Cost-effective systems for solid waste management

Manus Coffey

Choice of collection system is the key to managing refuse in cities — yet the developing world has produced very few success stories in this area. What factors and constraints influence this difficult decision for municipalities?

Uncollected solid waste, rotting in heaps on the ground and blocking drains, provides a breeding ground for rodents and insects, and is thus a transmission route for many diseases endemic in developing countries. Inefficient solid waste management (SWM) can be a more serious health hazard than the sanitation wastes from on-site sanitation systems.

About fifteen years ago, during an international conference on environmental issues, a decision was reached to produce a publication showing examples of successful — appropriate, affordable and sustainable — solid waste projects in developing countries. Not one of the participants in the working group could provide a single example of a success. Some small progress has been made in the intervening years, but there are still only a handful of success stories from developing countries around the world.

SWM is generally seen as a low priority within a city's financial constraints and the people concerned are often low-status, short of resources and weak on management (see Adrian Coad's article, page 6). When waste management systems break down, and a city reaches crisis point, consultants from the industrialized countries are called in. In many cases these consultants try to impose the technologies which they know from the cities of their home countries, with little or no understanding of the different socio-economic, and in particular the different waste characteristics, found in lower-income countries.

Municipal waste — North and South

Municipal waste in the more industrialized countries has a large packaging content, low density, very little putrescible content, and little inert sand and ash. Typical waste

Country	Waste density (kg/m^3)
Industrialized countries:	
United Kingdom	150
United States of America	100
Middle-income countries:	
Egypt	330
Nigeria	250
Singapore	175
Tunisia	175
Low-income countries:	
Bangladesh	600
Burma	400
India	400-570
Indonesia	400
Nepal	600
Pakistan	500
Sri Lanka	400
Thailand	250
United Republic of Tanzania	330

NB: These figures do not take account of local variations within countries or changes in waste densities between the households and the collection vehicles. They should therefore only be considered as a guideline to variations between different countries.

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A woman street sweeper pushes a hand cart so badly designed that she is permanently deformed as a result of this work.

Table 1. Typical waste densities in different countries.

densities from different countries are set out in Table 1 — it can be seen that American and European wastes, for example, will have densities between 90kg/m^3 and 150kg/m^3. The refuse collection vehicles used in such countries must compact the wastes to enable an economic load to be carried. Regular collections and colder climates ensure that any putrescible wastes do not have time to decompose before collection, and any small amount of ash or sand is relatively harmless.

In a lower-income country, however, the waste density at the point of collection may be as high as 400kg/m^3 to 700kg/m^3 and there is obviously no need for compaction to achieve economic truck loads. Waste will generally contain a large proportion of putrescible material and if this is left for more than two or three days in a hot climate it will decompose to form highly corrosive acids. In addition, if roads are not paved or people are using wood or charcoal for cooking, there will be a high proportion of abrasive sand and ash.

The combination of high density, acidic and abrasive wastes means that the types of trucks used in more industrialized countries will last only a very short time because of overloading, corrosion of sheet metal bodies and abrasive wear of the moving compactor parts. Thus vehicles which may have a ten-year life in a high-income country may last for only two or three years in a low-income country. Despite this, time after time such vehicles are being recommended by consultants, promoted by high pressure salesmen and provided under aid programmes, sometimes with soft loans with repayments many times the real life expectancy of the equipment

provided. I visited one city in Africa which was trying to meet the capital repayments on four generations of refuse trucks (all of which had broken down) supplied by four different countries under long-term loans. They were still faced with trying to find a solution to their refuse problems.

Devising a cost-effective system

It is impossible within the limits of a short article such as this to demonstrate solutions to all developing country waste management problems, but the following guidelines may point the direction. The choice of the most cost-effective collection system is determined by many factors, not least of which are the socio-economic conditions under which people are living. Other significant factors include the density of the wastes which will determine the appropriate type and size of body to be fitted to any truck, animal cart or handcart to achieve optimum loads. In general waste densities will be highest in the lower-income areas of any city.

The volume of wastes generated per capita will also vary greatly between different income areas. In very low-income areas, the burning or burying of wastes on site may be the only practical and affordable solution.

The most appropriate haulage system will be determined by the distances between collection and disposal points. Handcarts can be cost effective over very short distances, for example, while tricycles will be more efficient over medium distances where there are paved roads and only small gradients, and animal carts can operate over uneven ground. Agricultural tractors and trailers are very efficient over distances up to perhaps 5km, while only trucks may be efficient over distances greater than this.

Where there are long distances between collection and disposal points, a combination of small manual or animal-drawn primary collection vehicles to bring the wastes to local transfer points, followed by larger transport vehicles to transport the wastes to the disposal site, may be the appropriate solution.

The choice of the optimum primary collection system will be determined by street widths, road surfaces and traffic conditions, as well as by haulage distances.

Transfer points can consist of a simple container to be collected by a tractor-

'I can look after my enemies but may God protect me from my friends.'
The Italian bandit, Guilliano.
This can well be applied to the agencies who provide such inappropriate equipment.

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Truck with loading height of around 2 metres; waste is falling onto the loader's head.

solid waste management

trailed container pick-up, or by a truck-mounted, pick-up system; or they may consist of small transfer stations located throughout the city with a capacity of 10 to 50 tons/day. Larger transfer stations, servicing a wider area, may have capacities from 50 tons/day upwards. The optimum transfer type and location will be determined by the population density in any particular area, the waste generated per capita, the waste density and the haulage distances.

The level of service to be provided will be determined by financial considerations. There will always be a preference for a high-level service with a daily refuse collection from each household, but this may not be affordable. A much lower cost but lower level of service may consist of containers to which people bring their own wastes with a collection every two or three days.

Fixed refuse compounds, which invariably act as breeding points for rodents and flies, and a constant reservoir of bacteria, should be discouraged.

Transport systems relying on specialized imported vehicles will invariably fail as a result of a lack of the service and spare parts provided. Wherever possible, locally manufactured truck bodies and other equipment should be used and the choice of the most appropriate truck chassis will be determined by the available parts and service back-up in each country.

The number of vehicles required and consequent capital and operating costs will be determined by the ease and speed of loading of the vehicle. Thus a collection system where each household is provided with a plastic bag which is then thrown directly into the truck may be more cost-effective than a system using bins, each of which must be carried by hand and emptied into the truck. However, reduced waste densities where there are bag collections and consequent disposal problems must be taken into account.

Any practices which will reduce the amount of waste to be collected and disposed of must be encouraged. These will include waste reduction, pre-collection house-to-house scavenging for recyclable materials and re-use of bottles and packaging.

Wastes from clinics and hospitals and many industrial wastes are extremely hazardous to the collection crews and must not be allowed to enter the normal

Choice of system should start with a detailed survey of the city to determine:

- local waste characteristics in each area
- per-capita waste generation rates in each area
- population densities in each area
- the level of service affordable by each community
- existing household waste storage systems
- street and traffic conditions in each area
- haulage distances to existing disposal facilities
- suitability of existing disposal facilities
- alternative disposal points and methods

- locations for transfer points
- market wastes
- commercial wastes
- clinical and hospital wastes
- industrial wastes
- service and maintenance facilities
- local equipment and manufacturing facilities
- strengths and weakness of local authority management
- availability and strength of private contractors
- availability of funding
- sources and methods for cost recovery
- suitability and enforcement of any legislation

household waste stream. Special collections and disposal facilities may be required.

It can be seen from this list that there are many factors to be considered in the selection of the most appropriate collection system, and that a single type of system is very seldom appropriate throughout any one city. A detailed survey of the city should be carried out (see box) before any decision is made. ∎

about the author:
Manus Coffey is a Waste Management Consultant specializing in solid waste management and sanitation in developing countries. Contact: Manus Coffey Associates Ltd, Waste Management Consultants, Kiltipper Road, Tallaght, Dublin 24, Ireland. Fax. +353 1 451 9604. E-mail: consult1@indigo.ie