Chapter 13

Selection of
The Best Technical System

13 Selection of the Best Technical System

13.1 Policy for Selection of the Best Technical System

13.1.1 Criteria for Selection

Considering the current situation and background of SWM in the study area, the following are policies for the selection of a technical system:

1) Systems and technologies to be adopted should be simple so that operation and maintenance are easy and inexpensive.

2) Foreign finance requirements for the purchase, operation and maintenance of facilities should be minimal. The use of locally available materials and services should be maximized.

3) Technical system proposals have to be consistent with the institutional requirements to ensure their efficiency.

13.1.2 Selection Procedure of the Best Technical System

An SWM technical system consists of various technical subsystems such as discharge and storage, collection and haulage, processing, recycling, street sweeping, final disposal, etc. A number of alternatives can be formed from the combination of these various subsystems. Hence, selection of the best technical system will be carried out according to the following procedures.

1. Examination of preconditions for selection of subsystems.
2. Identification of potential subsystem technologies for the study area.
3. Screening potential subsystem technologies.
4. Comparison of estimated unit waste collection and haulage costs for each vehicle type.
5. Selection of an optimum technical system.

13.2 Examination of Preconditions for Selection of Subsystems

The establishment of the best technical system is mainly influenced by the location and number of proposed disposal sites, that was determined based on the following policies established by the AMDC for the study in March 1998.

The existing final disposal site shall be utilized for as long as possible by improving the sanitary level and by making use of the whole site in the most effective manner.

A new final disposal site shall be constructed before the existing site is completely filled. The new site shall be sited in a location not to far from the city center so that the waste haulage distance will not exceed 15 km.

13.3 Identification of Potential Subsystems for the Central District

The screened potential subsystems for the Central District are listed in Table 13-1.

Table 13-1: Potential Subsystems for SWM in the Central District

Technical Systems	Technical Sub-systems	Sub-system Components
Discharge and Storage	• Source Separation	• Mixed discharge • Separate discharge
	• Type of Storage Equipment	• Paper or plastic sacks • Dustbins • On-site waste storage • Containers (1 to 2 m^3) • Large communal containers (more than 5 m^3)
Primary Collection	• Type of Collection System	• Handcart • Animal drawn cart • Pedal cart • Motorized cart
Secondary Collection and Haulage	• Collection Frequency	
	• Collection Method	• Mixed collection • Separate collection
	• Collection System	• Point collection • Curb side collection • Door-to-door collection • Bell collection • Public container collection
	• Collection Schedule	• Day collection • Night collection
	• Collection Vehicle	• Compactor truck • Tractor and trailer • Dump truck • Detachable truck
	• Transfer Station	
Street Sweeping	• Cleaning Method	• Manual street sweeping • Mechanical cleaning • Vacuum cleaning • Flushing
Processing and Treatment System	• Incineration	
	• Refuse Derived Fuel (RDF)	
	• Biogas Production	
	• Pyrolysis	
	• Composting	
	• Size Reduction	
	• Mechanical and Manual Sorting	
Recycling	• Government Related	
	• Private Sector Centered	
Final Disposal	• Method of Sanitary Landfill	
Maintenance of Vehicles and Equipment	• Preventive Service Workshop	
	• Full Service Workshop	

13.4 Screening Potential Technologies

13.4.1 Discharge and Storage System

Waste is generated on a somewhat continuous basis. However, collection occurs intermittently, a few times a week or perhaps daily, depending on the quantity generated at a specific location and climatic conditions. Therefore, it is necessary to provide proper on-site storage for waste until it is collected.

Storage is quite important because it can have a significant effect on:

- Public health and aesthetic conditions.
- Subsequent functional elements such as collection.
- Public attitudes concerning the operation of the system.

The effects on these aspects vary depending on the generation source, i.e., residences, shops, office buildings, etc.

Accordingly, this section deals with on-site handling and storage systems available for the study area.

a. Effects on On-site Handling and Storage

a.1 Public Health and Aesthetic Conditions

In the Central District, handling and storage of residential waste is extremely important because residential waste make up more than 60% of the total waste generation amount. Furthermore, most of the waste is generated in densely populated areas where there is limited storage space, thereby having significant impacts on public health and aesthetic conditions.

Public health concerns are related primarily to the infestation of storage areas for solid wastes with vermin and insects that often serve as potential vectors of diseases. By far the most effective control measure for both rats and flies is proper sanitation. Typically, this involves the use of paper, plastic bags, or containers with tight lids, the periodic washing of the containers as well as of the storage areas, and the frequent removal of biodegradable materials, which is especially important in areas with a warm climate.

Aesthetic considerations are related to the production of odors and the unsightly conditions that can develop when adequate attention is not given to the maintenance of sanitary conditions. Most odors can be controlled through the use of sealed containers and with the maintenance of a reasonable collection frequency, or through the timely discharge of waste by dischargers with punctual waste collection services. To maintain aesthetic conditions, the container should be scrubbed and washed periodically.

a.2 Subsequent Functional Element

Storage and collection are separate operations but must be closely coordinated. The type, size and location of containers are very important factors in determining the most efficient collection system. Large public containers are favorable in terms of

maintaining public health and aesthetic conditions but difficult to load manually. Small containers are quite convenient for loading waste but reduce waste collection efficiency because they require more frequent stops for loading.

b. Present Storage Systems

There is no appropriate regulation obliging dischargers to use suitable containers when discharging waste, thereby causing sanitary and aesthetic problems, as heaps of waste scatter everywhere. In addition, this condition also makes the loading of waste onto waste collection trucks difficult.

c. Potential Storage Systems

The applicability of the use of the following five storage systems, commonly used in many countries, in the Central District are discussed below.

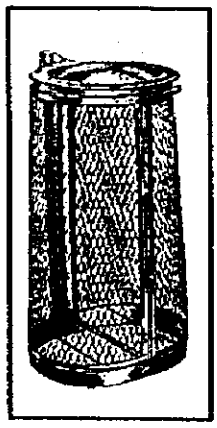
- Paper or plastic sacks
- Dustbins
- On-site waste storage
- Containers (1 to 2 m^3)
- Large communal containers (more than 5 m^3)

There is a wide range of issues to be considered in the selection of the best storage system for the Central District. The examples are as follows.

- The amount and composition of waste discharged.
- Waste composition and components.
- The collection frequency, most often determined by climate and waste composition.
- The space available near the source and the accessibility of the area to collection vehicles.
- Environmental and occupational health hazards.
- Suitability to the actual environment, i.e., functions suitable for the actual user.
- The ability to stand misuse, rough climate, and animals scavenging.
- The total investment and operational costs over a given period.
- The habits and traditions of users and collection crews.

d. Storage System

d.1 Paper or Plastic Sacks



The paper or plastic sack system generally entails the use of 20 to 80 liter sacks for the storage and handling of waste, that is later collected for further haulage and disposal. They are therefore expendable. This system can be used by any discharger, i.e., residents, shop owners, etc.

Advantages

- The system is very sanitary because the sacks are disposable.
- The system is labor and time saving because the sacks are light in weight and expendable thereby requiring less time and effort for haulage.

- The system does not require any initial investment.

Disadvantages

- The system requires the continuous purchase of sacks.
- The use of disposable sacks increases the waste generation amount.
- Sacks can easily be torn by domestic animals or children or when too full.
- Contents of the sacks when left untied may scatter at pick-up points.

Applicability

Although sacks require less initial capital, the expenditure for its continuous purchase usually exceeds that for the provision and maintenance of permanent containers. However, although some citizens may find it difficult to cope with the associated financial burden, the use of sacks is still more affordable than permanent containers.

Currently, in the study area, the use of plastic sacks for storage and discharge of waste is common place. Most plastic sacks used are shopping bags, but some large discharges such as shops and some high income residents use bigger plastic garbage sacks that are sold in shops.

The Study Team observed that this system is suitable for the study area because no significant problems have risen. The use of shopping bags has no effect on the waste generation amount because they are distributed by shops for shoppers to carry their purchases. In some places, waste scattering often caused by domestic animals are prevented by the use of a waste stand.

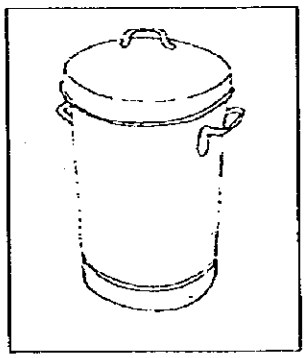
The waste stand system often used in Latin America is recommended because it helps to keep the site clean, if the cost involved is affordable.

In conclusion, the following systems are recommended; the most appropriate system should be selected by citizens depending on their preference, financial capability, etc.

1) Plastic or paper sacks
2) Plastic or paper sacks with a stand
3) Plastic or paper sacks with a cage

d.2 Dustbins

Dustbins refer to all small-size containers with lids, ranging from 30 liters to about 120 liters in size. One man can reasonably lift and empty containers weighing up to about 28 kg (70 liters), while two men are required to lift a 48 kg (120 liters) container. Dustbins of the former size may be used at individual premises or as communal dustbins for 6 to 12 families either at or farther from the collection points. They can also be used as litter bins for street sweepers or the general public. The dustbins may be made of galvanized steel or high density polyethylene and must be weather resistant.



Advantages

- This system provides sanitary conditions because waste stored can be completely covered.
- This system maintains aesthetic conditions.
- This system lasts for more than several years.

Disadvantages

- This system requires a large initial investment for the purchase of dustbins.
- Dustbins require periodic washing to maintain their sanitary condition.
- Dustbins are easily stolen because of their usefulness.

Applicability

At present, approximately 10% of dischargers use dustbins in the study area and the three most common types are: empty drums, plastic waste containers and plastic water buckets.

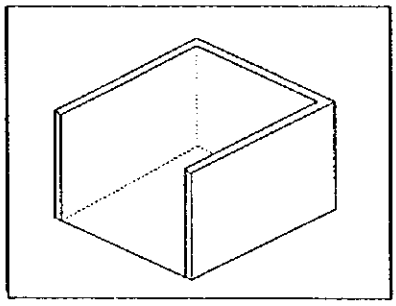
Plastic water buckets and plastic waste containers are suitable for the storage and discharge system, while empty drums are too heavy for loading waste onto a truck. The use of empty drums is not appropriate because it reduces the efficiency of waste loading procedures.

In contrast with the use of sacks, this system is less expensive in the long run. However, the initial capital required is too much of a burden for some dischargers. To enforce the use of this system, indiscriminately, will pose a financial constraint on many people.

In conclusion, the use plastic containers is appropriate, however, the use of empty drums should be discontinued.

d.3 On-site Waste Storage

The on-site waste storage unit is commonly made of bricks and mainly used to store communal waste. With this storage system, it is possible to keep different types of wastes separately in individual compartments. The usual capacity of this type of storage ranges from 1 - 2 m^3.



Advantages

- This system maintains aesthetic conditions.
- This system is sufficiently durable to last more than 20 years.
- This system is favorable for separate collection.

Disadvantages

- This system requires a large amount of capital.
- This system requires close monitoring for the maintenance of sanitary conditions.
- This system requires space.

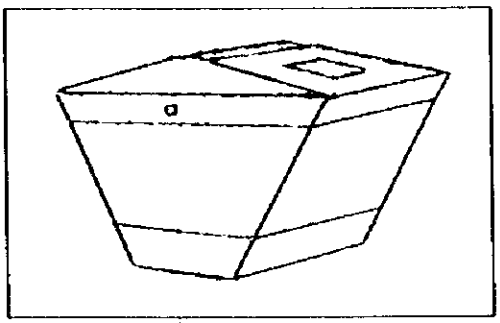
- It is very difficult to select a location for on-site waste storage because it is a permanent fixture and causes a public nuisance unless it is properly maintained.
- This system makes loading of waste onto waste collection trucks very difficult.

Applicability

This system requires close maintenance services, therefore, it is only applicable in places where strong public cooperation and participation are attained.

This system requires a large investment but the ensuing increase in collection work efficiency does not lead to cost-effectiveness. Therefore, this system is not recommendable unless users are willing to bear the extra costs and commit to participate in its maintenance.

d.4 Containers (1 to 2 m^3)



The container (1 to 2 m^3) system is commonly used for small apartment buildings, multi-purpose buildings, offices and commercial buildings.

Containers of any size may be used for the temporary storage of waste, but there are two main constraints. One is weight limitation for consistent manual haulage and transport to avoid undue fatigue and bodily injuries. Containers may be fitted with wheels and moved by a small hand truck from the storage stands to the collection vehicle or to an intermediate storage point. However, the use of containers exceeding the weight limitation for manual haulage and transport require that the surfaces over which these containers are to be placed and wheeled must be reasonably even, hard and without steps or steep inclines.

It is very important to wash the containers and clean its surroundings. The frequency of cleansing would depend largely upon the kind of waste stored in the containers. The cleansing of containers is difficult, exhausting, and costly. Cleansing is usually more satisfactory if it is undertaken in the central maintenance depot where high pressure jets and other cleaning equipment can be installed.

Advantages

- This system provides sanitary conditions.
- This system maintains aesthetic conditions.
- This system is sufficiently durable to last several years.

Disadvantages

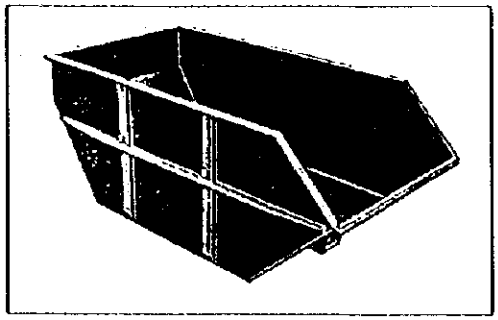
- This system requires a huge capital.
- This system encourage people to discharge more waste.
- This system requires even concrete floorings and equipment for lifting containers.
- This system requires periodic washing to maintain sanitary conditions.
- The operation of this system is considerably expensive.

Applicability

The required capital is too large as this system uses containers, lifting equipment, and even concrete floorings. Cost saving cannot also be expected from increased efficiency in waste collection activities. Conclusively, the introduction of this system is hardly cost effective.

d.5 Large Communal Containers

Containers measuring 5 - 20 m^3 or bigger are suitable for areas generating large quantities of waste. Special purpose vehicles are required for lifting, transporting and emptying such containers. A constraint on the use of such containers would be the need for room at the storage location for the vehicle to maneuver, to complete the container collection or exchange process.



Advantages

- This system provides sanitary conditions.
- This system maintains aesthetic conditions.
- This system is sufficiently durable to last more than several years.
- This system can curtail collection and haulage costs because it minimizes loading time.

Disadvantages

- This system requires a huge capital.
- This system requires special vehicles for lifting, transporting and emptying containers.
- This system encourage people to discharge more waste.
- This system attracts business people to put their wastes generated thorough their business activities.
- This system requires space for placing and lifting containers.
- Irregular collection can cause hazards as the huge amount of waste stored in these containers are left for a considerable period of time.

Applicability

In the study area, the large communal container system is applicable for various purposes such as for a collection point for street sweeping waste, market waste, and for waste generated from areas where vehicles cannot gain access.

The required capital is quite large as this system not only requires containers but also special vehicles. The introduction of this system would be financially difficult without financial contributions from a donor. However, because of the financial benefit that can be gained from this system, i.e. reduced collection and haulage costs -- usually much greater than the cost for containers and special vehicles -- its introduction shall be taken into consideration together with the collection and haulage system.

This system is one of the more promising options for marginal areas where vehicle access is limited.

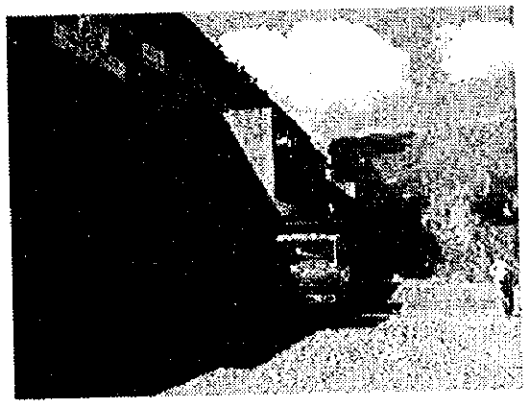
d.6 Rampa (Waste Storage Hopper)

A system using waste storage hoppers called "rampas" in Honduras, that are used at markets, is shown in the picture to the right.

The waste collected is carried and stored in hoppers once and then dropped onto a dump truck by opening the gates.

Advantages

- This system is applicable for conventional dump trucks.
- This system can minimize the loading time.



Disadvantages

- This system requires a large capital.
- This system requires a wide space.
- This system requires a height differential.

e. Conclusion of the Storage System

The absence of a proper waste storage system in the study area is one of the main reasons behind the inefficient waste collection work. To rectify these conditions, proper handling and storage systems should be introduced.

The plastic dustbin system is recommended but the use of metal drums should be discontinued.

The system whereby the waste is stored on-site is generally not recommended for residential and commercial areas, unless users are willing to shoulder the required extra costs and to maintain the storage area properly.

The large container system requires a huge investment but contributes to the reduction of large collection and haulage operation costs. However, this system is only recommendable if the problem of initial investment can be solved. The size of containers shall be determined according to their purposes and distribution. These containers are usually placed at collection points for markets and areas that have been developed without any prior planning and therefore inaccessible to waste collection vehicles. If containers are placed in residential or commercial areas, they can encourage people to discharge more wastes, and in addition they can attracts business people to put their wastes generated through their business activities. Therefore, the way of using containers requires careful considerations.

The plastic sack system that is currently in widespread use is appropriate and this system used concurrently with a waste stand is also appropriate.

The waste storage hopper system is very appropriate for markets.

The use of a skip or plastic sacks highly depends on the collection and haulage system to be adopted. Therefore, the best storage system shall be selected from these two systems in line with the proposed collection system.

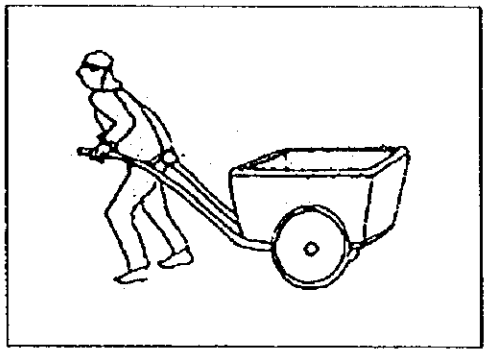
13.4.2 Primary Collection

In areas with inaccessible roads, waste has to be carried to designated points for collection. People living near collection points find it easy to discharge waste by themselves, but those further away have difficulties doing so. Therefore, a primary collection service, which is the haulage of waste from residences to collection points, should be established for the latter.

This section discusses the suitability of several potential systems for the area.

a. Handcarts

Handcarts are commonly used in developing countries for various purposes. In particular, collection along very narrow streets that are inaccessible to motor vehicles. Typically, handcarts are made of open boxes that are attached to a frame, and the only way of emptying the cart is to discharge the load onto the ground. Reloading is then carried out with a shovel or a basket. The typical operation radius of a handcart is about 1 km[1].

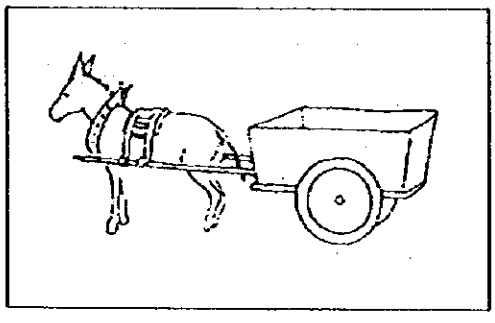


Improvements in the design of handcarts over the years have been primarily concentrated on ensuring that unloading of waste collected does not entail contact with the ground. The use of a number of covered containers, usually between four and six, which can be lifted off the cart for unloading, has enabled the cart to carry loads of about 150 kg, which can be speedily and hygienically transferred to secondary collection containers or vehicles.

This system is applicable to the most problematic areas although the work involved is very labor intensive.

b. Animal Drawn Carts

Horses were widely used in North America and in Europe for door-to-door waste collection up until World War II. In Japan, cows were used for waste collection until the 1960s. Horses, mules, donkeys and cows are still used in several countries around the world. The capacity of animal carts generally ranges between 2 and 4 m^3. In some cases, the carts are equipped with bodies that can be



[1] "Solid Waste Management for Economically Developing Countries", L. F. Diaz et. al., ISWA and CalRecovery, 1996

tipped, by either pivoting the body or by using a manually-operated worm and nut mechanism. The effective radius of operation is about 3 km[2]. Animal carts have the following advantages and disadvantages:

Advantages

- No consumption of fossil fuels.
- Relatively quiet operation.

Disadvantages

- It is less maneuverable than human handcarts.
- The required capital cost is higher than human handcarts.
- Animal carts may interfere with traffic.

Applicability

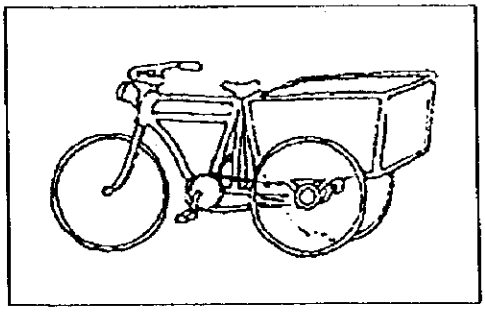
Considering the development level and the topographical conditions prevalent in the Central District, this system of using animals is deemed to be inappropriate.

c. Pedal Cart

Pedal carts are commonly used in Latin America and in Asia. They have an effective operation radius of about 2 to 3 km[3].

Advantages

- It has a larger operation radius than handcarts because it has more speed.
- Environmentally sound system.



Disadvantages

- Its volumetric capacity is less than the handcart.
- It requires more capital than handcarts.

Applicability

This system is technically suitable for the Central District.

d. Motorized Cart

A motorized cart is a motorbike equipped with a cart in front or at the rear. This system can be used generally up to a gradient of 20%.

Advantages

- It has a wider working radius than handcarts and pedal carts, because it has more speed.
- Its volumetric capacity exceeds that of a pedal cart.

[2] "Solid Waste Management for Economically Developing Countries", L. F. Diaz et. al., ISWA and CalRecovery, 1996
[3] "Refuse Collection Vehicle for Developing Countries", UNCHS

Disadvantages

- Its volumetric capacity is less than the handcart.
- It requires more capital than the handcarts and pedal carts.

Applicability

This system is applicable for marginal areas with less than a 20% gradient. However, it will not be widely used because it is costly. Financial support should be acquired before the introduction of this system.

c. Conclusion of the Primary Collection System

The primary collection system to be selected must require as little capital as possible because the fees for collecting waste through this system, based on the number of trips, are expensive in itself and also the areas proposed for this system have a limited financial capability. The mode of haulage shall also be maneuverable because the roads in areas where primary collection is needed are unpaved, very steep, and very narrow.

In conclusion, the handcart and pedal cart systems are considered to be most suitable for the Central District.

13.4.3 Collection and Haulage System

The objective of the waste collection and haulage system is to collect and to haul waste from specific locations to a disposal site at regular intervals, with minimal cost and in a reliable manner, and with due considerations for sanitary conditions. It is very important to always bear in mind that the cost for the collection and haulage of waste is by far the most expensive part of the overall waste management system.

The collection and haulage system is mainly affected by the following aspects:

- collection frequency
- collection method (mixed or separate)
- collection system
- collection schedule
- collection vehicle
- haulage distance
- haulage method
- transfer system

a. Collection Frequency

Collection frequency is determined in view of sanitary conditions, operation and maintenance costs. For organic waste, the more frequent collection is carried out, the better in terms of maintaining sanitation. However, because this would mean higher costs, collection frequency should be minimized as long as sanitation is not compromised.

Considering the tropical climate, i.e. high temperature, waste composition including a high percentage of organic fractions, and high population density, etc., a twice or thrice weekly collection is recommended for the Central District.

b. Collection Method (Mixed or Separate Collection)

A separate collection system is required when processing or recycling is introduced. Introduction of incineration technology requires separate collection of combustibles and non-combustibles. Composting requires separate collection of organic and inorganic materials, while recycling requires separate collection of recyclable and non-recyclable materials.

A separate collection system requires additional costs because it necessitates more storage space, and reduces waste collection and haulage efficiency.

Another issue to be kept in mind is people's willingness to cooperate in source separation. Because this requires the change in people's habits, way of living and the social system by conducting public education and motivation programs, it would take some time before it is adequately implemented.

In principle, mixed collection should be implemented in the Central District providing that no processing technologies are introduced.

However, the study acknowledges the importance of conducting a separate discharge system, even without a separate collection system, at an early stage to succeed in the future introduction of a separate collection system.

c. Collection System

To consider the appropriateness of the collection system, the main factors considered are: collection efficiency, town layout, and present use of the area.

Table 13-2: Summary of Collection Systems

Collection System		Summary
Point Collection		Dischargers carry their own waste to specified waste collection points; later the discharged waste is collected by waste trucks.
Curb Side Collection		Each household is responsible for placing the containers at the curb on collection day and for returning them to their storage location.
Door to Door Collection	Set-out - Set-back	Containers are set out from the premises and set back after being emptied by additional crews that work in conjunction with the operators responsible for loading the collection vehicle.
	Setout	Set-out collection is essentially the same as set-out-set-back collection, except that residents are responsible for returning the containers to their storage location.
	Backyard Collection	The collection crew enters the premises and collects wastes from their storage location.
Bell Collection		The collector calls out to the residents to discharge their waste upon the arrival of collection vehicle at a given collection point.
Public Container Collection		Residents discharge waste regardless of collection day. This collection method produces a high collection efficiency.

In the Central District, point collection, curb collection, bell collection and door-to-door collection are used. Since the bell collection system has been used for a long time, it is still widely used even though it is inappropriate under the current circumstances. The point collection and curb collection systems are widely used in residential areas depending on the town structure.

The following collection systems are recommended for further examination:

- point collection system for residential areas
- door-to-door collection system for commercial, institutional and high income residential areas

d. Collection Schedule

Setting a proper collection time is important to achieve an effective collection system. The factors to be considered are traffic, current town structure, electrification, etc.

Night collection is generally inappropriate in most areas in the Central District except the city center where some street lighting are provided.

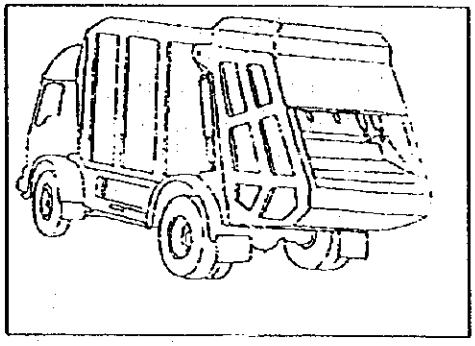
In the city center, traffic is highly congested and many vehicles park along the roadside between 8 a.m. and 5 p.m. Waste collection is not efficient during this period. Night collection is more efficient in areas where lighting is sufficient, although the noise this will generate is forecast to aggravate nearby residents. Therefore, collection work should be carried out in the early morning before 8 a.m., or in the evening before 9 p.m. for the city center.

e. Collection and Haulage Vehicles

e.1 Compactor Trucks

The use of rear end loading compaction vehicles have become the norm in many industrialized countries, where they are designed specifically for the following purposes:

- Maximization of productivity of a highly paid labor force.
- Compaction of low density waste to achieve higher payloads.



In industrialized countries, these compaction vehicles are used to haul waste from the collection points having a natural density of 100 to 200 kg/m^3. A compaction ratio greater than 200% is necessary to financially justify the adoption of such a vehicle. In the Central District, the average waste collection density is 200 kg/m^3 and the compaction ratio has already reached 200%.

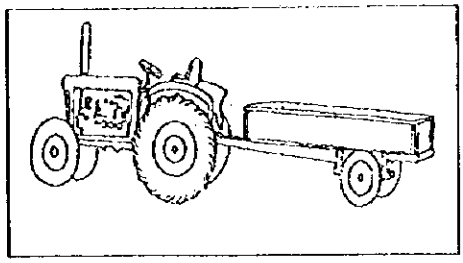
Conclusively, these vehicles are appropriate in areas where the road is paved in the study area, as confirmed by the time and motion survey.

The maintenance of compactor trucks require a higher level of technological skill. According to our investigation, the AMDC mechanics have enough skills and machinery to maintain compactor trucks and this is supported by the fact that compactor trucks have operated efficiently since 1988.

e.2 Non-Compaction Vehicles

There are many types of non-compaction vehicles, and these are generally distinguished by loading form.

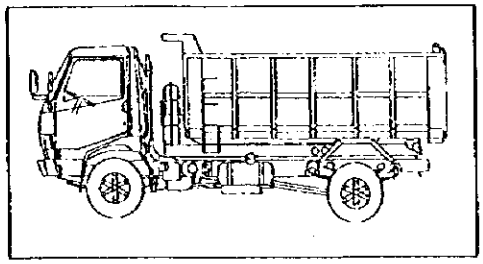
e.2.1 Tractors and Trailers



Tractors and trailers can be useful in certain areas close to the landfill. They can travel over relatively rough terrain and can be used in connection with street sweeping services. The trailer can be parked at fixed locations where significant amounts of waste have accumulated over a certain period. For example, in areas where waste produced from pruning trees have accumulated. One tractor, on this basis, could service several trailers during the course of a day.

These vehicles, however, are only useful for street cleansing in the Central District and perhaps for the cleansing works of the Parks Department. They are not applicable to the routine collection of domestic waste because of the expensive tractor parking fees that would be incurred. The alternative - manual loading of trailers from roadside dumps - is not recommendable either.

e.2.2 Dump Trucks



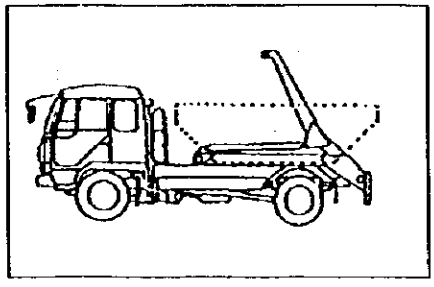
Dump trucks are fairly basic and do not incur excessive maintenance costs.

Dump trucks are effective for loading large heaps of waste with a wheel loader. However, the accumulation of waste heaps in the streets is neither environmentally-friendly nor economical. The use of dump trucks is less productive because of the considerable time consumed for waste loading activities.

Loading is normally carried out manually, hence it is extremely slow and tiring due to the considerably high loading elevation (1.3 m at the side door of the present dump truck in the Central District). When loading, waste is handed over from the ground to the workers inside the truck who pack the load. Furthermore, the loading operation is unhygienic.

Aside from low productivity, the collection crew for this kind of operation demands higher wages than the crew for hoist trucks. Therefore, this is not a recommendable system for the Central District. However, because of its wide applicability and ease in maintenance, dump trucks are favored by private contractors and can therefore be an option.

e.2.3 Detachable Container Trucks



A wide range of detachable container trucks are available, handling containers from 1 to 30 m^3. They are, for example, a hoist truck, an armroll truck, a roll-on roll-off truck, etc. It was proved by the time and motion survey that these trucks were highly productive since they were able to collect waste filled containers in one lift within a few minutes.

With the relatively short distance (7 km from City Center) to the current disposal site, this system can accomplish between five and eight loads per day.

The detachable container truck itself is cheaper than a compaction truck and can achieve a higher payload in the course of a day than any non-compaction vehicles.

The containers may be manufactured locally, the system is robust and can handle a wide range of wastes. The vehicles are easy to maintain provided spare parts are available, especially for the container hoist system.

Container trucks have a faster average road speed than tractor-trailers, and shall hardly affect the normal flow of traffic.

The system is recommended for future waste collection services in the marginal area in the Central District, provided that a sufficient quantity of spare parts are purchased together with the trucks that are furnished with satisfactory facilities for their storage.

f. Transfer of Waste

Waste discharged in transfer stations are hauled to the final disposal sites using large trucks with a capacity of 20 to 50 m^3 to minimize overall transport costs. A transfer station is where waste from collection vehicles of limited capacity are loaded into vehicles (or rail cars for rail transfer stations) of larger capacity for haulage to a disposal site.

The main purpose of using a transfer station is to reduce the net cost of transporting waste from collection areas to the final disposal site. The issue of whether or not to build and operate a transfer facility almost entirely depends on economic factors.

Although this system reduces haulage expenses, it requires additional cost for the construction of a transfer station, as well as for dumping and loading work. Accordingly, this system is not financially beneficial unless the disposal site is located far away.

The present disposal site is located 7 km away from the city center. Generally, the construction of a transfer station is considered to be impractical if the transport distance is less than 20 km (one way). Therefore, no financial benefits can be expected from the introduction of a transfer station in the present system.

g. Conclusion of the Collection and Haulage System

The best collection and haulage system for the Central District is concluded below.

Collection frequency	• 2 or 3 times weekly
Collection method	• Separate discharge with mixed collection system
Collection system	• Point collection for marginal areas • Curb collection for standard residential areas and commercial areas
Collection schedule	• Day collection for standard areas • Night collection for congested areas
Collection and haulage vehicles	• Compactor trucks for standard areas • Detachable container trucks for marginal areas
Haulage system	• Direct haulage without a transfer station

13.4.4 Street Sweeping System

a. Introduction

Street sweeping is one of the most visible of all government services. Consciously or not, residents allow their opinions on the effectiveness of street sweeping programs influence their assessment of the credibility of their municipal leaders and local officials. Visitors instinctively rate municipalities based on their external conditions, i.e., cleanliness. Dirty cities cannot attract foreign investors. These opinions should be positively used to stimulate the residents to build a better city.

Street sweeping programs were conducted mainly to remove litter and dirt so that streets appear presentable, and traffic will not create dust. Specifically, in some areas, regular street sweeping is necessary to prevent sewers from becoming clogged. It is also recognized that dust is a potential pollutant.

Municipalities must balance the costs for adequate street sweeping and effective litter control programs, sewer improvement operations, projects to ensure safety of pedestrians and vehicle occupants, air and water pollution countermeasures, and economic development. Public education programs alone, however, will not help eliminate street litter. Debris also accumulates from air pollution fallout, animal excreta, oil drippings, parts dropped from vehicles, spillage from solid waste collection, as well as mud tracked onto pavements.

b. Street Sweeping Methods

As practiced today, street sweeping methods may be grouped conveniently under these general headings:

- manual sweeping
- mechanical sweeping
- vacuum sweeping
- flushing

b.1 Manual Street Sweeping

Manual street sweeping is by far the oldest method. However, it still retains certain advantages as follows:

Advantages

- low capital
- great flexibility of operation
- applicable to cleansing of areas where debris accumulation is most frequent
- makes cleaning beneath parked vehicles possible
- makes cleaning rough cobble stone pavements possible
- produces less noise
- creates more job opportunities
- requires minimum equipment, repair and maintenance costs

Disadvantages

- difficulty in supervision
- dangerous under heavy traffic conditions

The equipment required for manual sweeping is simple and inexpensive. Sweepers use stiff bristled brooms, wheelbarrows, shovels, and few other tools for special tasks.

b.2 Mechanical Sweeping

Mechanical sweeping entails the use of as many machines as possible, usually of various sorts. Three or four-wheel sweepers are mainly used for wide main roads. Self-propelled sweepers and water sprinkling-trucks are also used for mechanical sweeping.

Advantages

- great productivity
- low manpower requirement
- ensures safe operation

Disadvantages

- huge capital
- high maintenance cost
- low flexibility of operation
- difficult to conduct in narrow areas
- produces lots of noise
- difficult to conduct under heavy traffic

Mechanical sweeping is generally the cheapest sweeping method for wide roads. This method is generally suitable for roads exceeding 6m in width.

b.3 Vacuum Sweeping

Vacuum street sweeping is becoming increasingly popular in developed countries because it removes fine materials as well as larger debris without using water, thereby curtailing water-use expenses. The flicking action of the broom is not as effective on fine materials as is the vacuum.

Vacuum units can also pick up larger debris, ranging from cigarette butts to beer bottles at operating speeds of 20 km per hour. With the help of gutter brooms, this unit is able to loosen and deflect debris so it can be picked up. It is also equipped with an additional broom, which may or may not be used in picking up debris, to windrow dirt. This second broom loosens the street dirt and pushes it toward the vacuum nozzles where it is drawn into the storage compartment. A filter system traps the dust and confines it to the sweeper hopper.

Advantages

- high sweeping capability
- no harm to sewage pipes by dust
- produces only a very small amount of dust

Disadvantages

- requires huge capital
- requires high maintenance cost
- low flexibility of operation

- difficult to conduct in narrow areas
- produces lots of noise
- difficult to conduct under heavy traffic

b.4 Flushing

Street flushers hydraulically move debris from the street surface to the gutter. Since the disposal of street dirt in sewers and catch basins is regarded with increasing disfavor because it pollutes the environment, several municipalities now flush only to aid sweeping and not as the sole method of sweeping.

Flushing before sweeping washes street dirt to the curb for collection by motorized sweepers. This type of flushing ordinarily employs smaller quantities of water and lower nozzle pressures to keep the dirt from flowing into the inlets as well as minimize the risk of getting pedestrians and vehicles wet. The benefits of flushing after sweeping are: cleaner pavements and the discharge of only small quantities of dirt into inlets and catch basins.

Advantage

- produces no dust

Disadvantages

- needs a large amount of water
- may clog sewage pipes
- requires high maintenance cost
- low flexibility of operation
- difficult to conduct in narrow areas
- difficult to conduct under heavy traffic

c. Current Street Sweeping System

The AMDC currently employs the manual sweeping method. Most sweepers are women and they collect litter using a broom. The collected litter is carried to large communal containers placed at several locations using a wheelbarrow and stored. Then it is carried to the disposal site in a detachable container truck. Many trash cans installed along busy streets help to reduce the street sweeping work by encouraging people to discard litters into them.

A new trial of introducing mechanical sweepers for street sweeping works is initiated by a private contractor. The contractor to AMDC bought two mechanical sweepers and started the operation from 6th August 1998. These equipment are planned to used for trunk roads.

d. Conclusion of the Street Sweeping System

The flushing system is not at all suitable for the Central District in view of the current limited water resource and poor sewerage system.

The mechanical and vacuum sweeping systems are also not suitable for the Central District because they require large capital, and incur high operational and maintenance costs and in addition due to the congested road conditions in the town. This system might be applicable to the noncongested trunk roads.

Conclusively, manual sweeping is most appropriate for the Central District because of an abundant and inexpensive supply of labor force. The jobs that are generated by the sweeping system can contribute, albeit to a smaller degree, to the betterment of the Central District's economy. This system is also flexible and can cope with waste containing lots of sand.

13.4.5 Processing and Treatment System

This section considers the possible options for:

- The treatment of waste by altering or removing some of its undesirable characteristics (e.g. to reduce waste volume, to render waste inert)
- The recovery of some of the wastes either as energy (gas, steam or electricity) or as usable materials (e.g. waste paper, ferrous scrap, compost)

Several criteria of prime importance in assessing the suitability and viability of any system of waste handling, treatment or recovery are as follows.

- Technical feasibility.
- The degree to which the technology of the system is proven, i.e. are these plants actually in operation elsewhere?
- The reliability of the system and similar issues. (These questions are particularly important when considering latest technologies since, for example, many recovery systems are relatively recent developments).
- Its financial and economic implications: how much will the system cost to construct and operate; what are the potential benefits from savings in transport and disposal costs and from the sale of recovered products; what other economic benefits do the system offer in terms of foreign exchange savings, employment, etc. Of special importance here is the scope for actual selling and using any recovered products as this can frequently be less than is estimated.
- Its management requirements: how much qualified management and skilled labor will the system require to operate properly; how much cooperation will be obtained from the public, etc. Unless the necessary resources and skills are available, the system may be much less attractive than it initially appears.

Our assessment of the various operations below takes into account the prevailing conditions and problems in the study area, evaluating in broad terms the technical suitability and economic implications of different systems for handling, treatment and recovering solid wastes in the study area.

The following intermediate technologies are discussed in this section:

- Incineration
- Production of Refuse-Derived Fuel (RDF)
- Biogas Production
- Pyrolysis
- Composting
- Size Reduction

- Mechanical Sorting and Scavenging

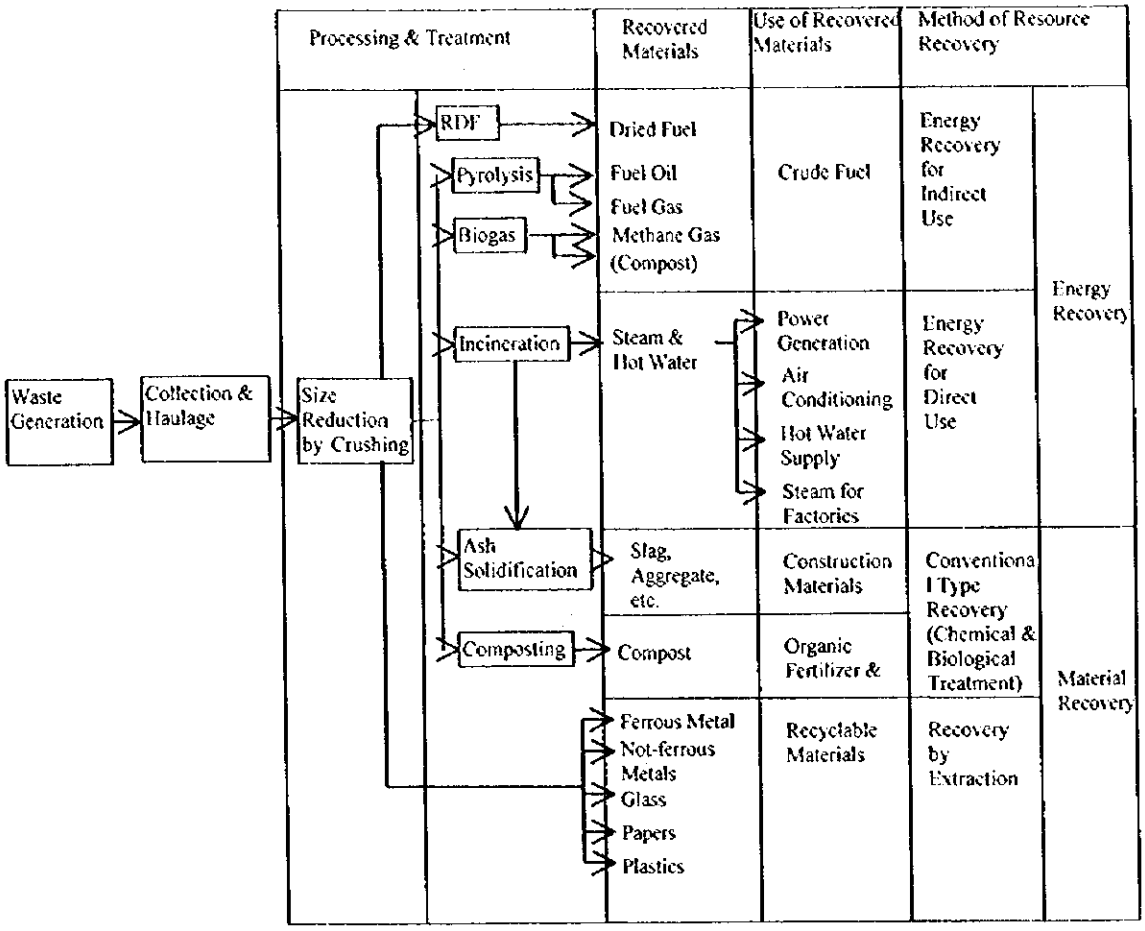


Figure 13-1: Processing and Treatment Technologies

a. Incineration

Incineration of municipal solid waste is one of the most popular method recently adopted for processing wastes in developed countries. Waste is mainly converted into stable oxidized gases and partly into stable inorganic matters by high temperature combustion. Of the various intermediate treatment technologies, incineration generally reduces waste volume to a large degree. It also stabilizes putrescible organic wastes. Energy from waste incineration can be utilized for the production of electricity and/or district heating, and the income from the sale of energy may contribute to the economics of the plant.

A general observation would indicate that incinerators may be feasible where land for landfilling is scarce, expensive or very remote from the actual solid waste generation center. Modern incineration and flue gas cleaning technology makes waste incineration an environmentally acceptable form of waste treatment, it is, therefore, possible to locate such plants even in densely populated areas. Accordingly, incineration has played a role in municipal waste management for more than 50 years in many major cities in Japan, Europe and the USA.

A modern incinerator consists of a number of basic components. Typically they include an unloading area, waste feeding device, burning grate area, combustion chamber, air supply system, residue quench and disposal system, flue gas scrubber and water treatment system, and stack. Selection and design of these basic components will be the deciding factor in differentiating one incinerator from another.

Major differences in typical modern incinerators are noted in both waste feed systems and grate designs. Feeding of waste may be accomplished by either batch or continuous mode. Batch feed of waste has experienced a decline in use over recent years in favor of continuous feed methods.

Applicability for the Central District

One of the most important factors that would determine whether incineration is feasible is the calorific values of the waste being generated. The required calorific value of waste to burn without supplementary fuel is 1,700 kcal/kg. According to the result of the waste composition survey, the calorific value of the waste generated in the Central District is estimated to be below 1,700 kcal/kg due to the small fraction of combustibles. It will therefore require auxiliary fuel for thermal processing.

The income from the sale of energy generated by incineration of waste, either by the form of heat or electricity, is often expected when introduced. Generation of electricity by incineration of waste is not appropriate for the Central District because it requires very advanced technology not only for installation but also for operation and maintenance. Although the recovery of heat is easier in terms of technology, its demand in the Central District is estimated to be very minimal. Therefore, a large income from the sale of energy cannot be expected.

A purpose-built automated incineration facility involves very high capital outlay. The technology is sophisticated and requires high levels of technical expertise to operate. Appropriate gas cleaning equipment needs to be installed and operational and maintenance costs are high. In addition, it requires continuous spending for auxiliary fuel. Therefore, both the investment and O & M costs are too expensive.

It is accordingly believed that incineration is inappropriate in the Central District for technical and economic reasons.

b. Production of Refuse-Derived Fuel (RDF)

In this system the combustible fraction of the waste is separated by some mechanical or manual means primarily to extract the paper and plastic portions which is then either used as its raw state or compacted into pellets.

The production of refuse-derived fuel can be done in several ways. In some of the earlier systems, raw waste was first shredded to a nominal particle size of about 4 inches. More recent systems employ a rotary trammel before shredding. This trammel allows for prior separation of heavy, larger materials. After shredding, ferrous metals are separated magnetically for recycling. The remainder is then separated into a lighter, mostly combustible fraction and a heavier, mostly non-combustible fraction using an air classifier.

The lighter fraction is then further processed to produce the RDF through secondary shredding and screening. The RDF that is produced can be burned as coal or a primary fuel in a specially designed boiler.

Today, RDF systems are mainly adopted in the United States and Canada. But the extensive use of this technology elsewhere in the world may not be recommendable due to the following problems observed.

- Occupational health problems at the plants specially at manual sorting lines.
- The pre-treatment plant is capital intensive leading to high waste disposal prices in order to make the pellets competitive with coal.
- The pellets still have a high content of pollutants (heavy metals and chloride) which conventional coal fired plants are not equipped for filtering.
- There is a need to alter the combustion conditions of conventional boilers and burners if a significant amount of RDF is to be burnt.

Advantages

- Combustibles in municipal waste can be converted to substitute fuel which can be stored and is easy to handle.

Disadvantages

- Waste which can be converted to RDF is very limited, and their availability can be found only in waste with a high paper content.
- The market for RDF will be limited due to the necessity of a special burner which can burn hard solid fuel such as coal.
- Some technical difficulties such as explosions in crusher, clogging in storage silo, etc., have to be solved.

The viability of this system would depend on the composition of the waste. In the Central District the combustible fraction is very small and therefore such a system will not be viable.

c. Biogas Production

Biogas is the combustible gas developed when organic matter is decomposed under anaerobic conditions, i.e. without the presence of oxygen. The energy will be bound in the hydrocarbon compund methane, which is the main constituent of natural gas. Anaerobic degradation of organic matter, resulting in biogas production, is an efficient means of degrading organic wastes, and making it hygienic.

Anaerobic waste treatment is a well known process relating to treatment of farmyard manure, sewage sludge and industrial wastewater and other sludge. In the process, part of the organic material is transformed into carbohydrates, proteins, and fats by micro-organisms. First the material is decomposed by certain bacteria to organic acids and carbon dioxide, after this process other bacteria decompose the organic acids and convert hydrogen to methane. Biogas can be utilized both for heat and power generation. The residues are compost and can be utilized as a soil conditioner.

From a practical point of view, it is an advantage to place the biogas producing plant near a wastewater treatment plant, in order to supply the biogas plant with water to dilute incoming wastes, and to supply power to the wastewater treatment plant and achieve useful synergy.

It is possible to add the following wastes to biogas producing waste treatment plants:

- organic waste from households, including meat and vegetables.
- flowers, including herb wastes from gardens.
- coffee grounds - tea leaves including paper filters.
- fruit wastes.
- paper kitchen towels and tissues.
- organic sludge and wastewater from industries, including the food industry
- sewage sludge

However, one should exclude wastewater and waste containing heavy metals, and wastes from some branches of the chemical industry.

Its advantages and disadvantages are summarized as follows:

Advantages

- resource recovery of waste into potentially useful products, i.e., methane gas and compost
- minimal potential soil, water and ground water pollution
- possible location near urban areas

Disadvantages

- high investment cost
- only few years operational experience of municipal wastes
- haulage costs
- requires pre-sorting of organic wastes.

d. Pyrolysis

Pyrolysis or gasification of waste involves the "cooking" of waste in a furnace in the absence of air. Depending on the way the reaction is controlled, oil, ashes, and gas are produced.

Pyrolysis is a process for breaking down organic substances by applying heat, in the range of 700-1,200 °C, in the absence of oxygen or at oxygen levels insufficient for total combustion. Under these temperature and pressure conditions, organic materials break down to shorter chain organic compounds and in some cases are reduced to charcoal, a carbon residue. A variety of potentially useful products may be produced, depending on waste composition and operating conditions. Master products are charcoal, tar and pitch, light oil, organic acids, ammonium sulfate and combustible gases.

Theoretically, pyrolytic operations lend themselves well to a total recycling approach. Prior to the actual pyrolysis step, waste materials must go through a number of preparatory operations. Generally, solid waste is first shredded, glass and metals are separated, and these materials are sold where an available market exists. Unusable

residue, reduced to a small percentage of the original, is left for ultimate disposal at a sanitary landfill.

In the USA, the technology aims at recovery of storable energy, while in Japan it is being developed for non-pollution treatment system for waste.

Pyrolytic processing operations have the following advantages and disadvantages:

Advantages

- reduced land requirements for final disposal;
- reduction of solid waste to a minimum volume;
- little air or water pollution (since little or no oxygen is involved, combustion products may not be a factor of pollution.);
- recycling of solid waste into potentially useful products. Considering effective energy saving, production of such items as fuel oils, gas and steam are desirable and needed.

Disadvantages

- Large capital investment and high operation cost.
- The nature of oil or gas obtained from the facility is still insufficient for commercial use, therefore the market is limited to factory use only. The purification of oil or gas is cost intensive, and is not as effective as its cost may suggest.

Applicability

The pyrolysis of municipal waste to produce a marketable oil or gas product has not been proven feasible. The pilot plants that were being developed for this purpose have been closed.

Pyrolysis is not a recently developed technology, but has been around in various forms for thirty years or more. However, since its role in the treatment of municipal solid waste is still theoretical, it is not suited to the conditions of the Central District.

e. Composting

Waste composting is a method to achieve microbiological degradation of organic matter (residential and vegetable wastes, garden wastes, etc.), to produce a recycled organic product for use in agriculture, gardens, parks, etc.

The most important technical issue about composting concerns the precise nature of the product. Compost is not a fertilizer but a soil conditioner. It does contain some plant nutrients but its value lies primarily in that it improves the soil structure by introducing humus, promotes microbial activities, and can help to retain fertilizers and moisture in the soil. Before being offered for sale, it is important that the product is sterile and free from pathogens that could be harmful to crops and people. To achieve this, it is important to control temperature and moisture content to enable the necessary stages of decomposition to take place correctly, in order to sterilize the product.

Most essential measure for achieving success when composting municipal waste is that the waste is sorted into a "green fraction" (i.e. organic waste) and in a fraction

that is not appropriate for composting (plastics, glass, metals, etc.). Sorting may be conducted at a central composting plant (which would require mechanical equipment as well as manual sorting with due consideration of workers' hygienic conditions) or at the source (i.e. at the residences which would require a good deal of education).

The technology of composting municipal waste is well-established and operating experience and information is available in great detail. In spite of this wealth of experience, few of the waste composting plants around the world are economically successful. The drawbacks commonly experienced with composting are its high haulage cost and the low value of the compost products.

Many countries allow people to use compost only for flowers but not vegetables because of the associated possibility of including hazardous materials. Therefore the usage of compost is often restricted.

Advantages

- The required treatment method is simple.
- It helps to reduce the final disposal amount.

Disadvantages

- If composting is not preceded by any sorting, the compost produced will contain potentially polluted materials.
- The recovery rate of compost product is not high, normally 35% of the total weight. Rejected materials have to be hauled to the disposal site again.
- Reduction of waste volume cannot be expected compared with the incineration system.
- The quality of compost product highly depends on the quality of waste as raw material. Therefore, modification of the existing collection and haulage system is required.
- It takes a long time for fermentation.
- It requires a wide stock yard for fermentation.
- Compared with chemical fertilizers and chicken manure, compost has the following inconveniences due to the amount for the use of fertilizer.
  - high haulage cost
  - difficulty for spreading in plantation
- It generates an offensive odor.

Applicability

The price of chicken manure which is a competitor of compost is only Lps. 2 /46 kg in the Central District. Therefore it is predicted that composting will generate no financial benefit.

Considering its relatively heavy weight as a soil fertilizer or conditioner, it is predicted that few people will take compost even if it is free.

f. Size Reduction (Crushing and Shredding)

A size reduction facility is normally equipped with crushing and shredding functions, and is generally used as a pre-treatment facility of an incineration plant, composting

plant and other intermediate treatment facilities. It is also used to improve sanitary landfill operations.

Shredding reduces the volume of waste to be transported to the final disposal site for sanitary landfill operations. Shredded waste settles more rapidly than unshredded waste, making the landfill sanitary and less subject to complaints from nearby residents. This condition also ensures fewer spontaneous combustion during landfill operations. Because this condition attracts fewer rodents and insects, less insecticides and pesticides shall be required.

Shredded wastes cause less damage to the landfill equipment and trucks than unshredded waste, and has a high compaction rate.

The term "crush" has various meanings, i.e., shredding, milling, pulverizing, grinding, cutting, tearing, ripping, etc., for which appropriate machines are developed.

An ordinary hammer mill with a swing hammer attached to a horizontal or vertical shaft rotates very fast. Waste is dumped from above, and discharged from the opening at the bottom after it is pulverized by the shearing force of the cutting board.

The degree to which a machine can grind the waste depends upon the substances to be crushed and the size required by the treatment system. The pulverizing process will be accompanied with sieving, if necessary.

Advantages

- Shredding and crushing (size reduction) contribute to the work efficiency of other intermediate treatment facilities.
- It is well adapted to the local conditions and intended plans because (1) shredding reduces the volume by about 50%, thus making haulage easier and more efficient, and (2) shredded waste spreads more easily. Shredded waste is compacted better in the sanitary landfill and takes up less space making the landfill area last longer.
- Shredding and crushing produce a more compact and ultimately more stable sanitary landfill, hence raising the post-closure value of the land.
- Since shredding and crushing facilitate waste compaction, ensures fewer spontaneous combustion and propagation of fewer flies and rodents during landfill operations, particularly if solid waste disposed receives a final cover.
- Shredding and crushing definitely increase compaction, making landfills denser and reduce the percentage of settlement.

Disadvantages

- The use of the rotary type hammer crusher consumes a large amount of electricity as it usually requires a high powered electric motor.
- Damage due to explosion caused by flammable matters in waste may occur frequently. Therefore, strict checking and sorting out of dangerous matters have to be done.
- Frequent repair works or replacement of damaged parts shall be necessary for the tremendous wear and tear of mechanical parts such as hammer beaters, shear blades, etc.

Applicability

This system is useful when used with other processing and treatment technologies. However, this will increase the burden of operation and maintenance. Since a simple technical system is appropriate for the Central District this system is not recommendable.

g. Mechanical Sorting / Scavenging

Mechanical sorting and scavenging are inexpensive technologies used to recover as much valuable materials as possible from waste generated without causing any secondary environmental pollution.

Metals, non-ferrous metals, papers, cardboard, glass, plastics, rags, leather are separated manually or by use of an air classifier or a magnetic separation equipment, depending on their respective characteristics. Air for the operation of an air classifier can be supplied by low-pressure blowers or fans.

Advantages

- With the various sorting devices such as pneumatic, mechanical, and magnetic separation equipment, sorting is effectively executed under hygienic conditions.
- Many sorting systems are relatively simple and easy to operate.
- These sorting systems require comparatively lower investment, utility and maintenance costs.

Disadvantages

- This system does not contribute to the compaction of waste as its use is generally limited to relatively dry waste with an abundance of inert materials.
- Objects rejected after usable materials are sorted have to be re-hauled to the landfill site.
- The materials obtained by mechanical separation are generally of inferior quality in comparison to materials manually sorted out. For example, with the pneumatic device, materials recovered are usually a combination of lighter components, e.g. plastic and paper. Each fraction cannot be completely separated because the specific gravity of both materials is almost equal to the specific weight.
- Manual sorting puts the workers at risk due to the possible inclusion of infectious or hazardous wastes.

Applicability

This system can be technically suitable for the Central District. However, it is highly conceivable that this system will not be financially feasible due to the limited amount of recycled materials. There are only a handful of end users of recycled materials and the percentage of recyclable materials as a whole is still low, only 20%.

h. Conclusion

No large scale processing or treatment technology is recommended for the Central District in view of the city's current conditions. On-site/community based composting system may be adopted if there is a demand for compost in the area. Promotion of on-

site/community based composting for private use, not otherwise, may be a suitable means of promoting self disposal.

Middle scale mechanical sorting comprising a simple system is recommended from a technical point of view, however, the establishment of a proper operation and maintenance system is of more importance than to successfully introduce a mechanical sorting system.

Table 13-3: Characteristics of Possible Processing and Treatment Systems

			Contribution to Landfill			Special Cautions							
ITT	Recovered Material	Main Target of System	Volume Reduction	Harmless	Stabiliza -tion	Stability of Technology	Pre-treatment	Post treatment	Rejected Substances	Acceptability of Waste Quality	Marketability of recovered Material	Environmental Impact	Remarks
Incineration	Heat/or Electric Energy	Volume Reduction & Energy Conversion	A	B	B	A	Not Necessary	Not Necessary	Non-combustibles	A	(Electricity or Heat) D	B	- Initial/Running Cost - Possibility to find User of Heat
RDF	Solid Fuel	Conversion to Fuel	C	C	C	C	Necessary	Necessary	Non-combustibles	C	C	C (Noise & Dust)	- Marketability of Products
Biogas	Gas & Compost	Conversion to Fuel & Fertilizer	C	C	C	C	Necessary	Necessary	Glass, Stone, Plastic, etc.	C	C	B	- Stability of Market for Products
Pyrolysis	Gas or Oil	Conversion to Fuel	B	B	B	C	Necessary	Necessary	Non-combustibles & Carton	C	C	B	- Technology Still Under Development - Initial/Running Cost
Composting	Compost	Conversion to Fertilizer	C	C	C	A	Necessary	Necessary	Glass, Stone, Plastic, etc.	C	C	C (Odor)	- Stability of Market for Products
Size Reduction (Crushing & Shredding)	Ferrous etc.	Volume Reduction of Bulky Waste	C	C	B	B	Extraction of Explosive Objects	Necessary	Explosive Materials	C	C	C (Noise & Dust)	- Large Consumption of Electricity - High Maintenance Costs - Possibility of Explosion
Sorting (Mechanical or Manual sorting)	Ferrous, Glass, Paper, Plastic, etc.	Recycling	C	C	C	A	Occasionally Necessary	Necessary	Non-recyclables	C	B	B	- Stability of Market for Salvaged Materials

Note : A: Excellent B: Good C: Fair of ( ) shows considerations D: Poor and ( ) shows reason

13.4.6 Recycling

a. Introduction

Most developed countries began taking various actions in the mid-1980s directed toward recycling of solid waste. The commonly accepted definition of solid waste recycling would be the utilization of one or more waste components in such a way that they are not deposited in a landfill. Materials commonly recycled or recyclable wastes are paper, cardboard, glass, bottles, aluminum, ferrous metals, and plastics.

The primary benefits of recycling are conservation of natural resources and landfill space; however, the collection and haulage of materials require substantial amounts of energy and labor, and historically, most recycling programs are subsidized economically[4]. The requirements for a successful program are that there is a strong demand for recovered materials and that the market value of the materials is sufficient to cover collection and haulage costs.

b. Present Situation of Recycling in the Central District

b.1 Composition of Recyclable Waste

Table 13-4 shows the surveyed waste composition of the Central District in 1998, the standard waste composition of industrialized countries and the United States. This comparison shows that the present composition of recyclable waste in the Central District in 1998 is less than the average of industrialized countries: 29% for the Central District, 27-80% for industrialized countries, and 67.5% for the United States. However, in general the trend of waste composition of the Central District is within the range of that in industrialized countries. There are some significant characteristics of the waste in the Central District compared with the ones of developed countries.

- The percentage of kitchen waste content is quite high.
- The percentage of paper and glass waste content is lower.
- The percentage of ceramic and stone content is higher.

Table 13-4: Comparison of Waste Composition

	The Central District in 1998	Industrialized Countries	United States in 1990[b]
Kitchen	47.2 %	20-50 %	9.0 %
Paper	11.6 %	15-50 %	40.0 %
Textile	2.8 %	2-10 %	2.0 %
Plastic	7.1 %	2-10 %	7.0 %
Grass/Wood	11.6 %	-	20.5 %
Leather/Rubber	2.2 %	-	1.0 %
Metal	1.9 %	3-13 %	9.6 %
Glass	3.5 %	4-12 %	8.0 %
Ceramic/Stone	12.1 %	1-20 % (including others)	3.0 % (including others)
Others	0.1 %	-	-
Total	100.0 %	100.0 %	100.0 %

Note: Screened items are recyclable wastes.
Source:
[b]: "Integrated Resource Recovery, Recycling form Municipal Refuse: A state-of-the-art Review and Annotated Bibliography", UNDP Project Management Report Number 1, S. Cointreau, et. al. 1985

[4] Integrated Solid Waste Management, Engineering Principles and Management Issues, G. Tchobanoglous, et al, McGraw-Hill, 1993

[b]: Integrated Solid Waste Management, Engineering Principles and Management Issues, G. Tchobanoglous, et al, McGraw-Hill, 1993

c. Alternatives

Recycling systems may be divided into two types in terms of the degree to which governmental organizations are involved: government related recycling system and private sector centered recycling system.

c.1 Governmental Participation Dominated Recycling System

The governmental participation dominated recycling system is carried out as a means of economically controlling solid waste generation. This system obliges dischargers to conduct waste segregation and sorting, as well as separate discharge, collection and haulage. Although these activities incur additional costs they reduce the amount of waste for final disposal.

Many industrialized countries suffer from scarcity of space to construct landfills. In Japan, waste is often transported to disposal sites more than 500 km away from the main collection areas. Therefore, this system has become particularly common in industrialized countries as it reaps a considerable financial benefit by saving landfill space and reducing haulage costs.

Although a government related recycling system is considered to be more productive, they incur large collection and haulage costs, and their success is heavily dependent on public cooperation. Furthermore, because conditions prevalent in developing countries entirely differ from those in industrialized countries, the implementation of this system in the former could generate a different outcome. Therefore, this alternative is only recommendable for municipalities where solid waste management unit cost is very expensive. This is not the case in the Central District.

c.2 Private Sector Centered Recycling System

The government has an indirect and limited role in the promotion of this recycling system: that is the execution of public education programs on recycling. This system does not impose separate collection and any risk encountered is the sole responsibility of the private entities involved.

This alternative is suitable where risks and uncertainties associated with recycling are great and where the benefits could be nothing more than the additional cost this activity incurs. Accordingly, this system is recommended for the Central District.

d. Conclusion of the Recycling System

There are two problems to promote the recycling system in the Central District. One is only few reprocessing plants for recycled materials exist in Honduras and therefore the high haulage cost of recycled materials limit the expansion of recycling business. The other is the composition of recyclable waste in the Central District in 1998 is less than the average of industrialized countries: 29% for the Central District, 27-80% for industrialized countries, and 67.5% for the United States. Therefore the recycling business in Honduras is not stable and risky.

In AMDC, financial stability take precedence over environmental protection and conservation of natural resources. Therefore, AMDC is basically recommended not to take any steps toward recycling that would only involve a lot of capital. AMDC

should, however, start promoting recycling by source separation and discharge to control the rapid waste generation growth rate. Since it would take considerable time before the residents can adequately implement source separation and discharge, these activities should be introduced as early as possible regardless of whether the resulting wastes can be collected and transported.

13.4.7 Final Disposal

a. Possible Alternative Systems

Upon consideration of the possible alternative systems for final disposal, the following aspects are to be taken into account:

- location and number of final disposal sites
- final disposal methods
- landfill structure
- level of sanitary landfill development and operation

b. Location and Number of Final Disposal Sites

The AMDC will use the existing final disposal site while it has a remaining life-span. After it is filled up, the AMDC will use another disposal site.

c. Final Disposal Methods

The final disposal methods can be divided into the following three types:

- open dumping
- controlled tipping
- sanitary landfill

Although the open dumping method is generally employed in the existing disposal site, this operation shall be terminated in view of its adverse effects on landscape, public health and the environment.

Sanitary landfill practices should be adopted as it has been proven to be the most economical final disposal method in terms of controlling environmental impacts within an acceptable level.

The advantages of sanitary landfill are as follows.

- Where land is available, sanitary landfill is usually the most economical solid waste disposal method.
- Sanitary landfill is not investment intensive compared with other disposal methods, i.e., composting and incineration.
- In contrast to incineration and composting, sanitary landfill does not require additional treatment or disposal operations for residue, quenching water, unusable materials, etc.
- A sanitary landfill can receive all types of solid waste, eliminating the necessity for separate collection.

- A sanitary landfill is manageable; increased quantities of solid waste can be disposed of with a minimum number of personnel and equipment.
- Submerged land may be reclaimed for use as parking lots, playgrounds, golf courses, botanical gardens, etc.

d. Landfill Structure

There are five types of landfill structure as shown below.

- anaerobic landfill
- anaerobic sanitary landfill
- improved anaerobic sanitary landfill
- semi-aerobic sanitary landfill
- aerobic sanitary landfill

Either of the above landfill structures contribute to the mitigation of environmental pollution. Figure 13-2 illustrates each of the above landfill structures.

Anaerobic landfill

As leachate generated in landfill layers is hardly drained, the landfill layers constantly maintain an anaerobic condition. The quality of leachate is very poor, generating a bad odor and attracting vectors and vermin.

Anaerobic sanitary landfill

Cover soil is applied onto each layer of waste thereby preventing the outbreak of bad odor and incidental fires, and the propagation of harmful insects to a certain extent. However, leachate and gas generation problems remain.

As in anaerobic landfill, the landfill layers maintain anaerobic conditions.

Improved anaerobic sanitary landfill

In addition to cover soil, this landfill structure is constructed with a leachate drainage facility at the bottom of the disposal site. Leachate quality is improved and anaerobic conditions are maintained.

Semi-Aerobic sanitary landfill

Leachate quality is favorably improved with constant drainage. Drainage pipes stimulate natural ventilation, achieving aerobic conditions in the landfill layers and consequently accelerating solid waste decomposition.

Aerobic sanitary landfill

In addition to the drainage pipes used in semi-aerobic landfills, air supply pipes are introduced for forced air injection. This helps achieve aerobic conditions in the layers, thereby accelerating solid waste decomposition and stabilization and improving leachate quality.

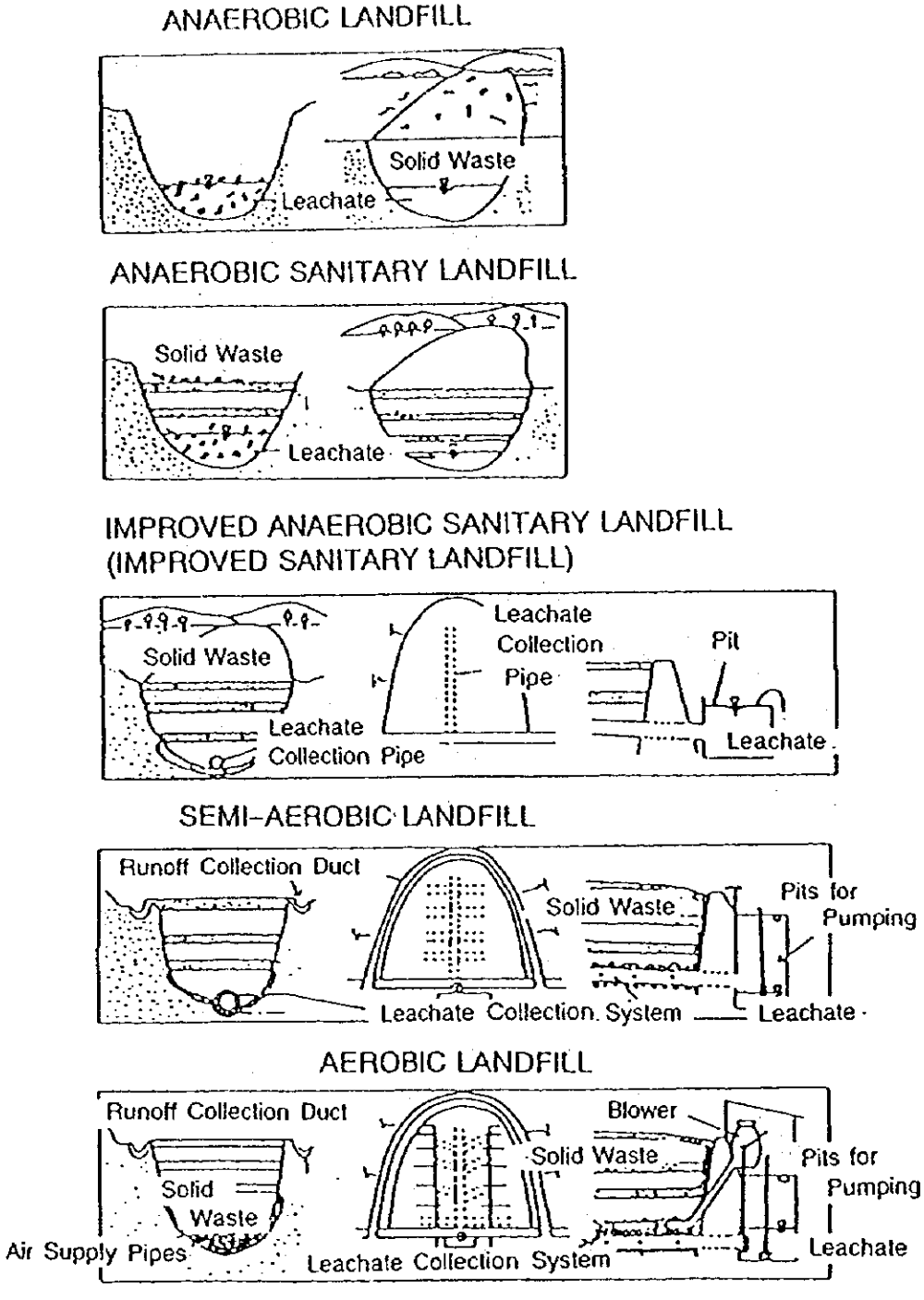


Figure 13-2: Landfill Structures

c. Level of Sanitary Landfill Development and Operation

The sanitary landfill development and operation levels are classified as follows:

- Level 1: Controlled tipping
- Level 2: Sanitary landfill with a dike and daily soil covering
- Level 3: Sanitary landfill with primary leachate circulation system
- Level 4: Sanitary landfill with leachate treatment system

The prospective sanitary landfill development and operation levels are illustrated in Figure 13-3.

The sanitary landfill development and operation levels, mentioned previously, are described below.

Level 1: Controlled Tipping

Introduction of controlled tipping through:

- establishment of access to the site.
- provision of cover materials to prevent fire outbreaks and dispersion of rank odor.
- establishment of inspection, control and operational recording system for incoming waste.

Level 2: Sanitary Landfill with a Dike and Daily Soil Covering

Introduction of sanitary landfill through:

- establishment of a disposal site boundary to eliminate scavenging.
- providing sufficient cover over waste disposed.
- enclosing the disposal area with a dike.
- construction of a divider between present and future landfill areas.
- establishment of a drainage system in order to divert storm water from surrounding areas away from the disposal site to reduce leachate.
- construction of environmental protection facilities, such as a buffer zone, litter control and gas removal facilities, in order to abate direct impact on surroundings.
- installation of gas removal facilities to achieve the conditions necessary for a semi-aerobic sanitary landfill.
- introduction of amenities for staff.

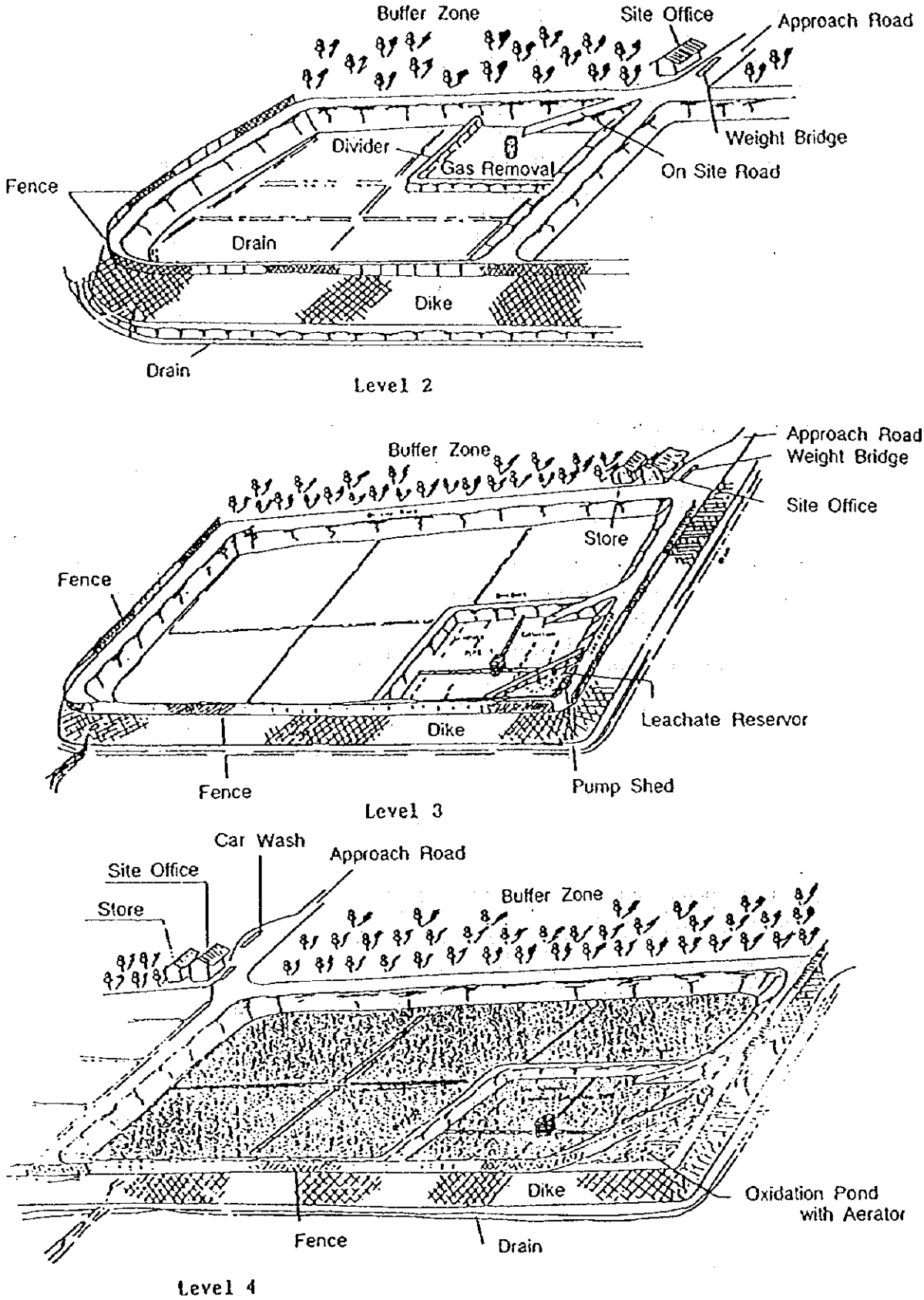


Figure 13-3: Illustration of Prospective Sanitary Landfill Development and Operation Levels 2, 3 and 4

Level 3: Sanitary Landfill with Leachate Circulation

Establishment of leachate control through:

- installation of leachate collection, circulation and monitoring facilities.
- installation of liners for seepage control.
- construction of a semi-aerobic sanitary landfill to accelerate waste decomposition and facilitate stabilization.
- introduction of water sprinkling for dust prevention.

Level 4: Sanitary Landfill with Leachate Treatment

Establishment of leachate treatment through:

- installation of an oxidation pond.

The above mentioned sanitary landfill development and operation levels are described and tabulated in Table 13-5.

Table 13-6 shows the environmental standard to be achieved by each landfill level.

f. Conclusion of the Proposed Sanitary Landfill Level

The sanitary level four which gives the least negative impact but requires the most expensive investment and operation cost is considered to be too difficult for AMDC to introduce due to the limited financial and technical capability.

Therefore, the sanitary level three should be targeted. However, it is unrealistic to introduce the level three immediately considering the present condition is the level one. Therefore the level two is targeted for the immediate improvement for the existing disposal site and the level three is targeted for a new disposal site.

Table 13-5: Outline of Sanitary Landfill Development and Operation

Items	Level of Sanitary Landfill				Remarks
	1	2	3	4	
1 Site Development					
1.1 Main Facilities					
a. Enclosing Structures					
• Enclosing dikes		A	A	A	
• Dividers		B	A	A	B requires a dike made of waste and soil
b. Drainage System					
• Surrounding drains		A	A	A	
• On-site drains (surface water)		A	A	A	
• On-site drains (spring)		A	A	A	If necessary
• Drains for reclaimed area		A	A	A	
c. Access					
• Approach roads	A	A	A	A	
• On-site roads	A	A	A	A	
• Others	A	A	A	A	Improvement of existing road network to access the sites
1.2 Environmental Protection Facilities					
Buffer zones		A	A	A	
Litter control facilities		B	A	A	Movable fences, etc.
Gas removal facilities		B	A	A	
Leachate collection facilities			A	A	
Leachate circulation facilities			A	A	
Seepage control facilities			B	A	
Leachate treatment facilities				A	
1.3 Building and accessories					
Site office	B	A	A	A	
Weighbridge	A	A	A	A	
Store			A	A	
Safety facilities		A	A	A	Gate, fence, lights, etc.
Fire prevention facilities		B	A	A	Water tank, extinguisher, etc.
Monitoring facilities			A	A	Monitoring well, etc.
Car washer			A	A	
2 Equipment					
Landfill Equipment	A	A	A	A	
Others			A	A	Water tanker, inspection vehicles, etc.
3 Operation and Maintenance					
3.1 Operation					
a. Personnel					
b. Cover material	B	A	A	A	B means insufficient soil cover.
c. Utility					
• Fuel tank	A	A	A	A	
• Water		A	A	A	
• Electricity	B	A	A	A	
d. Chemicals					
• Insecticide	A	A	A	A	
• Monitoring chemicals			A	A	
e. Others		A	A	A	Divider, drain for reclaimed area, leachate collection pipes, etc.
3.2 Maintenance					
• Main facilities		A	A	A	
• Environmental protection facilities		A	A	A	
• Building and accessories	A	A	A	A	
• Equipment	A	A	A	A	

A: necessary
B: necessary under certain conditions, or may be omitted when budget is limited

Table 13-6: Environmental Standards for Each Sanitary Landfill Development and Operation Level

Items		Sanitary Landfill Development and Operation Level			
		Level 1	Level 2	Level 3	Level 4
1	**Landfill Structure**				
1.1	Landfill Structure	Anaerobic Sanitary Landfill	Improved Anaerobic Sanitary Landfill	Semi-aerobic Sanitary Landfill	Semi-aerobic Sanitary Landfill
1.2	Achieved Condition	• Leachate generated in solid waste layers is seldom drained; an anaerobic state is maintained. Generally, the quality of leachate is poor. • Due to the prolonged decomposition of waste, stabilization is slow.	• Through gas removal facilities, the quality of leachate is slightly better than in Level 1; an anaerobic state is maintained. • The rate of decomposition is slightly improved.	• Leachate accumulated at the bottom of landfills is promptly discharged through drainage pipes (leachate collection pipes). The pipes also permit natural ventilation. • This structure facilitates decomposition of solid waste because a semi-aerobic condition is maintained. The quality of leachate is much improved and generation of offensive odor is further reduced. • Water content of solid waste is lower than Level 2	• Leachate accumulated at the bottom of landfills is promptly discharged through drainage pipes (leachate collection pipes). The pipes also permit natural ventilation • This structure facilitates decomposition of solid waste because a semi-aerobic condition is maintained. The quality of leachate is much improved and generation of offensive odor is further reduced. • Water content of solid waste is lower than Level 2
2	**Leachate and it's Impacts on Surroundings**				
2.1	Leachate Generation Amount	• Leachate is freely discharged outside both landfilling and reclaimed areas because of the absence of an enclosing structure. • Storm water flows into the landfill from the catchment area and increases leachate amount.	• As for reclaimed areas, surface water is drained and discharged outside. • Storm water from the catchment area is diverted into surrounding drains. • A divider separates the area for leachate generation from the working area. • The separation of the area for leachate generation reduces leachate amount.	• As for the reclaimed areas, surface water is drained and discharged outside. • Storm water from the catchment area is diverted into surrounding drains. • A divider separates the area for leachate generation from the working area. • The separation of the area for leachate generation reduces leachate amount.	• As for the reclaimed areas, surface water is drained and discharged outside. • Storm water from the catchment area is diverted into surrounding drains. • A divider separates the area for leachate generation from the working area. • The separation of the area for leachate generation reduces leachate amount.
2.2	Leachate Control Facilities	• None	Enclosing dike and divider prevent direct discharge of leachate.	• In addition to the facilities for Level 2 there are leachate cycling and monitoring facilities. • Leachate is discharged only during heavy rain from the regulation pond. Leachate discharged is therefore, diluted.	• Conditions are similar to Level 3 except for the continuous treatment of effluent which is discharged from oxidation pond.
2.3	Leachate Treatment Facilities	• None	• None	• The regulation pond may act as an oxidation pond.	• Leachate is treated in an oxidation pond with an

Items		Sanitary Landfill Development and Operation Level			
		Level 1	Level 2	Level 3	Level 4
					aerator.
2.4	Leachate Quality	• High leachate content, and the quality is the poorest of all the landfill levels. The quality is also not expected to improve much even after a long period of time.	• Amount of leachate is limited because of the dike and divider. However, leachate quality does not improve even after a certain period of time.	• Amount of leachate is limited as in Level 2. • The quality of leachate improves because of the semi-aerobic condition of the landfill. • Leachate circulation facilitates waste purification • Since leachate is discharged only during heavy rain, it is therefore, diluted.	• Amount of leachate is limited as in Level 2 • The quality of leachate will be improved in order to meet the effluent standards.
2.5	Leachate Impact				
a	Impacts on Ground water	• The degree of impact varies depending on the permeability of the bottom soil. • If the bottom soil is permeable, the impact on ground water will be immense because of the high pressure head and large amount of leachate.	• The degree of impact varies depending on the permeability of the bottom soil. • The amount of leachate is much less than Level 1. However, leachate would still have an immense impact if the bottom soil is permeable.	• A liner is laid to protect ground water from leachate seepage. • There is very little ground water contamination	• A liner is laid to protect ground water from leachate seepage. • There is very little ground water contamination.
b.	Impacts on Surface Water	• Because leachate is freely discharged from the landfill site, the impact on the surrounding water basin is very high.	• Discharge of leachate may occur when the divider is submerged and through seepage. • Although leachate amount is limited, the impact on the surrounding water basin is high because of uncontrolled and unimproved leachate.	• Discharge of leachate occurs only during heavy rain. • Leachate can be monitored. If the leachate to be discharged would affect the surroundings, the construction of leachate treatment facility is advocated.	• Effluent from the landfill site will satisfy the required effluent standards.
3	**Others**				
3.1	Vector control	• Encourages proliferation of flies, insects and rodents. • Entices the huge gathering of crows • Constant generation of rank odor	• Vector control is achieved and at a much improved level compared to Level 1.	• Vector control is achieved and at a much improved level compared to Level 1.	• Vector control is achieved and at a much improved level compared to Level 1.
3.2	Odors and Gas Production	• Occasional fires occur due to spontaneous ignition	• Conditions are much better than Level 1. • No fire outbreaks	• Due to semi-aerobic landfill structure, conditions are better than Level 2.	• Due to semi-aerobic landfill structure, conditions are better than Level 2.
3.3	Others	• Scattering of waste, dusty condition. • Deterioration of the landscape. • Noisy • Presence of scavengers.	• It is improved in all aspects.	• In addition to the condition achieved at Level 2, dust clouds are mitigated with the use of a water sprinkler.	• Same as Level 3.

13.4.8 Maintenance of Vehicles and Equipment

There are basically two possible alternatives for the maintenance of vehicles and equipment. The first alternative would be the allocation of preventive services to the AMDC workshop and large-scale maintenance services to private garages. The second alternative would be the allocation of all maintenance and repair works to the AMDC workshop.

Since preventive services are basic and essential for the maintenance of vehicles, the first alternative would be inexpensive as it would only require basic facilities and a minimum number of mechanics and workers. The private workshops must have sufficiently skilled personnel, to properly provide the AMDC's fleet with the required technical services. Since many private workshops in the Central District were assessed to have skilled mechanics to provide these services, the first alternative would be appropriate for the Central District.

The second alternative demands a large number of skilled mechanics, a large workshop, as well as sophisticated machinery. It is capital intensive and requires a lot of money for operation and maintenance, as well as management of technical difficulties that may arise, with a degree of uncertainty and risks.

Governmental organizations tend to inefficiently conduct operations due to inflexibility, political interference, lack of motivation among staff, slow decision-making processes, etc. Therefore, the services to be conducted by the AMDC should be minimized; the first alternative is concluded to be more appropriate for the Central District.

13.5 Selection of the Best Technical System

Following the examination of SWM technical sub-systems, the selection of the best SWM technical system for the Central District was proposed.

Table 13-7: The Best SWM Technical System

Category	Proposed Technical System
Discharge and Storage	1) Source separation • Separates recyclable and non recyclable wastes 2) Type of storage • Plastic sacks and plastic containers for common areas • Communal containers for marginal areas 3) Collection frequency • More than twice a week 4) Collection method • to introduce the separate collection for wastes 5) Type of collection method • Common areas: Curb collection • Marginal areas: Point collection with communal containers 6) Collection time • Most areas: Day collection for most areas • Traffic congested areas: Night collection 7) Type of collection vehicles • Common areas: Compactor trucks • Marginal areas: Detachable container trucks 8) Haulage system • Direct transport by motor vehicles
Primary Collection	Primary collection service is required only in marginal areas. Hand cart and pedal cart systems are used.
Secondary Collection and Haulage	Common areas • 15 m^3 compactor trucks • 15 m^3 compactor trucks Marginal areas • 5.5 m^3 hoist trucks Street sweeping waste • 10 m^3 roll-on roll-off
Street Sweeping	• Manual sweeping method
Processing and Treatment	• Only on-site/community based composting is encouraged.
Recycling	• Recycling activities are encouraged through institutional and educational programs as long as collection does not involve any large extra cost.
Final Disposal	1) Existing disposal site Level 2: Sanitary landfill with a surrounding dike, daily soil cover 2) New disposal site Level 3: Sanitary landfill with a liner for the prevention of leachate percolation into the ground
Maintenance of Vehicles and Equipment	• Preventive services are allocated to the AMDC workshop and large-scale maintenance services to provide private garages.

Chapter 14

Evaluation of the Proposed Master Plan

14 Evaluation of the Proposed Master Plan

14.1 Introduction

In view of the current urban sanitary problems, such as illegal waste dumping in slopes, vacant lands, brooks, rivers, streams, etc., in the marginal areas located around the capital, public awareness should be heightened to gain cooperation in the improvement of SWM through of a public campaign.

Low income rural migrants live in marginal areas, e.g., steep slopes and hillsides, that are not served by the regular collection services due to poor access roads and unfavorable topography.

Periodic clean-up operations are carried out in some areas under the "mobile municipality" program by AMDC. These operations are carried out in some *colonias*, but even though they fulfill an important function, they are far from being the real solution. Within this periodic clean-up operation program, the residents either stored their wastes for several days before the clean-operations, burnt them, or dumped them illegally in the city, thereby air, soil, and river pollution, and deteriorating aesthetic conditions as well as sanitary conditions favorable for pathogens and vectors to proliferate. Being a big social for the whole city, the urgent need to adopt countermeasures to improve the sanitary conditions of the community was recognized.

Accordingly, the "Campaign for Raising Awareness on Solid Waste Issues" and the "Experiment on the Implementation of the Best Collection System for Marginal Areas" were proposed and carried out to improve the aesthetic and sanitary environment, with due consideration of the technical aspects of SWM, as well as social and cultural aspects. These activities will serve to confirm the feasibility of the plans of this study and help anticipate any problems that may arise. Since the pilot projects determine the success of the project, the active participation of concerned institutions and people is a necessary.

The pilot projects covered the whole capital city, focusing on the *colonias* of San Martín, Ayestas and Tres de Mayo, which are under Sector 7 of the Central District. The present population and number of households in these *colonias* are shown in the table below:

Table 14-1: Present Population and Number of Households in the Pilot Project Areas

Colonias	San Martín	Ayestas	Tres de Mayo	Total
Total Population	1,677	8,319	13,437	23,433
Number of Housing	250	1,300	2,200	3,750

14.2 Campaign for Raising Awareness on Solid Waste Issues

14.2.1 Preparation Works for the Campaign

The following preparation works were executed in June 1998 in preparation for the campaign.

- Explanation of the purpose and detailed plan of the pilot projects to relevant organizations.
- Explanation of the purpose and detailed plan of the pilot projects and the collection system in marginal areas to community leaders and residents.
- Encouragement of the residents to participate in the clean-up operations through the help of community leaders and health center volunteers.
- Implementation of educational workshops and cooperation campaign.
- Hold a public logotype contest to select a campaign logo.

14.2.2 Relevant Organizations for the Campaign

In order to guarantee the smooth conduct and success of the project campaign, a series of meetings and discussions were carried out with the relevant organizations shown below:

- Social Development Manager's Office of AMDC
- Environmental Department of AMDC
- Health Center of Tres de Mayo (Ministry of Health)
- Educational institutions of the pilot project areas (Ministry of Education)
- Community groups, etc.

14.2.3 Design of Logotype, Poster and Banner

Public cooperation is fundamentals to the accomplishment of the goals related to solid waste problems in the marginal and urban areas of Tegucigalpa's Central District. Therefore, for the implementation of the campaign, AMDC carried out a logotype making contest with the support of the study team. The contest was open to all Central District residents. The selected logo was used in posters, stickers, T-shirts, cups, refuse bags, banners, leaflets and other publicity campaign tools. The contest was the first step towards encouraging public participation and improving public consciousness, as well as being, during the Study, the first public contribution to the improvement of the city's environment.

The logotype submission date was set for the middle of June 1998. The selection criteria were originality, neatness, creativity, design colors and identification with the

capital city and campaign objectives. Among the logos submitted (54 participants), the most descriptive designs were chosen and prizes were awarded to the first, second and third places.

The first prize was awarded to the caricature of a sympathetic small container, which symbolize the street container installed by AMDC in many areas of the city, with the following slogan:

"CAPITAL LIMPIA, CAPITALINO CONTENTO"

("CLEAN CAPITAL, HAPPY CITIZEN")

Based on the logotype a poster and publicity banner bearing the campaign message *"Let's make our Capital the most clean and beautiful city"*, was designed by the counterpart and the study team to promote the "Campaign for Raising Awareness on Solid Waste Issues".

The winning logotype and those that come second and third places, and the poster and banner are as shown below.

First Place

Second Place

Third Place

Figure14-1: Winning Logotypes

Poster and Banner

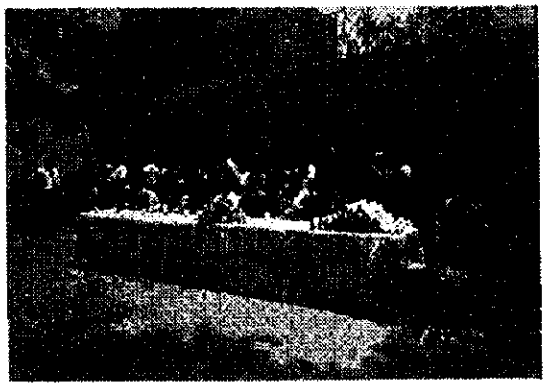
Figure14-2: Campaign Poster

Figure14-3: Campaign Banner

14.2.4 Execution of the Campaign

a. Implementation of the Campaign

The campaign project was implemented by the counterpart with the support of the study team in the whole city from the beginning of July until early August 1998. The campaign especially focused on the marginal areas of San Martín, Ayestas and Tres de Mayo, colonias located at the northwest of Tegucigalpa City.



Opening ceremony of the campaign organized by AMDC

During the experiment, the following activities were carried out to examine the feasibility of the proposed plan.

- Observe the changes in degree of public awareness before and after the campaign.
- Check the suitability of the proposed campaign tools and the proposed master plan projects through the results of the pilot projects.

a. Implementation Schedule

The pilot projects areas are as shown in the following figure. The pilot project implementation schedule is as shown in the table below.

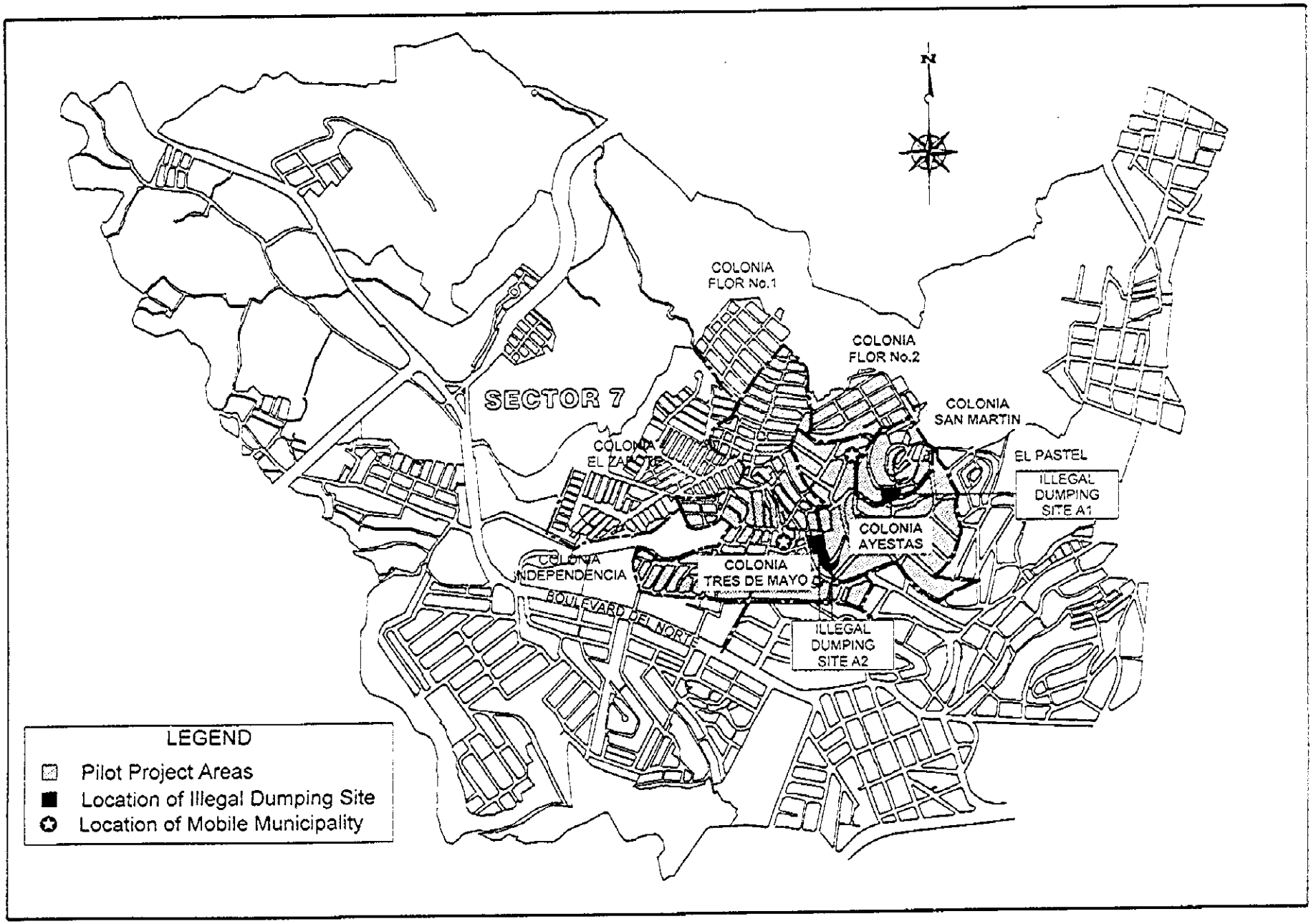


Figure14-4: Location of Pilot Project Areas

Table 14-2 Pilot Projects Implementation Schedule

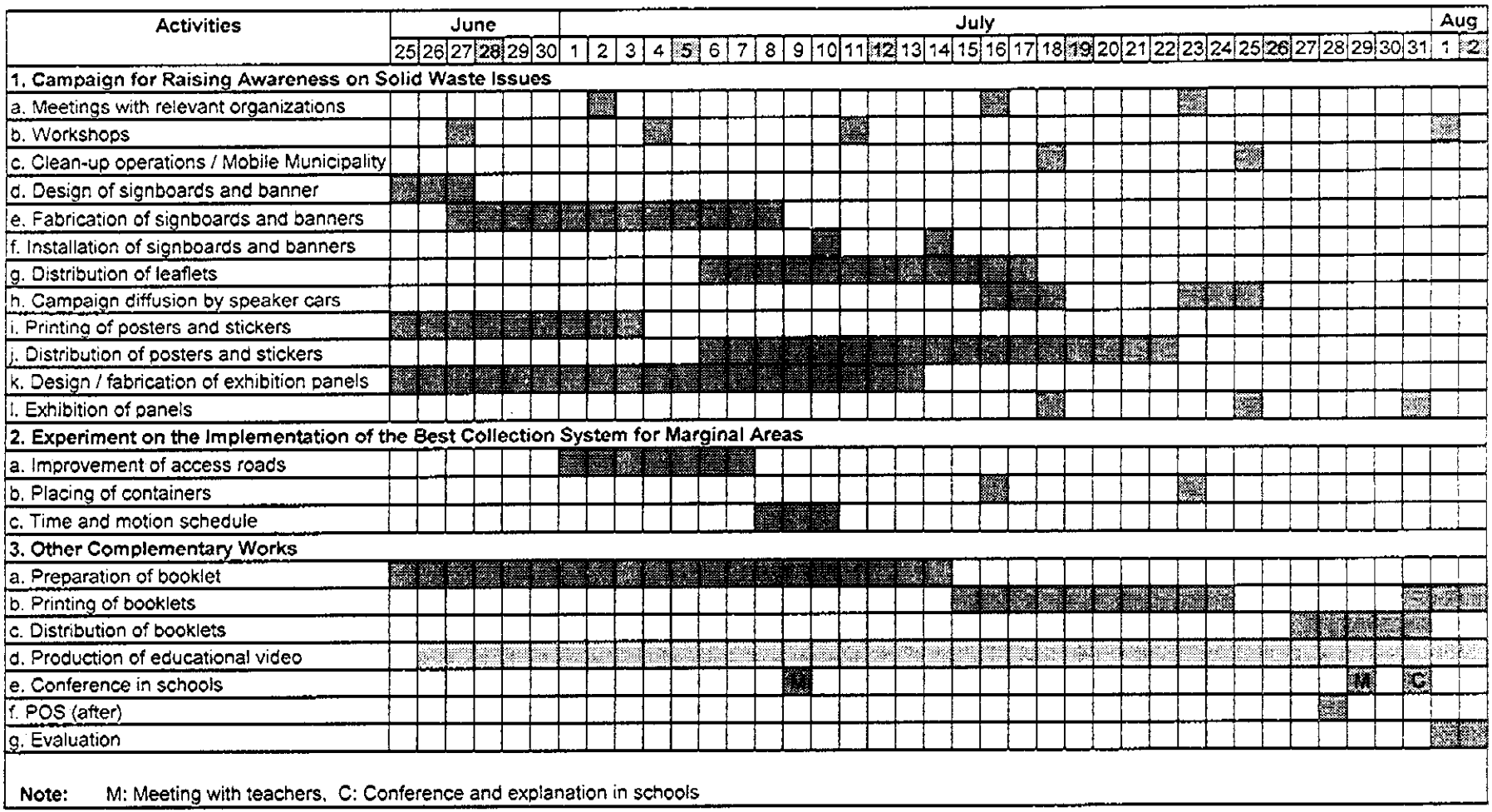


Table 14-2: Pilot Projects Implementation Schedule

Table 14-2 Pilot Projects Implementation Schedule

Activities	June						July																										Aug	
	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2
1. Campaign for Raising Awareness on Solid Waste Issues																																							
a. Meetings with relevant organizations																																							
b. Workshops																																							
c. Clean-up operations - Mobile Municipality																																							
d. Design of signboards and banner																																							
e. Fabrication of signboards and banners																																							
f. Installation of signboards and banners																																							
g. Distribution of leaflets																																							
h. Campaign diffusion by speaker cars																																							
i. Printing of posters and stickers																																							
j. Distribution of posters and stickers																																							
k. Design - fabrication of exhibition panels																																							
l. Exhibition of panels																																							
2. Experiment on the Implementation of the Best Collection System for Marginal Areas																																							
a. Improvement of access roads																																							
b. Placing of containers																																							
c. Time and motion schedule																																							
3. Other Complementary Works																																							
a. Preparation of booklet																																							
b. Printing of booklets																																							
c. Distribution of booklets																																							
d. Production of educational video																																							
e. Conference in schools															M																			M		C			
f. POS (after)																																							
g. Evaluation																																							

Note: M: Meeting with teachers C: Conference and explanation in schools

Table 14-2 Pilot Projects Implementation Schedule

14.2.5 Campaign Methods

a. General

The public campaign consists of attempts to improve individual, group and community behavior with regard to solid waste disposal through meetings, lectures and publications, in order to prevent diseases, and protect and improve public health. To achieve these objectives various campaign tools were used.

b. Campaign Tools

The following are the campaign tools used in the "Campaign for Raising Awareness on Solid Waste Issues" to promote public awareness and cooperation:

Table 14-3: Campaign Tools

Campaign Tools	Purpose
Signboards	12 message and indication signboards were installed in the marginal areas and final disposal site to encourage public cooperation.
Posters	3000 posters were distributed among institutions, commercial establishments, schools, community leaders and residents, to promote the campaign.
Stickers	As the stickers are very effective means of promoting the campaign because their handiness facilitates distribution to a large segment of the population. Accordingly, 15,000 stickers were distributed to institutions, commercial establishments, cars, buses, taxis, etc.
Banners	30 banners carrying the slogan below were installed all over the city: "Let's make our Capital the most clean and beautiful city" "Clean Capital, Happy Citizen"
Leaflets	4,000 leaflets were distributed within the marginal areas (2,000) and other urban areas (2,000) to promote public cooperation in clean-up operation.
Exhibition panels	10 educational panels on SW issues were prepared by the study team for use in seminars, education workshops, "mobile municipality" and other cultural events, to enhance public awareness and encourage public cooperation.
Booklets	Complementary tool for use in education programs for schoolchildren and in community lectures.
TV, video deck & video camera	A TV, video deck and video camera were provided to AMDC for the production of educational videos related to SW issues and other sanitary and environmental issues. A video was produced by the counterpart during the implementation of the campaign.
Overhead projector and screen	An overhead projector and screen were provided for use in meetings, seminars, conferences and educational workshops on SWM, sanitation and environmental issues.
A small generator, loud speakers & microphone	A generator, four large speakers, and a microphone were provided for the "mobile municipality".
Whiteboard	Whiteboard for meetings, conferences and workshops and other multiple purposes was provided.
Large tents	2 large tents for use in the outdoor free health care activity of the "mobile municipality" program, including the education of the public on hygiene and sanitary issues, were provided.
T-shirts and caps	700 T-shirts and 500 caps were distributed among the pilot project community residents, schoolchildren and participants in the clean-up operations activities.

As stated in the table above, message signboards were installed at 6 places in the marginal areas and indication signboards at 8 places in the final disposal site. Also, 30 banners bearing the campaign message were placed at different areas in the city to promote the campaign as shown in the figure below.

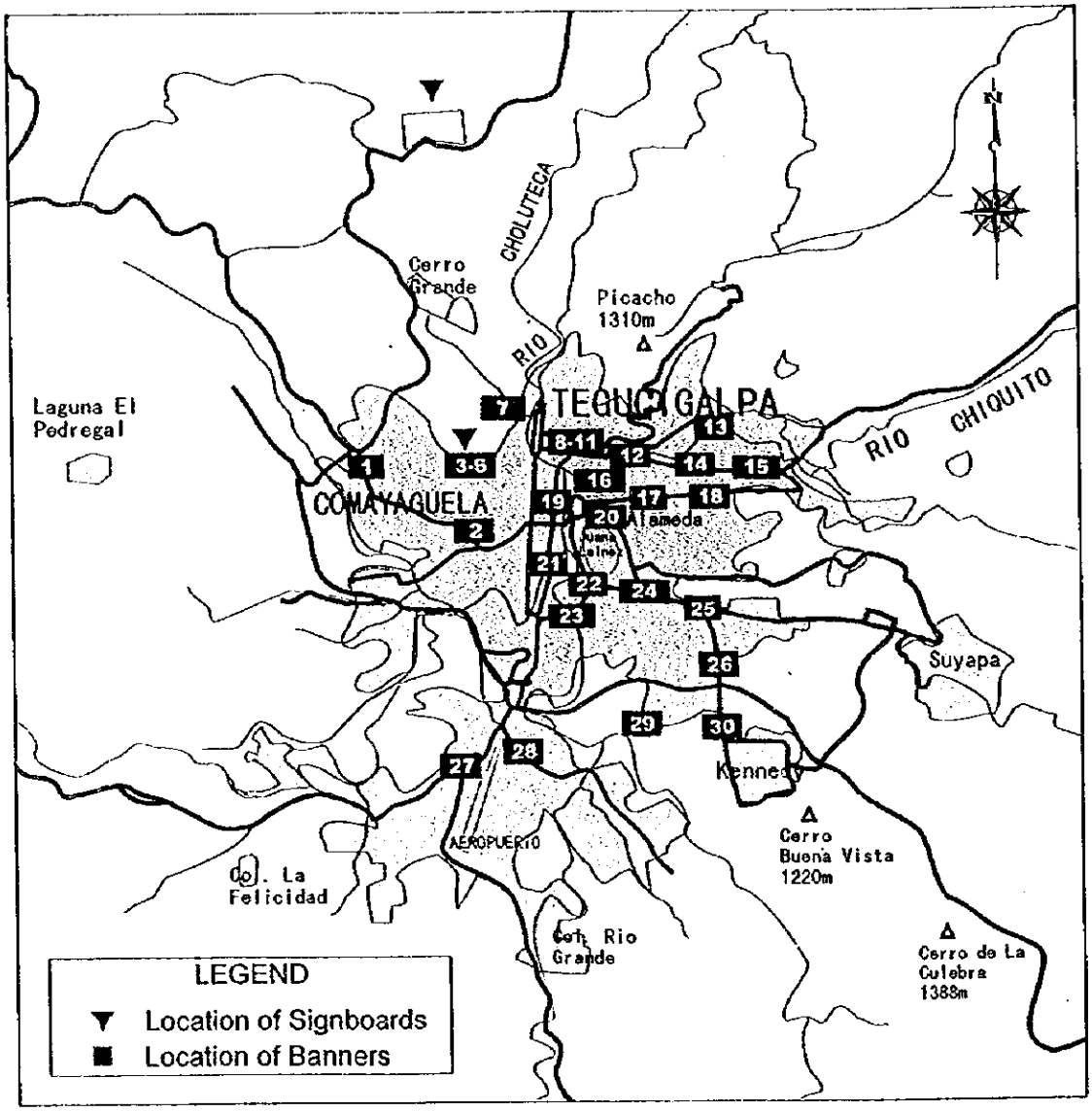


Figure14-5: Placement of Signboards and Banners

As previously mentioned, the purpose of the public education campaign is to enhance public awareness and promote public cooperation. Under this premise, and because of the importance of the active participation of the whole population and the relevant organizations involved, the team requested AMDC to plan and implement the campaign. The counterpart proposed the following methods and campaign tools, which were implemented with the team's support:

- Mass media: advertisements, press releases, TV and radio broadcasting, newspaper publications, targeting the general public or large segments of the population.
- Music festival and/or sport events through the "mobile municipality": festivals are likely to encourage the public to participate, attend and promote campaign activities. Therefore, AMDC through the "mobile municipality" program, carried out musical and sports events with the participation of the project area residents, including children.
- Distribution of refuse plastic bags bearing the campaign logo: 5,000 refuse bags bearing the logo "Clean Capital, Happy Citizen" were distributed to the public.
- Handicrafts bearing the campaign logo: piggy banks, pots, vases, penholders, etc.: various handicraft items were produced by the counterpart to promote the campaign.

AMDC implemented all the proposed methods in cooperation with relevant institutions, e.g., the Health Center of Tres de Mayo, several schools in Tres de Mayo, Ayestas, San Martín and Comayagüela, and the residents of the three *colonias* involved.

14.2.6 Community Training

a. General

The direct supervision of the training programs for the citizens or community programs is considered an effective means of relaying information to the population. This training was the most important public education method held in the selected areas of San Martín, Ayestas, and Tres de Mayo.

The training methods used were the following:

- House visits
- Workshops
- Tour of pilot project areas by the community leaders of beneficiary areas and institutional officials.

These training activities were conducted within a month by the counterpart and the team, and were reinforced through additional publicity by means of posters, stickers, distribution of T-shirts, caps, canvassing, leaflets, etc.

Table 14-4: Community Meetings and Workshops

Activity	Place	Participants	Responsible Organization
House Visits	*Colonias* of San Martín, Ayestas and Tres de Mayo	Family members	SDD of AMDC Health Center of Tres de Mayo
Workshops	Tres de Mayo, Ayestas and San Martín	Community leaders, volunteers from the health center, residents	SDD of AMDC ED of AMDC JICA study team

b. Meetings and Workshops

1) Meeting with the Community

The main goal of the meetings held on June 20 (20 persons) and June 27 (25 persons) with the community leaders, health center volunteers and residents of San Martín, Ayestas and Tres de Mayo, was to explain the objectives of the pilot projects and gain the support and cooperation of the people. The meetings were held in the Health Center of Tres de Mayo.

Residents of the pilot project areas showed a lot of interest and were grateful that their area was selected for the pilot project. All attendees indicated the willingness to cooperate with the implementation of the "Campaign for Raising Awareness on Solid Waste Issues" and the "Experiment on the Implementation of the Best Collection System for Marginal Areas".

According to the comments of the community, the residents should be educated on relevant issues first before any collection experiment is to be implemented. This comment is presumably attributed to the inadequate SWM and is also considered important in view of the raucous attitude of the waste collectors who, instead of collecting waste, end up littering the streets.

2) Workshop before Implementation of the Pilot Projects

Prior to the implementation of the pilot projects, two education workshops were carried out in the Tres de Mayo Health Center and the church in San Martin (July 4th and 11th, 1998, respectively) with about 30 community leaders and residents of the three *colonias* involved.

Workshop in San Martin

3) Workshop after Implementation of the Pilot Projects

This workshop was held in the Jorge Fidel Duron School in Ayestas after the implementation of pilot projects. The workshops was attended by the community leaders, health center volunteers and residents of the three *colonias* involved.

Workshop after Implementation of the Pilot Projects

All the participants were grateful for the implementation of the pilot project in their *colonias*. The majority of the attendees has participated in the campaign and agreed to cooperate in the sustainability of the collection experiment implemented in their *colonias* and in keeping the area of the containers clean.

14.2.7 Clean-up Operation and "Mobile Municipality"

a. Objectives of the Experiment

The experiment aims to demonstrate the impact of improved sanitary, environmental and esthetic conditions by eliminating illegal dumpsites located at the steep areas along the boundary of San Martín / Ayestas (A1) and Tres de Mayo / Ayestas (A2). The experiment also intends to achieve this aim by executing a clean-up operation in the public areas of the three *colonias* in conjunction with the "mobile municipality" program. Another objective of the experiment is to obtain basic data for the design of the feasibility study.

The experiment will further the understanding of the marginal area residents regarding the significance of sanitation issues, enhance public awareness, and encourage public cooperation in SWM improvement. Moreover, it will help change the residents waste management habits for the better, promote cooperation for the conduct of proper SWM, and consequently realize the campaign slogan.

b. Clean-up Operation

The experiment was carried out on the 18th and 25th of July 1998, in steep areas A1 and A2 (along the boundaries of San Martin/Ayestas and Tres de Mayo/Ayestas, respectively), and streets of these *colonias*, where the neighborhood is large. Being the largest receiver of waste amount, the selection of these steep areas was based on the extent of damage to the surrounding environment.

More than one thousand people participated and cooperated in the clean-up operation activities. The experiments were carried out with the participation of counterparts from AMDC, Ministry of Health (Health Center of Tres de Mayo), students from several schools, community residents and volunteers.

Upon consideration of the campaign objectives, the main emphasis of the clean-up operation was to gain the interest and active participation of the citizens. Many residents, teachers, students, health center volunteers and municipal workers participated enthusiastically, and the majority of the residents of San Martin and Ayestas (North), particularly women and children, were the most cooperative. The positive response from the residents and youth during these activities helped affirm how effective the clean-up operation organized and implemented by the counterpart, with the team's support, was in enhancing public awareness and encouraging public cooperation.

The campaign activities consisted of the following:

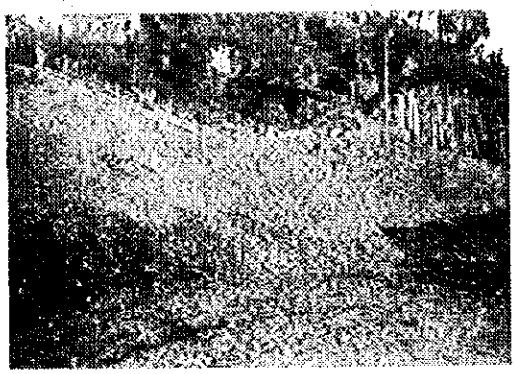
- Community meetings before the implementation of clean-up operation days to explain how the community can participate and cooperate.
- Canvassing before and during the clean-up operation day to request cooperation in cleansing activities held by promoters of the Social Development Manager's Office (AMDC) and volunteers of the Tres de Mayo Health Center (SS).
- Resident participation (main steep area A1: approximately 130 persons; city area: about 300 residents and 120 students from several schools; and main steep area A2: approximately 80 persons; city area: about 500 residents and 100 students from several schools).
- Use of 8 dump trucks, a wheel loader, excavator and tools, e.g. shovels, hackles, picks, brooms, refuse bags, *machetes*, gloves, etc.

In the first clean-up operations held in July 18, the activities were conducted late and slow due to the delay of the municipal personnel in bringing the cleansing tools. However, due to the initiative and hard work of the residents (see photo) the operation was about 100% satisfactory, and the objectives of the campaign were successfully attained.

Clean-up operation in Area (A1) carried out by the residents

On the other hand, on the second clean-up operation in July 25 (in Tres de Mayo/Ayestas West), the residents and students were not as enthusiastic as they were in San Martín and Ayestas North. It seems that the people were more interested in the "mobile fair" activities or would be motivated to cooperate in the activities if they were to receive material incentives (T-shirts or caps), rather than participate because they were a part of the community. However, the leadership and initiative demonstrated by municipal supervisors and workers -taking advantage of past campaign experiences- more than compensated for the lack of enthusiasm on the part of the residents.

Area A1: before the clean-up operation



Area A1: after the clean-up operation

c. "Mobile Municipality"

The "mobile municipality" is a program carried out by the Social Development Manager's Office. At present, it is successfully executed with the support of the Ministry of Health, as a tool to establish rapport between municipal authorities and the population of the Central District.

The areas considered to have basic needs that are not met were given priority for the implementation of the mobile municipality program.

This program covers the cultural, educational, recreational, sports, health and environmental aspects, to encourage the population to adopt good habits and healthy lifestyles. This aspect covered by the program are further categorized below:

- Health: ("health fair")
- Education: (educational conferences, hair cutting, promotion of traditional children's games, i.e., kite flying, spinning of tops, etc.)
- Culture: recreational and cultural activities, i.e., dances, musical events, after the clean-up operations
- Community participation: house to house visits and community meetings
- Sports: tournament and games, i.e., jumping rope, marble games, etc.

- Communication: educational message encouraging the residents to change their waste disposal manners
- Cleansing Department of Urban Development: clean-up operations.

The other aims of the "mobile municipality" program are to:

(1) generate good habits among adults and children, contributing to AMDC concept of "Healthy Capital" through education programs, (2) implement necessary activities for a healthy environment, and (3) reinforce cultural bonds of the capital city and increase national values and identity.

"Mobile Municipality" in Tres de Mayo

During the implementation of the clean-up operations under this program, the residents were observed to be very diligent in keeping their homes and surrounding clean. These operations were carried out successfully in the pilot project areas, but although they fulfill important functions, they are far from being the real solution to waste problems prevailing in other marginal areas around the capital city.

Therefore, considering the importance of these issues and to reinforce the "mobile municipality" program, the Social Development Manager's Office requested the JICA study team to provide equipment and other items for the implementation of educational programs in the community. The objectives of these educational programs were: (1) to promote public awareness and introduce public cooperation as a mean of keeping the city clean and healthy, and thus, (2) to improve SWM in the Central District.

The equipment and other items provided by JICA to implement the educational programs were as follows:

Table 14-5: Equipment for the "Mobile Municipality" Program

Equipment	Qty.	Purpose
Generator	1	To generate electricity and feed power to speakers to be used in the "mobile municipality" program.
Speakers	4	For use in cultural and social activities held outdoors.
Microphone	1	
Exhibition panels	10	Educational and informative panels on problems caused by waste, waste generation, waste collection, destination of waste, waste collection and disposal service expenses, and possible solutions.
OH Projector	1	OHP & screen to be used in seminars, meetings, workshops and conferences, etc.
Screen	1	
TV and video deck	1	To show educational videos on sanitary and environmental subjects.
Video camera	1	To film and produce educational videos on sanitary and environmental subjects.
Large tent (3.00 m x 6.00 m)	2	An open tent to attend to the needs of the community and a fully closed tent for health care services for women and others.

The above equipment were used for the implementation of the pilot projects in activities such as the opening ceremony of the campaign, conferences in schools, meetings and workshops in pilot project areas, and especially in the two "mobile municipality" and clean-up operation activities carried out in the marginal areas of San Martín, Ayestas and Tres de Mayo.

d. Results of the Clean-up Operations and Mobile Municipality Program

The table below show's the results of the clean-up operations and the mobile municipality executed on July 18th and 25th in the pilot project areas.

Table 14-6: Results of the Clean-up Operations and the Mobile Municipality Program

Activity	San Martin / Ayestas (North Sector)		Tres de Mayo / Ayestas (West Sector)	
	Result	○ Positive ● Negative	Result	○ Positive ● Negative
General Organization	Fair	●Lack of coordination between municipal departments	Good	○Well organized and coordinated activities between municipal departments and the Tres de Mayo Health Center
Organization for Clean-up Operation	Fair	●Delay in providing cleansing tools and personnel	Good	○Well coordinated activities by the Cleansing Section ●Inefficient transportation schedule and lack of fuel
Organization for Mobile Municipality Program	Good	○Good	Very Good	○Very good ○Good performance of children in the cultural activities
Diffusion and Promotion	Good	○Very Good ●Diffusion outside of the clean-up operation areas	Good	○Achievement of the objectives ●Large concentration of social promoters in the "Mobile Municipality" event
Community Participation in the Illegal Dumpsites A1 and A2	Excellent	○Clean-up operation initiated by the community residents ○Aproximately 130 participants	Good	○Participants of residents from San Martin and Ayestas (North sector) ○Clean-up operation started by municipality ○Approx. 80 participants ●Belated resident cooperation for the clean- operation
Community Participation in the Streets of the *Colonias*	Very Good	○General motivation to clean streets and homes ○Aproximately 300 participants	Good	○Degree of motivation same as in the preceding clean-up operations ○Approx. 500 participants ●There was no high cleansing motivation around the main "mobile municipality" attracted by fair events.
Student Participation	Good	○The participation of students was very positive in encouraging resident cooperation in the clean-up operation ○Participants: 120 students from primary, junior and senior high schools	Very Good	○The participation of students helped encourage residents to cooperate in the clean-up operation ○Good organization and supervision of the students. (100 students from the primary, junior and senior high schools)
Use of Containers	Very Good	○San Martin: 80% ○Ayestas: 62% ○Total : 71%	Good Total: 62%	○ Tres de Mayo: 45% ○ Ayestas: 62% Total : 54%

Activity	San Martin / Ayestas (North Sector)		Tres de Mayo / Ayestas (West Sector)	
	Result	○ Positive ● Negative	Result	○ Positive ● Negative
Residents satisfied with the Containers	Very Good	○San Martin: 97% ○Ayestas: 82%	Good	○ Tres de Mayo: 85% ○ Ayestas: 82%

Summary : The results of the clean-up operation activities were more satisfactory in the A1 illegal dumpsite in San Martin/Ayestas (North) than in Tres de Mayo / Ayestas (West).

A1 San Martin / Ayestas (North)

1) Factors which contributed to the clean-up operation

- ○ Initiative of the residents
- ○ Topographic accessibility
- ○ Separate activity and distance from the "mobile Municipality" area

2) Negative aspects

- ● Delay in providing cleansing tools and personnel by the Cleansing Section
- ● Lack of coordination between municipal departments and other relevant organizations

A2 Tres de Mayo / Ayestas (West)

1) Factors which contributed to the clean-up operation

- ○ Good coordination between relevant organizations
- ○ Good cooperation from residents of Ayestas and San Martin
- ○ Good performance of students in the clean-up operations
- ○ Good organization of the mobile fair

2) Negative aspects

- ● Late participation of the residents to start the clean-up operation activities
- ● Sloped topography, making manual cleansing activities difficult to execute
- ● Little participation from residents of *colonia* Tres de Mayo.

Conclusion: The "Campaign for Raising Awareness on Solid Waste Issues" had very positive results because the main objectives, which are shown below, were obtained:

To enhance public awareness on adequate SWM and introduce public cooperation as a means of keeping the city clean and healthy and to improve the aesthetic environment as well as sanitary conditions of the "colonias".

Table 14-7: Number of Participants in the Clean-up Operations

Area	Participants				Resident Cooperation	Work Performance	Clean-up Condition
	Residents	Students	Municip. Workers	Total			
Steep Area A1	115	-	15	130	Excellent	Very good	95%
Steep Area A2	60	-	20	80	Good	Good	80%
Wholel city (C1)	300	120	20	440	Good	Good	70%
Wholel city (C2)	500	100	10	610	Good	Good	80%
Total (Approx.)	975	220	65	1,260			

Note : Steep Area A1 : Located between San Martin and Ayestas (North)
Steep Area A2 : Located between Tres de Mayo and Ayestas (West)
Whole City (C1) : *Colonias* San Martin and Ayestas (North)
Whole City (C2) : *Colonias* Tres de Mayo and Ayestas (West)