authorities indicated that enforcement of point source separation on the public is difficult due to political reasons and interferences. However, in the case of commercial establishments, they are of the opinion that a control mechanism could be put in place when they issue trade licenses, because in the local authority policy, every trader should have a proper dustbin to dispose their waste. The secretaries of the three PSs are reluctant to introduce the practice of distributing bags among the public due to lack of funds. The public is not adequately taxed or no additional charge for handling the wastes, hence no income but expenditure for the LAs. The allocation of funds for SWM is low and legal action or change in the legal status is difficult under the present circumstances. They propose further awareness programmes to change the attitude of the public and initially to undertake this activity within a small selected area. They all agreed that a landfill site is essential for excess wastes (more than the capacity of composting plants) and for non-recyclable wastes.

Management of *pradeshiya sabha*

The quality of incoming wastes to the processing plant at Meewathura is poor, since the frequency of collection is low while trying to serve most parts of the large extent of PS. The actual delivery time to the processing plant as reported by PS differs and it is likely that the real situation of the management practices is not frequently monitored. The wastes are already contaminated with flies and causes odour problems, particularly so when late delivery takes place. The dumping of wastes in authorised and unauthorised locations is now becoming a serious health hazard.

The recorded data at Meewathura shows that the average waste quantity that is brought by each local authority, on average, is totalling to 4696 kg/day (Table 1). The actual collection is 16,500 kg/day. The remainder, approximately 12 tons, are dumped in the locations as mentioned above without any soil cover.

Unfortunately, the demarcated boundaries are such that one side of the road is handled by one authority, whereas the other side by another. This situation is not ideal in view of costs, management of resources, time management and enforcing of management systems.

Due to lack of resources, local authorities are unable to perform effectively. Labour availability is low and it is hard to find people who will work as waste collectors for the poor wages offered (Rs. 130/- per day) and so the cleaning and collection crews of LAs are unreliable. There is a lack of co-ordination among the LA officers regarding allocation of work and expected output of collection workers.

Lack of understanding of dignity of labour is one of the aspects the country as a whole should address. The workers are reluctant to perform their duties in public, particularly so of the stigma attached to the type of work done. The officers concerned are very indifferent and avoid their duties. There is lack of co-ordination between public health inspectors and the local authority officers, leading to conflict of interest as well as

negligence. They are not concerned of their responsibility and sometimes ignorant about it.

Improvement of composting plant

A recycling company is willing to buy two tonnes of cleaned polythene and thus a washing plant is needed. The accumulated stock of polythene should be dumped in a landfill or sold to a buyer. The capacity of the composting plant should be increased to handle at least 6 tons/day of solid wastes.

Site selection for landfill

The Udunuwera PS is not willing to have a common landfill at Sindurankanda, which is a suggested site within the local authority lands, reducing the number to two alternate sites for selecting the better option. One of the other options is to use the present open dumpsite of Gangawata Koralya PS, which is situated about eight kilo-meters away from Kandy at Gurudeniya, in close proximity (50 m) to the riverbank of the Mahaweli in the Victoria reservation. Although there is enough space, the river might inundate the proposed landfill when the reservoir is in its full capacity, though the return period seems to be long. It was pointed out that if the local authority continues with this practice of dumping wastes or constructing an engineered landfill, the Mahaweli Authority of Sri Lanka will take legal action against the PS. When considering the environmental factors, the Gurudeniya site is not suitable for a landfill.

The site at Sinha Haragama is about 14 km away from Kandy and is owned by the Maligatenna *grama niladary*. It is an unproductive land with steep gradients. The access road is also not properly constructed. Although the site is far away from human settlement, the cost that has to be borne in developing the site is too high. Therefore, the site is not economically suitable for a landfill.

Social aspects and suggestions for improving solid waste management

The higher authorities are presently examining the possibility of increasing the capacity to handle all the wastes generated in the three local authorities. Lack of funds, clear management directives and social awareness are the key issues to be dealt with improved management of solid wastes.

As indicated by Fernando *et al.* (1995) and by this study, people are willing to accept solid waste disposing as their responsibility. However, they are unaware of the negative impacts of waste accumulation. The attitude of the people should change through awareness, which should be created through social mobilisation. This must include all income groups, as the rich are also very irresponsible and programs should be conducted regionally and nationally. It is also vital that the PS should be aware of the issues so that they are able to tackle the problems rationally. There must be general environmental education that could be conducted by distributing leaflets written in all three languages. Awareness programmes should be conducted for schools, and business and urban

employees. Information sharing workshops, the state media, electronic media and schools could be used as means to educate people. Also people should be encouraged to process their waste at home.

According to Bandara (2001) waste is a business. The authorities must be made aware of this. In Malaysia, Indonesia and Thailand waste provides a substantial part of their income. There should be a co-ordinated governmental approach to make waste a business. It may be necessary to increase tax or establish a charging system in order to manage the waste more efficiently. The involvement of the private sector could increase the efficiency of the project.

It is difficult to carry out such advance programs with the kind of problems encountered in Sri Lanka. If these obstacles could be tackled, point source separation can be done successfully through participatory approach and be in a position to produce more non-contaminated compost from using urban solid waste, while reducing solid waste accumulation in urban centres (Basnayake, 1999). Following suggestions are made to improve the point source separation through participatory approach and integrated solid waste management system in the three selected PS areas;

- a. Effective awareness programs should be conducted on 'point source separation' among the public and officers of the local authorities.
- b. Bags or bins should be distributed and supervised regularly to check the efficiency of point source separation.
- c. Incentives should be provided not only to the public, but also for the tractor drivers and waste collectors, because they are the persons who can encourage the public.
- d. Questionnaire surveys should be conducted periodically to identify the problems associated with SWM so as to overcome the difficulties, which may discourage the programme.
- e. Combination of policy instruments such as market base instruments, command and control system, moral persuasion, and community action should be used in SWM.
- f. A common landfill site should be identified and operated.

CONCLUSIONS

There is a high percentage of biodegradable waste available for composting the urban solid wastes collected from the three selected local authorities. The composting plant at Meewathura can be improved if an effective point source separation programme could be established with the active participation of the community, mobilizing the existing resources and improving the management systems of the local authorities. However, this study reveals that there are grave problems encountered both by the community at large and the three local authorities in managing solid waste. The local authorities are inefficient and they lack resources and equipment and machinery to maintain the urban centres clean. Irregular collection of wastes seems to be the major problem. Also the waste collectors are corrupt and such corruption could be attributed to very low wages given to collectors, including the tractor operators. There are at least nine notable problems identified in point source separation.

Only 11.3% were separating wastes during the study period. However, 70% are willing to separate the wastes if bags are provided. Unfortunately, the local authorities do not have adequate funds for waste management and distribution of bags would depend on willingness to pay for the services. The other option is for the SWMRU to supply the bags and financially balance payments by recycling the bags and other materials. Also the labour requirement would be less for sorting the wastes at the compost plant. The statistical analysis indicated that there are no significant relationships between age, education or between locations. Local authorities are sceptical in enforcing legislation on point source separation due to many reasons like inadequate provision in the legislation and political interventions.

Since collection is irregular, the quality of waste arriving at the processing plant is low with already degraded and contaminated wastes, particularly with flies. Odour nuisance is a major problem. The capacity of the processing plant is insufficient to serve all three local authorities and over 70% wastes are dumped. The status of the Meewathura compost plant should be improved to process or dispose wastes that cannot be composted. An integrated management approach is needed with an additional composting plant along with a common landfill.

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