

CHAPTER II. FRAMEWORK FOR MANAGEMENT OF SOLID WASTE

A. Integrated waste management

This document is organised by waste management topics, which range from waste characteristics, to collection, to landfilling, and to public education and information management. Although these topics are discussed in detail later in the publication, some are also discussed generally in this chapter in the context of their relevance and application to supporting the basic framework for solid waste management. Specifically, this section discusses the relationships among the key topics covered in this book. Understanding these relationships is a key element in successfully achieving integrated waste management -- a single, overall approach to managing waste in a city, town, or region.

A1. ELEMENTS of a waste management system

A comprehensive municipal solid waste management (MSWM) system includes some or all of the following activities:

- setting policies;
- developing and enforcing regulations;
- planning and evaluating municipal MSWM activities by system designers, users, and other stakeholders;
- using waste characterisation studies to adjust systems to the types of waste generated;
- physically handling waste and recoverable materials, including separation, collection, composting, incineration, and landfilling;
- marketing recovered materials to brokers or to end-users for industrial, commercial, or small-scale manufacturing purposes;
- establishing training programs for MSWM workers;
- carrying out public information and education programs;
- identifying financial mechanisms and cost recovery systems;
- establishing prices for services, and creating incentives;
- managing public sector administrative and operations units; and
- incorporating private sector businesses, including informal sector collectors, processors, and entrepreneurs.

A2. WHAT is integrated waste management?

Integrated waste management is a frame of reference for designing and implementing new waste management systems and for analysing and optimising existing systems. Integrated waste management is based on the concept that all aspects of a waste management system (technical

and non-technical) should be analysed together, since they are in fact interrelated and developments in one area frequently affect practices or activities in another area.

A3. IMPORTANCE of an integrated approach

An integrated approach is an important element of sound practice because:

- Certain problems can be more easily resolved in combination with other aspects of the waste system than on their own. Also, development of new or improved waste handling in one area can disrupt existing activities in another area unless changes are handled in a coordinated manner.
- Integration allows for capacity or resources to be optimised and, thus, fully utilised; there are frequently economies of scale for equipment or management infrastructure that can be reached only when all of the waste in a region is managed as part of a single system.
- An integrated approach allows for participation of public, private, and informal sector participants, in roles appropriate for each.
- Some waste management practices are more costly than others, and integrated approaches facilitate the identification and selection of low-cost solutions. Some waste management activities cannot bear any charges, some will always be net expenses, while others may produce an income. An integrated system can result in a range of practices that complement each other in this regard.
- Failure to have an integrated system may mean that the revenue-producing activities are “skimmed off” and treated as profitable, while activities related to maintaining public health and safety fail to secure adequate funding and are operated at low or insufficient levels.

A4. METHODS for integrating a waste system

Planners can work toward integrated systems in a number of ways. The first task is to consider all aspects of the formal part of the waste system within one framework and to produce a plan based on the objectives of the entire system. One of the foundations of the framework for modern, integrated solid waste management systems is the solid waste management hierarchy, which specifies the precedence that should be given to key waste management activities that affect waste generation, treatment, and disposal. The hierarchy is discussed in more detail in the following section.

Second, in terms of jurisdictional and staffing issues, is putting all waste-related functions under the same division or agency, which is an important means of achieving integration. A third way of facilitating coordination and assessing trade-offs among all aspects of a waste management system is to create integrated financial structures that, for example, use disposal fees to finance materials recovery or public education. More broadly, it is important to assess all MSWM system costs, as well as identify opportunities for generating revenues.

A5. WASTE management hierarchy as a key element of integrated solid waste management

The waste management hierarchy is a widespread element of national and regional policy and is often considered the most fundamental basis of modern MSWM practice. The hierarchy ranks waste management operations according to their environmental or energy benefits. In virtually all countries, the hierarchy is similar to that shown in Table II-1, with the first entries having higher priority than those below them.

Table II-1. Solid waste management hierarchy

- Prevent the production of waste, or reduce the amount generated.
- Reduce the toxicity or negative impacts of the waste that is generated.
- Reuse in their current forms the materials recovered from the waste stream.
- Recycle, compost, or recover materials for use as direct or indirect inputs to new products.
- Recover energy by incineration, anaerobic digestion, or similar processes.
- Reduce the volume of waste prior to disposal.
- Dispose of residual solid waste in an environmentally sound manner, generally in landfills.

The purpose of the waste management hierarchy is to make waste management practices as environmentally sound as possible. The waste management hierarchy has been adopted in various forms by most industrialised countries. Its principal elements are also included in international conventions and protocols, particularly those dealing with the management of toxic or hazardous wastes, and in regional attempts to develop a coordinated policy on the reuse of various byproducts of waste management processes.

The hierarchy is a useful policy tool for conserving resources, for dealing with landfill shortages, for minimising air and water pollution, and for protecting public health and safety. In many developing countries, some aspects of this hierarchy are already in place, since traditional practices revolving around waste prevention, reuse, and recycling are prevalent.

At the same time, it should be recognised that all waste management practices have costs, as well as benefits. This means that the hierarchy cannot be followed rigidly since, in particular situations, the cost of a prescribed activity may exceed the benefits, when all financial, social, and environmental considerations are taken into account.

B. Stakeholders

Appropriate practice in waste management systems necessitates clear delineation of jurisdiction and responsibility, with all stakeholders participating in system design, and with those affected, at every level, aware of the lines of accountability.

Governments will generally have final jurisdiction and responsibility for overall policy and for management of the MSWM system, whether or not the government itself is performing the waste management functions. The following participants all have some important relation to waste management and, in some cases, significant levels of responsibility for policies or operations.

B1. RESIDENTIAL waste generators

Local residents' preferences for particular types of waste service, their willingness to source separate recyclable materials, their willingness to pay for the service, and their capacity to move waste to communal collection points all have an impact on the overall waste system. Incentives can affect residents' preferences and behaviour.

B2. BUSINESS waste generators

Businesses also produce waste, and the business sector can become a significant player in the waste management system, particularly, as is increasingly the case, when businesses must pay directly for their waste service. As with residents, incentives can play an important role in shaping behaviour.

B3. PUBLIC health and sanitation departments

The maintenance of public health and sanitation is an important public responsibility and, especially in developing and transition countries, is usually under the jurisdiction of the municipal public health department. In an integrated system, this department often has inspection and enforcement responsibilities, but is not directly involved in collection or disposal operations.

B4. PUBLIC works departments

These local government units most often have operational responsibility for waste collection, transfer, treatment, and final disposal. Frequently, however, the collection of recoverable materials or management of private contractors is the responsibility of a different department, often creating conflicting goals and activities that work against each other.

B5. NATURAL resource management agencies

These agencies often have responsibility at the local or regional level for activities relating to materials recovery or composting. This splits these activities away from waste management functions, resulting in poor integration. Sound practice most often means putting all of the functions under the same agency or department.

B6. NATIONAL or state/provincial environmental ministries

Overall, waste management policy generally is established at these levels. With respect to materials recovery policies, there is less policy-making at this level in developing countries. Sound practice includes not only setting policies, but putting programs in place to implement them and to establish integration consistent with the policies.

B7. MUNICIPAL governments

In most countries, city or town governments have overall responsibility for waste management operations -- ensuring that collection takes place and that the collected materials are delivered to processors, markets, or disposal facilities. Financing for vehicles, crews, and other equipment usually is provided by the municipal government, which is ultimately responsible for the entire process.

B8. REGIONAL governments

Regional bodies or large city governments often have responsibility for landfills, incinerators, composting facilities, or the like, particularly in countries where there is a shortage of disposal space at the local level. Regional governments in charge of these facilities generally have access to a stream of revenues from fees paid by waste collection companies for disposal.

B9. PRIVATE sector companies

Private sector companies tend to be involved in collection of waste, in street sweeping, in the recovery of materials, and, increasingly, in the construction and operation of landfills, incinerators, and compost plants, as concessionaires or contractors from the responsible government authority. Unlike governments, private companies do not have any direct responsibility for maintaining public sanitation or health, so their involvement is limited to functions in which they can make a profit. If there is no stream of revenue, it is not reasonable to expect private sector involvement.

The necessary revenue stream, however, can come from direct charges or allocations from government.

B10. INFORMAL sector workers and enterprises

In developing countries, but also to a significant extent in industrialised and transition countries, individual workers and unregistered, small enterprises recover materials from the waste stream, either by segregated or specialised collection, by buying recyclable materials, or by picking through waste. These workers and enterprises clean and/or upgrade and sell the recovered materials, either to an intermediate processor, a broker, or a manufacturer. Informal sector workers sometimes manufacture new items using the recovered materials, making, for example, gaskets and shoe soles out of discarded tires.

B11. NON-GOVERNMENTAL organisations

Non-governmental organisations (NGOs) are yet another set of participants in the waste management field. NGOs often have a mission of improving the environment or the quality of life for poor or marginalised groups; as part of this mission, they may stimulate small-scale enterprises and other projects. Since waste materials represent, in many cases, the only growing resource stream, these organisations frequently base their efforts on extraction of certain materials not currently being recovered and processing them to add value and produce revenue. In Latin America, a number of composting projects were started this way.

B12. COMMUNITY-BASED organisations

In a number of locations where there is insufficient collection or the neighbourhood is underserved, community-based organisations take an active role in waste management operations. These organisations, which are smaller in scale or local NGOs, may form primarily as self-help or self-reliance units, but they may, over time, evolve into service organisations that collect fees from their collection clients and from the sale of recovered materials. NGOs working with informal workers and community-based entrepreneurs often seek recognition for these organisations as part of the waste management system.

B13. POOR and residents of marginal and squatter areas

Waste service, much like other public services, frequently follows political power and clout, leaving the residents of poor and marginalised areas with inadequate service (or no service at all), dirty streets, and the continual accumulation of refuse and faecal matter on the streets and in other public areas. Very often, these people have the greatest need for improved or expanded waste service.

B14. WOMEN

Waste handling disproportionately touches the lives of women, particularly in some developing and transitioning countries. Women often collect the waste and set it out or move it to community transfer areas. Women are far more likely to be involved in materials recovery than in other comparable types of physical work. This is perhaps because they are in daily contact with the waste in their homes, and perhaps because women tend to be among the most marginalised groups of some societies.

C. Cost and cost recovery

Since proper waste collection and disposal are necessary to maintain the cleanliness and public health of a community, these services benefit both the generators and the community as a whole. In this context, proper waste collection includes both regular collection service and cleanup of wastes that generators have disposed in an unacceptable manner (i.e., litter).

Not all “waste” is considered to be waste by everyone, however. Scavengers and small-scale recyclers successfully extract value from other people’s wastes. This process can potentially be managed so that the informal sector often involved in such activities complements ongoing institutionalised waste collection, rather than interfering with it. As discussed in this document, there are serious health and social problems associated with scavenging, but the point is that much “waste” actually has value to someone. Those who remove recoverable materials from the waste stream are reducing the waste disposal costs of the whole community. In industrialised countries, there is now an increasing awareness of the value of sorting out the reusable and recyclable components of the solid waste stream.

In the end, though, some quantities of waste must be collected and disposed, and this service must be paid for in some manner. Additionally and depending on local circumstances, other waste management services may require funding in some form, including public education and processing of waste for recovery and reuse of recyclable materials.

C1. FEES and charges

Until recently, in most countries, especially developing countries, countries in transition, and European social democracies, the management of waste has been considered to be the responsibility of government, financed by general revenues. In recent years, partly as a result of austerity and structural adjustment policies and pressures from multilateral financial institutions, and partly as a result of pressures to limit taxes, governments have increasingly focused on identifying specific revenue sources for waste management. This has led to a series of innovations relating to fees and charges for waste collection and disposal.

C1.1. Charging directly for waste service

One approach to the financing of waste systems is to obtain payment from those who benefit from the service. On the simplest level, waste generators benefit from collection service, and there have been some attempts, particularly in North America, to get households to pay directly for their own waste removal on the basis of how much waste they are setting out. The system of unit fees for waste removal works well and represents sound practice when individuals want to get rid of their waste and can afford the fees. It works poorly when people are too poor to pay fees, when the fees are simply too high, or when there are ready alternatives and no controls for disposing of wastes, such as by throwing them into the countryside.

Fees can be used to finance waste collection or other aspects of the waste system. Fees can also be used as incentives to generators to create less waste.

C1.2. Indirect charges

In some locations, charges for waste are linked to other public services that people are willing to pay for, such as water or electricity. Including waste charges in water and (if present) sewer charges allows some cost recovery; studies have shown that water and electrical energy consumption are rough indicators of waste generation.

C1.3. Incentives and penalties

Charges and fees can also be used as incentives to encourage “good behaviour” and to discourage “bad behaviour”. For example, the price of disposal can be increased and the cost of materials recovery subsidised to give people incentives to source separate. In some instances, fines can be used to discourage illegal dumping.

C2. STRUCTURING financing for waste management systems

Sound practice in financing waste management systems usually entails differing treatment of fixed costs and variable costs. Fixed costs, which establish waste or materials collection, processing, or disposal capacity, may be paid from general tax revenues. The rationale for this is that there are benefits to all members of society for having the overall solid waste management system in place. Once societies reach a certain level of sophistication, they may be able to recover a certain portion of fixed costs from commercialised collection, processing, and disposal operations, and not rely solely on general tax revenues to fund these activities.

Variable costs can appropriately be paid from direct or indirect fees, thereby being linked to the activities giving rise to the costs in the first place.

One key to developing sound cost recovery systems is tracking all costs accurately. A surprising number of municipal governments do not actually know the total costs of collection or disposal, so they have no basis on which to set or defend fees. Establishing well functioning, transparent, full-cost accounting systems should be a high priority wherever they do not yet exist.

C3. STRATEGIES for cost containment and enhanced efficiency

This section discusses some examples of practices that can result in improved financial management and cost recovery.

C3.1. Privatisation

Pressures on government to reduce taxes, while increasing and improving levels of service, are leading to an exploration of privatisation as an option for waste management functions. Privatisation can take various forms. A government can award a contract to a private firm for specified MSWM services; it can contract with a private firm to construct a waste management facility, which the firm may subsequently own or operate; it can license a private firm to carry out MSWM activities and recover its costs directly from those served; or it can allow qualified firms to participate in open competition.

Certain functions in municipal solid waste lend themselves well to being privatised, while in other cases sound practice will almost always involve government control and operation.

Privatisation tends to work well in the following areas:

- collection of waste or recyclables -- payment to the private contractor is based either on total waste collected or on number of households in the service area;
- construction of waste facilities;
- operation of transfer stations, compost facilities, incinerators, or landfills under contract to a public-sector entity;

- development of private waste facilities, once the price for landfilling has risen to a level where other strategies become cost competitive; and
- in circumstances where there is sufficient government infrastructure to manage a competitive bidding process, to contract with the private firm, to monitor its work, and to hold the private firm accountable for adequate performance of tasks.

Privatisation does not usually work well:

- in small or sparsely populated areas, since there usually is insufficient earning potential due to low waste volumes;
- when the government entity with jurisdiction is too small or too politically weak to be able to manage the contracting processes effectively;
- when badly designed; for example, if there is little no monitoring and enforcement of contract terms; or
- as a substitute for government responsibility, such as if a private firm were to be hired to monitor compliance with environmental regulations by other private firms.

C3.1.1. Importance of competition in privatisation

A key issue in privatisation of municipal solid waste management is the role and management of competition. This is particularly important in developing countries, where the private sector, both informal and formal, may not be sufficiently mature to offer effective competition.

Competition may improve a privatised waste function. Competition promotes good performance by private contractors, since their desire to maintain a contract is a powerful incentive for performing well. Competition is healthy:

- at the time of bidding or contract negotiation;
- to ensure that the full range of services is available;
- when it is well managed through contracting, granting of concessions, or franchising; and
- to prevent formation of monopolies.

At the same time, there are limits to the effective use of competition in solid waste management. One such limit is in the collection of wastes from households -- “unbridled” competition, though avoiding monopoly, can drive up prices because of the high costs of numerous low-volume operators. In such instances, using a competitive process to select a single operator for a period of time may be a better alternative.

It is, of course, advisable to introduce new approaches with care so that they do not unwittingly kill off marginal, informal sector activities best viewed as complements to the formal waste management system.

C3.2. Support for small-scale enterprises

Recognition of and support for small-scale and informal sector waste-related enterprises is a significant element of sound practice, especially in developing countries, and to a lesser extent in

transition and industrialised countries as well. These businesses usually remove materials from the waste stream, at low cost, saving the government money. Disruption of their operations can increase the burden on public works and sanitation budgets significantly.

In recent years, a number of projects have attempted to gain official recognition for these enterprises, to institutionalise their market niche, and to shelter their operations from disruption during waste system upgrading and modernisation. This has been done by:

- awarding or arranging contracts between informal sector enterprises and the city or formal private sector collection companies;
- organising cooperatives;
- providing equipment, supplies, clothing, gloves, and shoes, or even vehicles, to improve working conditions; and
- designing new waste facilities to include rather than exclude these operations.

Taking these and other steps to support small and informal enterprises generally improves efficiency and cost effectiveness while supporting subsistence activities and an important economic niche.

D. Other important issues and strategies

D1. UNDERSTANDING characteristics of waste generated

An important element in improving waste management systems is the need to attune chosen technologies to the character of the waste that is generated in a particular location. If wastes are wet and dense, as they are in most developing countries, buying compactor trucks will often be a waste of money. If wastes have low calorific value, it will not be possible to incinerate them without using supplementary fuel. If considerable amounts of toxic waste have entered the general municipal solid waste (MSW) stream, leachate from dumps will be particularly dangerous. On the other hand, if a portion of the waste stream consists of organics or can be easily separated into organics and non-organics, composting may become a viable waste management strategy.

D2. MAJOR differences between industrialised and developing countries

One theme that appears consistently throughout this book is the enormously different conditions in which industrialised and developing countries must work to solve MSWM problems. Developing countries often have:

- low labour costs and extreme shortages of capital, which together call for low-tech solutions to MSWM problems;
- a waste stream dominated by organic waste, which means that: a) incineration is difficult unless undertaken in conjunction with a program that achieves source separation of organics, and b) composting is especially important if large amounts of waste are to be diverted from landfills;
- a complex informal sector that is very active in the collection, separation, and recycling of waste;

- significant mixing of industrial hazardous wastes with MSW;
- few people who are adequately trained in solid waste management activities, and a high proportion of the urban population with low levels of education; and
- inadequate physical infrastructure in urban areas, which makes collection of waste particularly difficult.

At the same time, it should be recognised that there are also similarities between industrialised and developing countries with regard to MSWM issues. In neither case does the public want MSWM facilities near residential areas and, in both cases, the amount of waste being generated is increasing. In both industrialised and developing countries, adopting an integrated approach to waste management is important. Related to this, people throughout the world are recognising the importance of waste reduction as the first stage of the waste management hierarchy and as an essential element of MSWM. Methods of waste reduction are described in more detail in the last part of this chapter.

D3. IMPROVING management capabilities

In many instances, particularly in developing countries, the greatest impediments to efficient and environmentally sound handling of MSWM issues are managerial, rather than technical. Improving the operational and management capabilities of individuals and institutions involved in MSWM at the local level is therefore extremely important. For this reason, this book considers these issues in two of the topics addressed: management and planning, and training.

Even with new efforts to make funds available for MSWM activities, it is certain that funds will at least appear to be insufficient for the foreseeable future. Managers must therefore be attuned to every opportunity to use their resources more efficiently.

D4. PUBLIC involvement

The public can play a role in promoting efficient, financially sound, technically competent management of waste issues by demanding accountability from the MSWM system. Although in many countries the public has long grown accustomed to having low expectations of government, the pressing and very visible problems brought about by the absence of effective MSWM systems may inspire stronger demands for good performance from public managers and any private companies with whom they work.

Public education is important in achieving the goal of public involvement. This book includes a section on public education for each of the regions.

D5. SPECIAL wastes

Special wastes are those types of solid waste that require special handling, treatment, and/or disposal. The reasons for separate consideration include: 1) their characteristics and quantities (either or both may render them difficult to manage if they are combined with “typical” municipal solid waste); or 2) their presence will or may pose a significant danger to the health and safety of workers and/or the public, to the environment, or both.

Some examples of special types of wastes are given in Table II-2. These wastes are very different from each other, so they should be managed and handled separately if feasible. Typically, in developing countries, special wastes are set out for collection, collected, and/or disposed along with wastes from commercial businesses and residential generators. Ideally, these wastes should

not enter the municipal solid waste stream, but quite frequently they do, particularly in developing countries.

Table II-2. Examples of types of special wastes

- Pathological or infectious medical waste from hospitals, clinics, and laboratories
- “Hazardous” waste in the household waste stream (e.g., oil-based paints, paint thinners, wood preservatives, pesticides, household cleaners, used motor oil, antifreeze, batteries)
- Discarded tires
- Used oils
- Electronic waste (e-waste)
- Wet batteries
- Construction and demolition debris
- Municipal wastewater treatment (sewage) sludge, septage, and slaughterhouse wastes
- Industrial hazardous waste, and some types of industrial solid waste (e.g., metal cuttings from metal processors or cannery waste)

Special wastes can cause significant health and environmental impacts when managed inadequately. Persons that may come into direct contact with the wastes, such as waste collectors and scavengers, may be subject to significant health and safety risks when exposed to some types of special wastes, e.g., industrial hazardous waste. Toxic components of these wastes can enter the environment, for example, poisoning surface and groundwater bodies. Hazardous wastes can also degrade MSW equipment used to manage solid waste (e.g., collection vehicles), or the performance of the equipment.

Special wastes are discussed in this document because of the potential negative effect that they can have on the MSWM system. Still, it is important to point out that this section only superficially reviews the topic of special wastes. If the reader is involved in any part of the management process for special wastes, further additional reference materials and training are extremely important.

Proper management of special wastes is quite difficult in most developing countries, particularly in those countries where regular MSW is not managed adequately. Three issues are usually always relevant: 1) the party or organisation responsible for managing special wastes is seldom clearly identified and the necessary entity may not even be in existence; 2) available resources to manage solid waste are scant and priorities have to be set; and 3) the technology and trained personnel needed to manage special wastes are seldom available.

In the absence of countervailing reasons, the development of sound practices in the management of special wastes should follow the integrated waste management hierarchy applied in other areas of MSWM, i.e., waste reduction, minimisation, resource recovery, recycling, treatment (including incineration), and final disposal. As with the management of other types of MSW, the proper application and programmatic emphasis of this hierarchy to special wastes depends on local circumstances (e.g., available technologies, waste quantities and properties, and available human and financial resources).

Effective management of special wastes begins with an assessment of their potential impacts on human health and safety and on the environment. The environmental benefits of properly handling hazardous wastes can be very large, since in some cases small quantities of hazardous wastes can cause significant damage. However, even though all hazardous wastes present some risks, the quantities are not always sufficient to warrant separate collection and disposal. As points of reference, Organization for Economic Co-operation and Development (OECD)

guidelines and US environmental regulations specify minimum quantities of material that need special treatment as “hazardous waste”. Obviously, specific decisions regarding the management of special wastes will necessarily depend on the capabilities of individual countries to carry out such programs.

A number of alternatives for handling of special wastes have been or are in the process of being devised in response to the various needs of developing and industrialised countries. These practices are summarised in this section for the most frequently encountered special wastes.

D5.1. Medical waste

Medical waste is one of the most problematic types of wastes for a municipality or a solid waste authority. When such wastes enter the MSW stream, pathogens in the wastes pose a great hazard to the environment and to those who come in contact with the wastes.

Wastes generated within health care facilities have three main components: 1) common (general) wastes (for example, administrative office waste, garden waste and kitchen waste); 2) pathogenic or infectious wastes (these types also include “sharps”); and 3) hazardous wastes (mainly those originating in the laboratories containing toxic substances). The quantity of the first type of general wastes tends to be much larger than that for the second and third types.

Segregation of medical waste types is recommended as a basic waste management practice, as indicated in Table II-3. However, thorough separation is possible only when there is significant management commitment, in-depth and continuous training of personnel, and permanent supervision to ensure that the prescribed practices are being followed. Otherwise, there is always a risk that infectious and hazardous materials will enter the general MSW stream.

Table II-3. Recommended methods for managing medical waste

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|--|--|
| Source separation within the health care facility | <ul style="list-style-type: none"> • Isolates infectious and hazardous wastes from non-infectious and non-hazardous ones, through colour coding of bags or containers • Source separates and recycles the relatively large quantities of non-infectious cardboard, paper, plastic, and metal • Source separates compostable food and grounds the major fraction of organic wastes and directs them to a composting facility if available • Includes and is characterised by thorough management monitoring program |
| Take-back systems | <ul style="list-style-type: none"> • Where vendors or manufacturers take back unused or out-of-date medications for controlled disposal |
| Tight inventory control over medications | <ul style="list-style-type: none"> • To avoid wastage due to expiration dates (a form of waste reduction) |
| Piggy-back systems for nursing homes, clinics, and doctors' offices | <ul style="list-style-type: none"> • Can send respective wastes for treatment to proper health care waste treatment facilities using health care waste collection and transport systems located in the vicinity |
| Treatment of infectious waste through incineration, or by disinfection | <ul style="list-style-type: none"> • Includes autoclaving, chemical reaction, microwaves, and irradiation • In the case of incineration, the processing may be performed within the premises of the health care facility (onsite) or in a centralised facility (offsite). An incinerator is difficult and expensive to maintain, so it should be installed in a health care facility only when the facility has sufficient resources to properly manage the unit. Otherwise, a centralised incinerator that provides services to health care facilities in one region or city may be more appropriate. Regardless of location, the incinerator must be equipped with the proper air pollution control devices and operated and maintained properly, and the ash must be disposed in a secure disposal site. In the case of disinfection, residues from these processes should still be treated as special wastes, unless a detailed bacteriological analysis is carried out. |
| Proper disposal of hospital wastes | <ul style="list-style-type: none"> • In many developing countries, none of the treatment systems discussed in this table are widely available, so final disposal of infectious and hazardous components of the wastes is necessary. Since in many developing countries there are no landfills specifically designed to receive special wastes, infectious and hazardous health care wastes normally are disposed at the local MSW landfill or dump. In this case, close supervision of the disposal process is critical in order to avoid exposure of scavengers to the waste. Final disposal should preferably be conducted in a cell or an area specially designated for that purpose. The health care waste should be covered with a layer of lime and at least 50 cm of soil. When no other alternative is available for final disposal, health care wastes may be disposed jointly with regular MSW waste. In this case, however, the health care wastes should be covered immediately by a 1 m thickness of ordinary MSW and always be placed more than 2 m from the edge of the deposited waste. |

D5.2. Household hazardous waste

Households generate small quantities of hazardous wastes such as oil-based paints, paint thinners, wood preservatives, pesticides, insecticides, household cleaners, used motor oil, antifreeze, and batteries. Examples of such wastes are shown in Figure II-1. It has been estimated that household hazardous waste in industrialised countries such as the United States accounts for a total of about 0.5% (by weight) of all waste generated at home [1]. In most developing countries, the percentage probably is even lower.



Courtesy: CalRecovery, Inc.

Figure II-1. Examples of household hazardous wastes

There are no specific, cost-effective, sound practices that can be recommended for the management of household hazardous wastes in developing countries. Rather, since concentrated hazardous wastes tend to create more of a hazard, it is best to dispose of household hazardous wastes jointly with the MSW stream in a landfill, where the biological processes tend to exert a fixating effect on small amounts of toxic metals, while other toxic substances are diluted by the presence of MSW or are broken down into less toxic intermediates during the process of decomposition in the fill.

When resources are available (typically in industrialised countries), appropriate methods and necessary conditions for separation of household hazardous wastes from the rest of the MSW stream include those given in Table II-4.

D5.3. Used tires

The management of used tires poses a potential problem for even the more modern MSWM systems, for reasons related both to the tires' physical properties and their shape. Tires are composed primarily of complex natural and synthetic rubber compounds, both of which have substantial heating value, and various other materials. The recovery of rubber from used tires can be very energy-intensive, and such processing may generate hazardous substances and other

types of process residues. Illegal stockpiles of used tires can create substantial land use problems, harm the environment, and serve as breeding grounds for insects and other small animals that harbour pathogens that are detrimental to human health. Stockpiles can self-ignite and cause fires that are very difficult to control, resulting in negative human health and environmental impacts.

Table II-4. Methods and conditions for promoting the separation of household hazardous wastes (HHW) in industrialised countries

- The priority waste streams for separation are identified with reference to the damage that they may cause when released into the environment, and with reference to the type of disposal that would be available if the waste were not separated. For example, the separate collection of mercury-based batteries might be a priority if the primary means of waste disposal was incineration, a process ill suited to ease of control of mercury emissions.
- Frequent public education and convenient collection service are required for successful HHW source-separation programs.
- Notification at the point of purchase, or on the packaging, that certain consumer items contain dangerous or hazardous materials necessitating special handling and disposal practices.
- Utilisation of point-of-purchase take-back systems for those items that can be collected using such systems, such as used batteries, discarded medicines, and used oil.
- Emphasis placed at the policy and program levels on redesigning consumer products to make them less dangerous or hazardous (such as reducing or eliminating the mercury content in batteries).
- Personnel handling HHW must receive initial and subsequent training, but do not necessarily have to be licensed or trained chemical technicians.

When whole tires are disposed in a landfill, they often rise to the top and make it difficult to maintain the soil cover over the wastes. When dumped illegally, tires can become breeding grounds for mosquitoes and other forms of life that can spread disease, such as dengue. Some appropriate methods of managing used tires are described in Table II-5. The informal sector oftentimes serves as a means to reuse or recycle used tires.

D5.4. Used oil

Used oils are generated primarily in gas stations and in mechanics' shops. These oils generally are discharged in the most convenient location and frequently enter the sewage system, causing problems in the treatment plants or in the receiving bodies of water. When oil is collected haphazardly as part of the MSW stream, it causes problems at the landfill and often becomes part of the landfill leachate. Some recommended methods of managing used oils are described in Table II-6.

Table II-5. Appropriate methods for managing used tires

- **Reuse** through retreading for extended service; shredding and grinding for use in road paving material; and cutting them up for use as padding in playgrounds and buffers on railway tracks. It should be noted that processing of tire materials must be conducted under controlled conditions, as it generates dust and buffings, which may be carcinogenic to workers and are potentially dangerous when released.
- **Thermal destruction in cement kilns** with subsequent energy recovery. This process requires cement kilns, adapted to receive solid fuels. This form of final disposal of tires has been shown to be practical in both industrialised and developing countries.
- **Processing in pyrolytic reactors.** Emissions control systems are critical as organic vapours are generated. As a result, the process can be relatively expensive and will usually become cost effective only when the accumulation of tires becomes a hazard due to potential fires or expensive due to conflicting land use.

Table II-6. Some methods of managing used oil

- **Re-refining into lubricating oil.** Processing used oil for reuse as a lubricating agent is a good method of managing used oil. However, one potential hazard associated with such processing is that the residues from re-refining may be deposited in the MSW stream or in drains. Education must be utilised to explain the problems caused by this casual, improper method of disposal. Ideally, residues should be burned in a cement kiln equipped with the proper type of pollution control systems. When this is not possible, residues should be placed in sealed containers and placed in a special area at the landfill disposal site.
- **Use as a fuel.** Used oil has considerable value as a fuel due to its high specific energy content. However, combustion of used oil can result in emissions of heavy metals into the environment if the combustion system lacks suitable environmental control equipment. When used oil is used as a cement kiln fuel, an added measure of pollution control is achieved by virtue of the fact that the heavy metals present in the oil are absorbed into the cement matrix.

D5.5. Electronic waste (e-waste)

During the last few years, there has been a substantial reduction in the cost and a commensurate increase in the availability and usage of a variety of electronic products. Although the list of relatively new products is long, some of the most common products include personal computers, printers, monitors, television sets, and cellular telephones. As the usage of these and similar products increases, a large number of them are replaced and disposed each year. Improper treatment and unsafe final disposition of these materials has resulted in several problems, which have far reaching implications. One key problem is that related to the fact that most electronic products contain several types of hazardous materials, such as mercury, arsenic, lead, cadmium, and others. If the electronic products are improperly treated or discarded along with the general municipal solid waste, the hazardous materials in the products can be released and result in negative impacts to the public health and to the environment.

One practical solution to the management of e-waste involves the implementation of segregated collection and adequate processing. Current methods for the treatment of e-products include mechanical and chemical processing of the products for the recovery of valuable materials and the removal and/or reduction of the toxicity of the residue.

D5.6. Wet batteries

Used wet batteries are typically generated by car maintenance facilities and vehicle battery suppliers. This type of battery contains acid and lead, both of which are hazardous to humans and to the environment if not properly managed. Environmentally acceptable processing of wet batteries for materials recovery requires trained and experienced facility personnel. Recycling of batteries typically involves draining and neutralisation of the acidic liquid, and recovery of the lead in a non-ferrous foundry.

D5.7. Construction and demolition debris

Construction and demolition (C&D) debris are generated regularly in urban areas as a result of new construction, demolition of old structures and roadways, and regular maintenance of buildings. These wastes contain cement, bricks, asphalt, wood, metals, and other construction materials that are typically inert. In many cases, the biological inertness of C&D debris means that it can be disposed in landfills with lesser restrictions than those required for MSW, which has substantially higher biodegradable content and potential for polluting the environment. However, it must be pointed out that C&D debris may contain some hazardous materials, such as asbestos and PCBs, although this circumstance is most probable in the case of industrialised countries. Very large volumes of demolition waste are generated during natural disasters (earthquakes, floods, typhoons, and others) and during wars.

City authorities need to protect against disposal of these wastes in the streets and on vacant lands, since these locations can become illegal, uncontrolled dumps with their attendant negative consequences. On the other hand, disposal of C&D debris in MSW landfills can be costly and a poor use of landfill capacity. Thus, other alternatives to disposal of C&D may be warranted and should be considered in any event. Processing and recycling, as shown in Figure II-2, are alternatives.



Courtesy: CalRecovery, Inc.

Figure II-2. Storage of construction and demolition debris at a processing facility

Sound practices for the management of C&D wastes are based on the concept of prevention, reuse, and recycling of waste. When these practices cannot be implemented, proper disposal must be considered. Since these wastes are primarily inert or they can be processed to be so in some cases, they can be used for fill, for example in former quarries, as road base, or in coastal cities, to gain land at the ocean front or for the construction of levees. Some sound practices for diverting C&D debris from landfill disposal are described in Table II-7.

Special landfill sites for the final disposition of construction and demolition landfill sites are also an option. Siting of these landfills is less difficult than for regular MSW landfills since the potential environmental impact in the majority of cases is relatively small.

Table II-7. Sound practices for diverting construction and demolition debris from landfill disposal

- Waste prevention can be promoted through **inventory control and return allowances for construction material**. This ensures that unused materials will not get disposed of unnecessarily.
- **Selective demolition**. This practice involves dismantling, often for recovery, of selected parts of buildings and roadways before the main demolition (wrecking) process is initiated.
- **Onsite separation systems**, using multiple smaller containers at a construction or demolition site to store sorted recyclable materials, as opposed to gross disposal of mixed materials in using a single roll-off or compactor.
- **Crushing, milling, grinding, and reuse of secondary stone, asphalt, and concrete materials**. These materials can be processed to conform to a number of standards for construction materials. Recovery and reuse of these types of materials is facilitated by the existence of approved specifications for road construction materials and by governmental procurement policies that promote or stimulate purchase of recyclable materials.

D5.8. Bulky metallic waste

Bulky metallic waste is composed of metallic objects that occupy large volumes (e.g., greater than 1 or 2 m³) and are composed of high-density material, either when encountered singularly or in combination. Examples of bulky metallic waste are old vehicle bodies, structural steel, large metallic appliances, and discarded fabricating equipment. The most prevalent material of construction for bulky metallic waste is steel, although other types, such as aluminium, are also encountered to a lesser extent. This type of waste is considered a special waste because it is difficult to handle, process, and dispose using the more common and conventional municipal solid waste management equipment. Special, large-capacity equipment is normally required to collect, process, and dispose of bulky metallic waste. Also, much of bulky metallic waste is potentially recyclable. However, the feasibility of recycling is a function of the costs of processing, availability of markets, transportation costs, etc. An example of bulky metallic waste is given in Figure II-3.

Management of bulky metallic waste is a particularly difficult problem for rural and isolated communities (e.g., remote islands) because of limited space for storage and/or disposal, limited financial resources, and long distances to recycling markets.

D5.9. Municipal wastewater treatment (sewage) sludge, septage, and slaughterhouse wastes

Municipal wastewater treatment (MWWT) sewage sludge (biosolids) is generated as a consequence of processing municipal wastewater for safe discharge to the environment. The

sludge is composed of the semi-solid or solid residues remaining after processing of wastewater. Septage, on the other hand, is the material pumped from septic tanks serving residences. Both MWWT sludges and septage contain large quantities of pathogenic organisms, and they often contain chemical contaminants, as well, if liquid discharges at the source are not pre-treated before disposal into the sewer. These materials, therefore, require proper treatment and disposal.



Courtesy: CalRecovery, Inc.

Figure II-3. Bulky metallic waste being loaded for transport to market

Slaughterhouse wastes can be used to produce ingredients in the manufacture of soil amendment, animal feed, and glues. The traditional methods of sun-drying, breaking up bones manually, composting in pits (sometimes with the addition of household organics), and steam digestion carry various types of health risks, and cannot be considered acceptable practices.

Small-scale aerobic composting of animal wastes, including manures, hide scrapings, and tannery and slaughterhouse wastes, can also produce a soil amendment, but carries some risks in terms of spreading pathogens if the wastes are not properly sterilised. All of these activities generate leachate and the associated unpleasant odours, and are typically associated with poor working conditions and risks to worker health, but may be profitable and provide subsistence income. Appropriate methods of management of these types of materials could involve introducing technical and health improvements, rather than entirely eliminating the activities themselves. Other appropriate methods of management are described in Table II-8.

D5.10. Industrial waste

The collection of industrial waste typically is not under the jurisdiction of municipal authorities in industrialised countries. However, in developing countries, where proper industrial waste management systems are not in place, such waste often enters the MSW municipal solid waste stream.

Waste generated from industrial sources can have non-hazardous and hazardous components, with non-hazardous waste usually representing the greater part of the volume. The hazardous component of this waste, while generally being relatively small in volume, can pose significant environmental and public health problems.

Table II-8. Practices for reducing and handling sewage sludge and septage

- **Preventing the generation of large volumes of sludge**, through separation of sewers and storm drainage systems.
- **Minimisation of reliance on centralised sewage systems**, through the installation of onsite treatment of human waste and household wash water, when feasible.
- **Land application**, but only when very frequent sludge testing shows that metal, salt, nitrogen, etc. contents are within tolerable limits, and when the administering authority has the resources and commitment to maintain high standards for monitoring and testing. In practice, this will mean that in many situations the safety of land application is questionable as a viable and appropriate method of management.
- **Treatment such as drying, liming, composting**, or co-composting with yard waste or organics, followed by land application. These methods are designed to return the organic matter in the waste to the land. As indicated above, however, certain constituents of the sludge can make land application inadvisable.
- **De-watering and disposing in landfills**. It is important to note that sludges should be de-watered as much as practical before entering a landfill in order to avoid the production of large volumes of leachate.

Appropriate methods for the proper management of hazardous industrial wastes vary substantially, depending on the specific quantities and characteristics of the waste, cost of management, local regulations, and other factors. The planning and design of methods and facilities for managing industrial hazardous waste are beyond the scope of this publication. The Bibliography, however, includes a useful work by Batstone, et al., which can be used as a general reference. In any case, best waste management practices incorporate separation of hazardous industrial waste from MSW. In those cases where municipal authorities are forced to provide a temporary solution for the disposal of hazardous waste, specially designed cells should be provided within the municipal landfill. These cells must be isolated so that scavengers cannot come into contact with the hazardous waste.

D6. WASTE reduction

The logical starting point for the proper management of solid waste is to reduce the amounts of waste that must be managed, either informally managed within the generator's site or formally (externally) managed by another entity once the waste is discarded by the generator. Thus, the reduced waste quantities do not have to be collected or otherwise managed.

As used in this document, the term "waste reduction" means reduction, or in the limit, prevention, of waste at the source or potential of generation. Waste reduction includes reuse of wastes within a generator's site or related sites (e.g., reuse of industrial scrap in the manufacture of products), or reuse of materials in essentially their current form by a similar group (e.g., reuse of secondhand clothes). Waste reduction includes reduction in quantities or in toxicity of waste. Methods of waste reduction include preventing the generation of waste in the first place.

Reduction of waste is a primary element of solid waste management hierarchies, promoted by a number of international, regional, and national agencies or organisations. A number of economically developing countries have solid waste management hierarchies that list reduction of

waste as the highest priority among the generic methods to manage solid waste (other generic methods include, but are not limited to, recycling and land disposal). This hierarchy follows that enumerated in Agenda 21, the agreement reached among participating nations at the United Nations Conference on Environment and Development in Rio de Janeiro in 1992. In particular, Chapter 21 of Agenda 21 emphasised that reducing wastes and maximising environmentally sound waste reuse and recycling should be the first steps in waste management. At the World Summit on Sustainable Development held in Johannesburg in 2002, these principles of Agenda 21 were reaffirmed. Additionally, the Summit advocated an increased urgency and effort to accelerate implement the principles.

D6.1. Importance of waste reduction

In affluent countries, the main motivations for waste reduction are frequently related to the high cost and scarcity of suitable sites associated with the establishment of new landfills, and the environmental degradation caused by toxic materials in the deposited wastes. The same considerations apply to: 1) large metropolitan areas in developing countries that generally are surrounded by other populous jurisdictions, and 2) isolated, small communities (such as island communities). However, any areas that currently do not have significant difficulties associated with the final dispositions of their wastes disposal pressures can still derive significant benefits from encouraging waste reduction. Their solid waste management departments, already overburdened, are ill-equipped to spend more funds and efforts on the greater quantities of wastes that will inevitably be produced, if not otherwise controlled, as consumption levels rise and urban wastes change.

D6.2. Key concepts in municipal waste reduction

Action for waste reduction can take place at both the national and local levels. At the national level, some strategies for waste reduction include:

- redesign of products or packaging;
- promotion of consumer awareness; and
- promotion of producer responsibility for post-consumer wastes.

At the local level, the main means of reducing waste are:

- diversion of materials from the waste stream through source separation and trading;
- recovery of materials from mixed waste;
- pressure on national or regional governments for legislation on redesigning packaging or products; and
- support of home composting, either centralised or small-scale.

D6.3. Building on what is working

As explained in the following paragraphs, people in many developing countries already carry out significant waste reduction practices. In designing strategies for further waste reduction, the first principle should be to build on what exists and appears to be working. In general, sound practices for the majority of cities and towns in the developing world rest upon:

- facilitating the existing private sector (formal and informal) in waste reduction where current practices are acceptable, and ameliorating problems encountered by all relevant stakeholders through access to capacity-building, financing, and education; and
- designing such assistance to be an integral component of the strategic plan for municipal solid waste management.

Developing a feasible strategic plan requires an understanding and assessment of local practices in waste reduction, waste recovery, and recycling.

D7. SYSTEMS of waste reduction

D7.1. Industrialised countries

Perhaps in no field of municipal solid waste management are the differences between the industrialised countries and the developing countries so apparent as in waste reduction and materials recovery. Rising overall living standards and the advent of mass production have reduced markets for many used materials and goods in the affluent countries whereas, in most of the economically developing countries, traditional labour-intensive practices of repair, reuse, waste trading, and recycling have endured. Thus, there is a large potential for waste reduction in economically developing countries, and the recovery of synthetic or processed materials is now being emphasised. Public or consumer financing of the full range of initiatives for waste reduction (from changes in manufacturing and packaging, to waste reduction audits to identify waste reduction opportunities) are practiced by several affluent industrialised countries.

One of the main motivations, from the point of view of municipal authorities, is to reduce materials that must be collected and deposited in landfills. At the national level, under the concept of producer responsibility, governments have created agreements and legal frameworks designed to reduce the generation of waste. For instance, industry is given responsibility for achieving certain levels of packaging reduction goals of a certain percentage within a given time period.

D7.2. Developing countries

In many developing countries, waste reduction occurs naturally as matter of normal practice because of the high value placed on material resources by the people, as well as other factors. Consequently, reuse of a variety of materials is prevalent. The motivations for materials reuse in developing countries include: scarcity or expense of virgin materials; the level of absolute poverty; the availability of workers who will accept minimal wages; the frugal values of even relatively well-to-do households; and the large markets for used goods and products made from recycled plastics and metals. Wastes that would be uneconomical to recycle or of no use in affluent societies have a value in developing countries (e.g., coconut shells and dung used as fuel). If one takes into account the use of compost from dumps sites as well as materials recovery, in countries like India, Vietnam, and China, the majority of municipal wastes of all kinds are ultimately utilised.

Waste reduction that could be achieved by legislation and protocols (such as agreements to change packaging) is not, at present, a high priority in these countries, although some are now moving in this direction. Because unskilled labour costs are low and there is a high demand for manufactured materials, manufacturers can readily use leftovers as feedstock or engage in waste exchange. Residuals and old machines are sold to less advanced, smaller industries. Public health is benefiting from plastic and boxboard packaging that reduces contamination of foods, and much of the superior packaging is recovered and recycled.

In offices and institutions, cleaners and caretakers organise the sale of paper, plastics, etc. At the household level, gifts of clothes and goods to relatives, charities, and servants are still significant in waste reduction. All cities and towns have markets for used goods. However, the greatest amount of materials recovery is achieved through networks of itinerant buyers, small- and medium-sized dealers, and wholesaling brokers. The extent to which the waste trading enterprises are registered (“formalised”) varies in developing regions: in Latin America and Asia, there is more formal registration than in Africa. The system is adaptive to market fluctuations, as the lowest level workers form a dispensable labour cushion: they must find other work, if they can, when there is reduced demand for the materials that they sell.

From the point of view of waste reduction, the traditional practices of repair and reuse, and the sale, barter, or gift-giving of used goods and surplus materials are an advantage to the poorer countries. Quantities of inorganic post-consumer wastes entering the MSW stream would be higher if these forms of waste reduction did not exist.

D8. PRIORITIES for cities of developing countries

The hierarchy advocated in many industrial countries with high standards of living (with waste reduction given highest priority) may not be appropriate for most communities of less developed countries. Rather, the first priority in most cases should rest with identifying methods to divert organics from entering the municipal solid waste stream, which then requires organised collection and other forms of management. The reason is that organics are usually the largest component of MSW and the greatest reduction in wastes for collection and disposal can be achieved by diverting this component of the waste stream.

Due to lack of development of manufacturing capacity in most developing countries, waste reduction in that sector is not as important as it is in industrialised countries. Nevertheless, developing countries need to be alert to the growth of wasteful practices that may result from modern industrial processes and new modes of consumption. With reference to the latter, for instance, increased usage of and reliance upon thin plastic film for packaging can lead to increased littering of this material, which, if not controlled, can eventually clog surface drainage systems and pollute rivers and other bodies of water. Implementing legislation and incentives at the national level is one potential means of properly dealing with materials that may pose special problems related to management of litter and to adverse environmental consequences of disposal.

E. Summary

The range of issues to be considered in designing a well functioning MSWM system can be overwhelming, even to planners who have considerable resources available. In most of the world, where such resources and expertise are scarce, MSWM issues are even harder to resolve. MSWM, despite its prominent position as an urban problem, is not the only problem competing for the attention of urban managers. Its low status as a field of work has meant that MSWM issues often receive less attention than other urban problems.

The keys to making progress in this field lie in these areas:

- responsible planning and design of an integrated MSWM system, which works to reduce the quantity of waste generated and to handle waste in a coordinated fashion. Essential to this is understanding the nature of the wastes generated.
- adoption of new strategies for revenue generation that move away from sole reliance on a government-owned and -operated MSWM system. In many cases, a balanced mix of public

and private systems can lead to a waste management system that is more flexible and efficient than a wholly publicly-owned and operated system.

- incorporation of small-scale enterprises and the informal sector into the MSWM system; and
- installation of a system of accountability and responsibility at the local level. Residents and businesses can be motivated to act responsibly in MSWM issues. But, most importantly, accountability entails significantly improving the training and capabilities of the managers and planners responsible for the MSWM system.

F. Reference

1. CalRecovery, Inc., *Characterization and Impacts of Nonregulated Hazardous Waste in the Solid Waste of King County*, prepared for Puget Sound Council of Governments, Seattle, Washington, USA, December 1985.