CHAPTER V. STREET CLEANING

A. Introduction

Street sweeping is one facet of a solid waste management system in which public education and public relations play critical roles. Unfortunately, very little information is available in the literature on the various aspects associated with street sweeping. The wastes deposited on the streets create a negative visual impact, particularly on visitors, and thus indirectly affects the economy of the city.

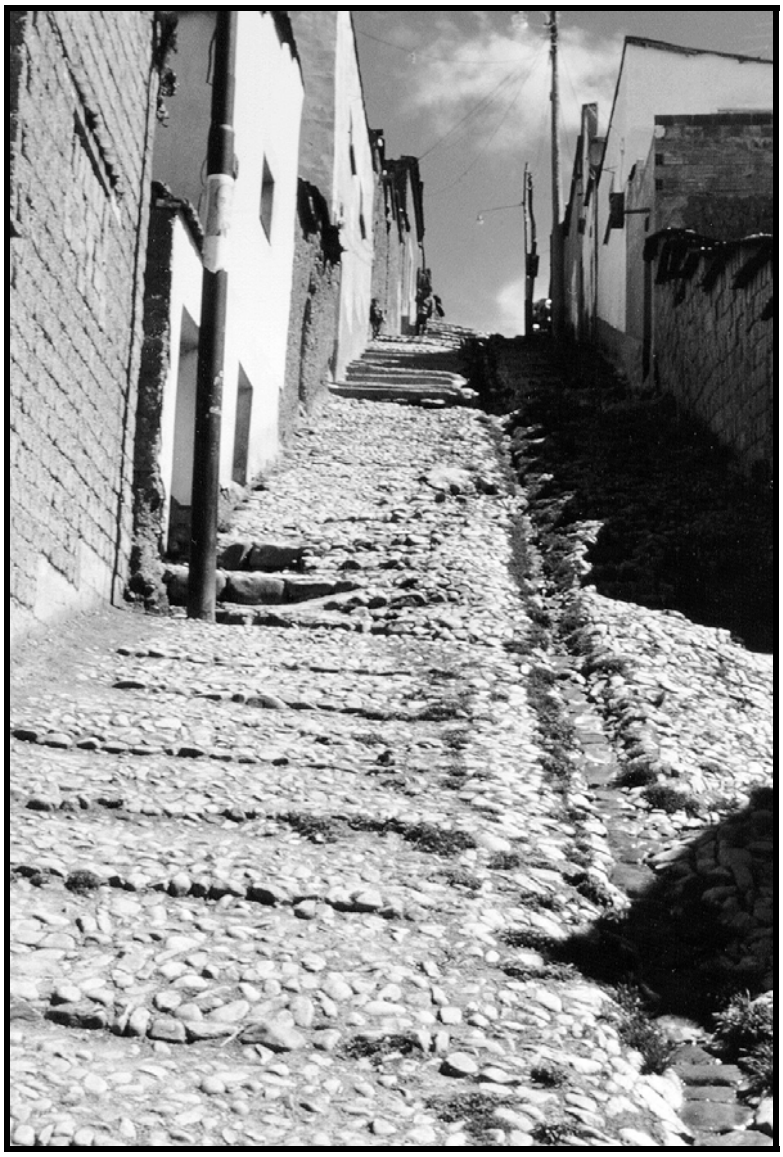
In many cities, particularly the small ones in economically developing countries, only the paved streets are swept. Since not all of the streets are paved, a relatively high portion of the city does not receive street sweeping services. Views of typical streets in marginal and low-income areas are shown in Figures V-1 and V-2.

Courtesy: CalRecovery, Inc.

Figure V-1. Unpaved streets in marginal area in Latin America

A considerable amount of the work associated with street sweeping is due to inappropriate behaviour on the part of the public, such as discarding litter in the street. Additionally, in many cities in developing countries, particularly in medium- and low-income areas, a high proportion of street wastes is generated from deficiencies in the refuse collection system. Due to the poor coverage of the collection system, a number of people opt for discarding their wastes in the street or in vacant lots. In essence, this situation merely transfers the responsibility for removing the wastes from the refuse collection crew to the sweeping crew. Other causes that lead to the large quantities of litter that may be observed in some cities in developing countries are: improper or no cleanup activities after completion of public works projects, inadequate or inappropriate species of plants and trees selected for urban landscaping, erosion of soil from vacant lots and unpaved streets, inefficient or non-existent storm drainage systems, accumulation of construction

materials as well as construction debris on the streets, and spillage of wastes set out for collection by either scavengers or animals. It is fairly common for the collection system in large metropolitan areas to conduct special operations to remove wastes from well known illegal disposal sites. Obviously, the costs involved in collecting wastes that have been scattered in the street are considerably higher than the costs of collecting the wastes by means of conventional containers.



Courtesy: CalRecovery, Inc.

Figure V-2. Narrow and steep "street" in a low-income area

Despite the fact that municipalities may spend approximately 10% to 20% of their budgets on street cleaning and sweeping, the process is not normally optimised. There are several types of tools, equipment, and methods (both manual and mechanical) available for street cleaning. Because of the tasks and costs involved in the process, street cleaning is also a system in which there are opportunities for savings by simply improving the efficiency of the process.

The primary objectives of policies associated with a street cleaning system should be: 1) the provision of efficient, cost-effective waste collection services from the source, 2) reduction of street litter through regulation, public education, and enforcement, 3) the use of systems that achieve high labour productivity, and 4) the design and use of effective tools and equipment.

B. Types of street wastes

For purposes of solid waste management, street wastes can be classified into three main categories, depending upon the type of generator. The classification is as follows: 1) wastes generated by natural causes, 2) wastes generated by road traffic, and 3) wastes generated by the public (behavioural wastes) [1]. A discussion of each type follows.

B1. WASTES generated by natural causes

As the name implies, these wastes are generated by natural phenomena and are difficult to avoid. They include dusts blown from unpaved areas, and leaves and flowers that fall from trees and plants in the community. Since wastes produced by natural events cannot be avoided, the method of management must be control, for example, the use of such measures as planting of vegetation and other artificial methods to prevent erosion in empty lots, planting of adequate trees and vegetation as wind breakers, and careful selection and regular maintenance (e.g., pruning) of the trees planted in the city.

The result of poor stormwater management and high rainfall leading to the accumulation of sand, mud, rocks, and other debris in a city in Latin America is shown in Figure V-3.

Courtesy: CalRecovery, Inc.

Figure V-3. Impact of poor stormwater control on street sweeping

B2. WASTES generated by traffic

Motor vehicles can generate a relatively high proportion of street wastes. Motor vehicles deposit dirt and mud, as well as oil and rubber on the roads. Particulate matter from diesel emissions also accumulates on streets, trees, and building surfaces, creating a public nuisance. In addition, in developing countries, it is common to transport materials in vehicles that are uncovered, and there can be accidental spillage of a vehicle's load. Additionally, animals drawing vehicles can deposit excrement on the road surface. Mud is often carried out of construction sites, adhered to the tires

of motor vehicles, and subsequently deposited on adjacent roads. In general, traffic wastes are unavoidable; however, it is possible to control them through public education and the promulgation of appropriate rules and regulations. Regulations requiring that loads be covered to reduce spillage and that vehicles be properly cleaned before leaving muddy construction sites can positively contribute toward the reduction of wastes generated by traffic.

B3. WASTES generated by the public

There are two major sources of wastes generated by the public: 1) litter thrown onto the streets by pedestrians, and 2) residential and commercial wastes swept or discarded from private premises.

As previously indicated, a large fraction of these wastes can be controlled, provided that an efficient and reliable refuse collection service is in operation and that litter bins are provided for use by pedestrians. These two conditions should be complemented by a continuous program of public education, combined with strong legislation and enforcement procedures. Another potential solution to reducing the amount of litter is to offer a free or relatively inexpensive program to collect non-conventional wastes such as construction and demolition debris, tree trimmings, and others.

C. Manual street cleaning

The design of a conventional street includes three distinct surfaces: a roadway for vehicular traffic, a gutter, and a sidewalk on both sides of the street for use by pedestrians. The sidewalks are slightly elevated and are separated from the roadway by a curb and gutter. The gutter is the lowest part of the road structure and serves to control, collect, and direct stormwater to a drainage location or system. The gutter is provided with outlets or discharge points at certain intervals to prevent stormwater from accumulating on the roadway.

Typically, it is not necessary to sweep the surface of a roadway. The reason is that vehicular traffic usually generates turbulent forces that are sufficient to direct dust and litter from the crown of the road toward the gutters. Consequently, in most places, the process of street sweeping consists of cleaning the sidewalk and the gutters. In some cities, such as is the case in Montevideo, Uruguay, it is traditional to wash the sidewalks. This tradition, of course, results in another set of problems.

Usually the wastes that accumulate on the sidewalks consist primarily of light materials (i.e., leaves, paper, plastic, matches, and cigarettes) and some dust. On the other hand, a relatively high concentration of heavy materials and dust has the tendency to accumulate in the gutters. Consequently, the tasks for cleaning each one of these surfaces are different.

Although these principles apply to most streets of a typical city, the quantity and types of wastes generated varies in proportion to the level of human activity and the public's sense of civic duty. Therefore, the required frequency of sweeping can fluctuate from several times a day to once a week.

C1. EQUIPMENT

The typical equipment used for manual street cleaning includes: brooms, shovels, and handcarts.

C1.1. Brooms

There are two general types of brooms used for street sweeping, depending upon the type of material used for their manufacture. The first type is that made from long fibres and formed into a

bunch (this type is commonly used in Asia, although they are also used in some areas in Latin America). The second type is that in which bunches of filaments are inserted into a wooden section (about 10 cm by 10 cm in cross section and 40 to 50 cm long); this section is attached to a wooden pole. Due to the fundamental differences in their design and the type of materials used for their manufacture, each type of broom is used differently. The broom made from long fibres has the length and flexibility to allow the user to take long strokes without the fibres exerting high pressure on the ground. These characteristics make this type of broom an excellent tool for sweeping litter and leaves from unpaved surfaces. On the other hand, the stock broom is pushed ahead of the sweeper. The sweeper uses short strokes to push the litter in front of him. The filaments in this type of broom are shorter and stiffer than those of the bunch broom; therefore, this broom generally is used to remove materials that have the tendency to adhere to the surface of streets. Depending upon the width of the stock and the stiffness of the filaments used, these brooms are excellent tools for collecting dust and sand.

Stock brooms of about 30 cm filled with a natural fibre have been widely used in the United States and in Europe for sweeping gutters. Recently, synthetic fibres such as polypropylene have replaced some of the natural fibres.

Consequently, a sweeper should be equipped with two types of brooms, one for the gutter and one for the paved areas.

C1.2. Shovels

The function of the shovel is to pick up the material that has been swept into a pile with the broom for placement in a container. The main type of shovel that is used for this purpose is a large straight-blade shovel made of plastic or metal. Metal shovels are heavier than plastic ones but tend to last longer and are more versatile, particularly to remove materials adhered to the paved areas.

C1.3. Handcarts

Handcarts are widely used for street sweeping throughout the world. A description of handcarts is provided in another section. Street sweepers usually modify the equipment they are provided with to suit their needs. Various types of carts observed by the authors in economically developing countries are shown in Figure V-4.

C1.4. Additional equipment

All sweepers should be provided with uniforms, gloves, safety equipment, and, in some instances, plastic bags. In some locations, it may be necessary that the sweepers use a cutting tool to remove weeds and brush.

D. Mechanical sweeping

The majority of mechanical sweepers are mobile units that use a vacuum system to collect the waste materials. Generally, the suction action is complemented by one or more rotating brushes for dislodging residues that adhere to the surface of the road. There is a wide range of mechanical sweepers. They vary in size from very small units controlled by a pedestrian, to large mechanical sweepers mounted on a vehicular chassis. The large mechanical sweepers generally are equipped with an auxiliary engine to generate the vacuum and, in some cases, are fitted with a hose that can be controlled by an operator to pick up refuse from areas that are difficult to reach (i.e., dry leaves from drainage ditches). The operating speed of the smallest machines is about 2 to 3

km/hr, that of the largest sweepers is 10 km/hr or greater. Mechanical sweepers are efficient for the collection of light litter, fine dust, and sand from roadways.

Figure V-4. Samples of some handcarts used for sweeping in developing countries

The conditions typically found in economically developing countries limit the role of mechanical sweepers to that of simply supplementing manual sweeping. Mechanical sweepers normally are found in the large metropolitan areas of developing countries. The degree to which mechanical sweepers are utilised for a specific application should be based on thorough analyses of advantages and disadvantages, as well as the costs associated with using them as opposed to using manual sweepers. In addition, mechanical sweepers have the tendency to be extremely

maintenance-intensive units. The internal mechanisms may be damaged in the process of collecting large objects illegally disposed on the streets. Consequently, these machines should be supported by well equipped maintenance facilities stocked with a complete inventory of replacement parts.

E. Design of sweeping systems

The typical task of a manual sweeper can be divided into two main phases: 1) sweeping and loading the wastes into a storage container, and 2) transporting the full container to a transfer point where it can be emptied. In terms of efficiency, the first activity is productive while the second is not. The second activity is not productive because the time used in transporting the container for unloading is time that is not spent performing the main task of sweeping. Similarly to the waste collection phase of waste management, one of the main objectives in designing a system for manual sweeping is to maintain the total amount of time spent on transport to a minimum. This objective can be accomplished in either of two ways: 1) minimising the distance over which the collected wastes have to be transported, or 2) providing the maximum size of receptacle for the wastes that are collected.

E1. VEHICLES

One of the most appropriate solutions to maintaining the time spent on transporting wastes to a minimum is by equipping the sweeper with a cart and a sufficiently large container. The gross weight of the cart when loaded may be as much as 200 kg if the terrain is relatively level, and less in hilly districts.

In order to keep the total efficiency relatively high, the design of the cart should avoid the need to empty its contents on the ground at the transfer point. Emptying swept up litter onto the ground prior to transferring it is fairly common in several regions around the world. Besides the potential negative environmental impacts, this process results in the time-consuming task of having to load the wastes either into another container or into a vehicle. One potential solution is to design the cart such that the container can be removed and emptied by the sweeper into a temporary storage or transfer facility. Some of the most important design features of a handcart are:

- the frame should be made out of light tubular metal supporting a platform on which are placed one or more portable containers;
- the wheels should have a large diameter, with rubber tires, preferably pneumatic, using ball or roller bearings (to reduce friction);
- the containers should have a capacity of 50 to 80 L each, depending on the density of the wastes; and
- the frame should be equipped with brackets to accommodate the ancillary equipment (brooms and a shovel).

In some cases, teams of three to five individuals are used. In this situation, a vehicle with a capacity larger than 50 L is necessary. Possible alternatives include the use of animal-drawn carts or a small motor vehicle. One important criterion for this option is that the vehicle follows the sweepers relatively closely because piles of sweepings that are left unattended are likely to be scattered by traffic or wind.

E2. SCHEDULING

The planning of an effective manual sweeping system requires the classification of streets, or sections of streets, according to the required frequency of sweeping. The classification can be done based on location, level of traffic, type of surface, character of area (e.g., commercial, residential), and others. The following is a typical method of classification:

Class	Character of Street	Frequency of Sweeping
1	city centre shopping	5 x daily
2	market areas	5 x daily
3	city centre, main streets	2 x daily
4	suburban area shopping	2 x daily
5	city centre, minor streets	1 x daily
6	suburban main streets	1 x daily
7	residential streets, low-income	3 x weekly
8	residential, high-income	1 x weekly

Frequency requirements and classification systems should be determined by each municipality based on time and motion studies, and site visits. The results of the studies will indicate the length of street that a person can sweep at the required frequency. For example, time and motion studies may show that for Class 1 streets, one sweeper can be assigned between 250 and 300 m/workday, while for Class 8 the length may be as great as 5 km. On the basis of this information, a city can be divided into routes for sweepers that will result in fairly uniform workloads, despite great differences in the lengths to be covered [1].

Besides the frequency, the time of the service should be carefully defined to avoid traffic, parked vehicles, and pedestrians. Night or early morning hours, particularly in non-residential areas, seem to be the most appropriate times.

Sweepers generally work 8 hours each day. In many instances, the shift begins as early as 3:00 or 4:00 am. Most sweeping stops 5 to 6 hours later (to avoid traffic) and resumes at about 2:00 pm until the shift is completed.

E3. ORGANISATION of manual sweepers

The organisation of manual sweepers usually requires the establishment of depots. The depots can be used for managing the sweepers, for transferring the wastes that have been collected, and for providing a certain amount of comfort to the workers. The depot should include the following facilities: an office for the supervisor or foreman, an area where sweepers report to work, a parking area for the handcarts, storage for tools and equipment, a transfer area for the waste materials that have been collected, bathrooms, lockers, and a resting area.

Each depot should be located such that the distance travelled by the sweepers is kept to a minimum. If it is not possible to establish district depots, then the sweepers usually are requested to report to a central facility to collect their equipment. The sweepers are then transported to and from their respective routes. The alternative solution is to have the sweepers store their equipment in a nearby park or municipal facility so that they do not have to travel long distances to report to work. However, a supervisor would have to check each day to make sure that the employees have indeed reported to their assigned area.

Sweeping is a strenuous activity, and can be dangerous if it is incorrectly scheduled or improperly assigned. This is particularly the case when sweepers are assigned to clean roadways at night that are travelled by vehicles moving relatively fast. In addition, personnel selection sometimes is inadequate, and oftentimes older members of other solid waste management divisions (e.g., collection crews) are transferred to sweeping duties. The physical condition and age of the sweepers obviously impact the efficiency of the system.

E4. TRANSFER facility

The design of a street sweeping system, particularly in large metropolitan areas, should include transfer facilities. The transfer facilities should be located within a reasonable distance of each route. As previously indicated, the transfer facility would ideally be located in the same parcel as the district depot. This location would allow for almost continuous supervision of the site and thus avoid its use as a disposal facility for residential or commercial wastes. There are several designs that can be adopted for a transfer facility. Brief descriptions of some of the most common systems currently in use are presented. One system calls for the use of a trailer having capacities of 5 to 8 m3. This trailer would be exchanged two to four times per day. The other system requires the use of steel containers, with a capacity of about 4 to 5 m3 and exchanged four to five times per day. The third alternative relies on the use of exchangeable bins so that the sweepers can remove the full ones and replace them with an empty one at the transfer facility. This design requires that a vehicle and a crew be assigned the task of collecting the contents of the full bins at regular intervals throughout the day.

In the event that it is not possible to build or establish a transfer facility, it is possible to schedule a vehicle to collect the wastes from the sweepers. The success of this system depends upon careful routing and the development of fairly precise schedules for both the sweepers and the vehicles. The application of this system offers the advantage that the sweepers are able to devote their entire time to sweeping and, thus, can achieve a high efficiency. The system does not eliminate the need for other facilities such as rest areas and storage areas for carts.

In quest for reaching high levels of productivity, some municipalities have instituted a system whereby the sweepers are provided with plastic bags, which are used as inserts in their bins. Once filled, the bags are removed, tied, and placed in pre-arranged locations to be picked up by a collection crew. Disadvantages of this option include the relatively high cost of purchasing the plastic bags, as well as the environmental impact of disposing of the plastic.

In other locations, such as that shown in a marginal area in La Paz, Bolivia, the sweepers collect the debris on a tarp. The tarp (including its contents) is tied around the sweeper's back to move from street to street. Sweepers in the process of cleaning a street are shown in Figure V-5. Eventually, the sweepers unload the wastes in pre-determined locations for collection by conventional vehicles.

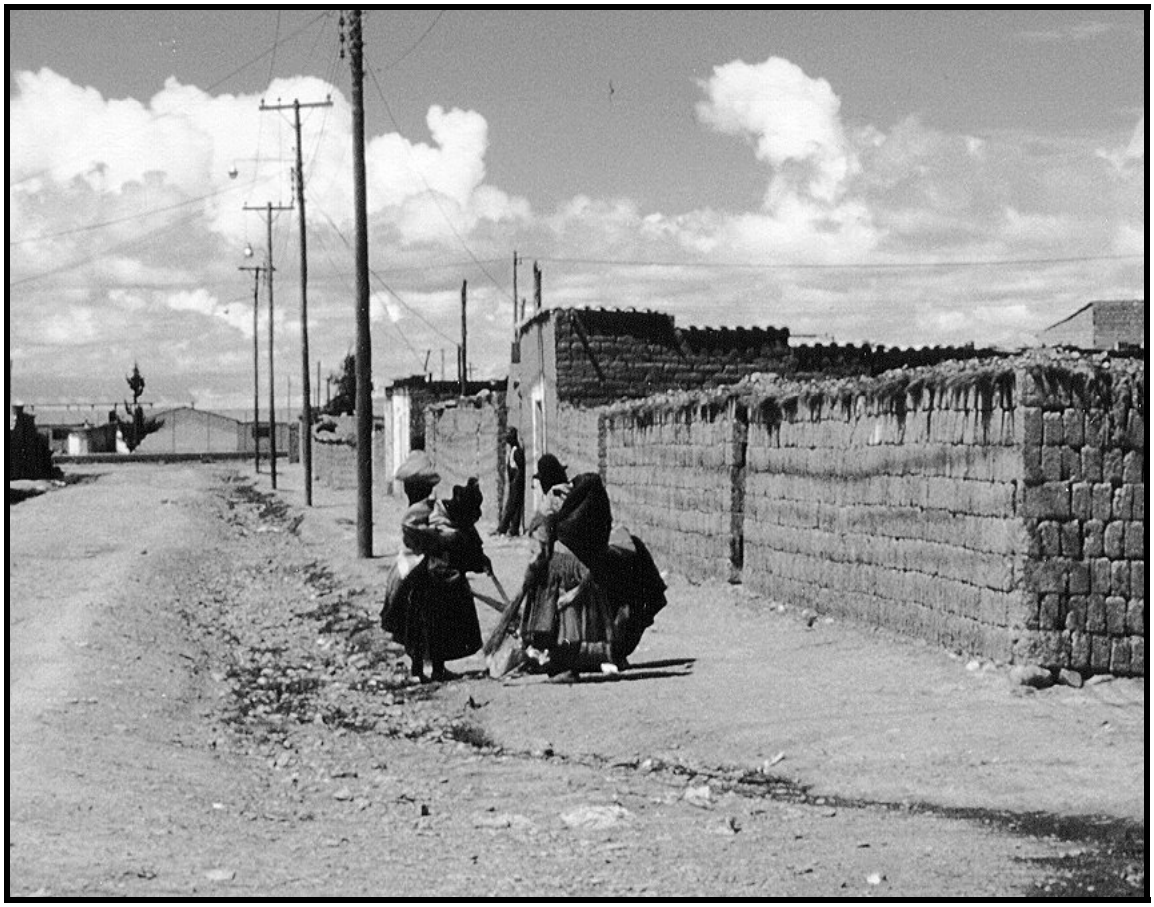
F. Litter bins

Litter bins constitute a basic requirement for the control of litter. The bins should meet the following criteria: 1) practical and inexpensive design; 2) spaced at convenient intervals; 3) emptied frequently; and 4) easy to empty, clean, and repair or replace.

F1. DESIGN of litter bins

Litter bins should be made of non-flammable materials because cigarettes are often thrown into them. Consequently, some types of plastics cannot be used for this application.

The bins should include an outer casing of standard colour and lettering, and an insert that can be easily removed for emptying. The size of the bin is a function of location, spacing, and frequency of emptying. The normal maximum size should be about 100 L. The top aperture of a litter bin should be partly covered to avoid the loss of contents in high winds and also to prevent the placement of oversize objects.



Courtesy: CalRecovery, Inc.

Figure V-5. Labourers in the process of sweeping unpaved street using bunch brooms

F2. SITING and emptying

Placement or siting of litter bins can be based on the classification of the streets (i.e., location, level of traffic, etc.). Small bins can be attached to lighting posts, street signs, or similar units. Large litter bins should be mounted on the sidewalk, although this requirement can be costly and results in obstructions. It is important to design the units so that they can be fastened to something in order to avoid theft and vandalism. At the same time, the design should be such that they can be rapidly disconnected for emptying.

Small bins could be emptied by sweepers, whereas the large ones should become part of a route for a special collection vehicle. It is important to plan the location of the bins, to keep track of their condition for repair or replacement, and to assign responsibility for their emptying.

G. Legislation

A large percentage of street litter is generated due to the lack of public education and inappropriate behaviour. Consequently, legislation can play an important role in achieving high standards of cleanliness and reducing the total workload of sweeping. The following types of legislation can make substantial contributions to the reduction of street wastes:

- Reduction in dirt and mud: Require that builders and contractors provide facilities for cleaning the tires of vehicles leaving the site to avoid deposit of mud on adjacent roads. In addition, dust control measures within the site should be enforced.

- Reduction of street litter: Establish regulations that prohibit sweeping of refuse from a house, shop, or other premises onto public pavement. In addition, establish a set of fines for dropping litter in a public place.

- Reduction in traffic wastes: Require that vehicles cover their loads. Establish a system of fines for failure to secure or cover a load.

- Control the type of vegetation that can be planted on or near the streets.

- Regulate the management of construction materials, as well as the disposal of construction and demolition debris.

- Require the maintenance of vacant lots (walls, cleanup, fencing, etc.).

It should be kept in mind, however, that most types of regulations or legislation will not be successful if they are not properly enforced, well understood, and accepted by the majority of the public. Consequently, legislation should be preceded by the introduction of a good waste management system and efficient services. In addition, the legislation should be complemented by a comprehensive public education campaign to enlist cooperation.

H. Reference

1. Flintoff, F., Management of Solid Wastes in Developing Countries, WHO Regional Publications, South-East Asia Series No. 1, World Health Organization, New Delhi, India, 1976.

Part II

Processing and Treatment