5 Environmental Issues and Best Practices for Solid Waste Management

A. Solid Waste Collection and Disposal Systems

Brief Description of the Sector

More than 70 percent of Latin America s people live in urban areas. An estimated 300 million city dwellers generate 225,000 tons of solid waste every day, much of which is discharged into water bodies, open dumps, and wetlands, contaminating surface and ground water. The quantity of waste generated per person is steadily increasing, while the quality of that waste is decreasing. Waste generated per person has grown from 0.2-0.5 kilograms a day 30 years ago to 0.5-1.00 kilograms a day today. Meanwhile, the composition of household and business waste has shifted from being almost entirely biodegradable to being much less so, including increasing amounts of high-value recyclables, plastics, and hazardous materials.

Rapid urban expansion, much of it unplanned, generates waste much faster than existing collection and disposal capacity, creating increasingly unserved or underserved populations. Some large cities--Brasilia, Caracas, La Paz, Medellin--boast extremely high coverage for solid waste collection (90 percent), though it is unclear whether these figures include collection from squatter settlements. Other municipalities, such as Santiago, collect from fewer of their populations (57 percent), and most smaller cities and towns have even more limited coverage--if they have coverage at all. In developing countries, solid waste management services (primarily transfer and disposal) can consume 20-50 percent of municipal spending, and households and neighborhood associations often pay for primary waste collection services directly. In tropical regions it is recommended that waste be collected daily. This makes the challenges and costs of solid waste management in the tropics even more daunting.

Only a small amount of the region s waste is disposed of in sanitary landfills; most is deposited in open dumps or semi-controlled unlined landfills with no groundwater protection, leachate recovery, or treatment systems. Separation

Inside...

and treatment of organic waste is almost non-existent; of the dozen or so large-scale composting facilities in Latin America, virtually none are operational.

Recycling and recovery of high-value waste streams, such as paper, are higher in Latin America than in many industrialized countries and carried out by employees of municipal collection services and other independent collectors, including microenterprises and waste-pickers. Low-value organic waste streams are not recovered by waste-pickers. In poorer areas of cities and towns, these wastes accumulate at roadsides, are burned by residents, or are disposed of in illegal dumps. Manual street-sweeping may partially mitigate the substantial amount of trash in city streets--a responsibility of the solid waste authority that is sometimes contracted out to small-scale enterprises.

Only a small amount of the region's waste is disposed of in sanitary landfills.

Municipally funded services in Latin America and the Caribbean are provided through an array of institutional arrangements, including contracting, selling concessions, franchising, and the direct provision of service by municipal employees. In Guatemala all service is contracted privately. In many cases, collection and disposal by individuals or small enterprises have proven better at keeping pace with rapid urban growth than government systems. However, coverage is still often incomplete, and a large proportion of waste remains uncollected. Hazardous and pathogenic materials from residential, business, industrial, and medical facilities are often disposed of illegally along with general wastes in dumps or landfills.

Recycling and recovery of high-value waste streams, such as paper, are higher in Latin America than in many industrialized

Municipal waste incinerators are too expensive for most communities and are not used. Incinerators for individual buildings are generally illegal in Latin American and the Caribbean. Though some hospitals and cities have incinerators for medical waste, they tend to be operated inappropriately.

Potential Environmental Impacts

The typical municipal solid waste stream (MSWS) will contain general wastes (organics and recyclables), special wastes (household hazardous, medical, and industrial waste), and construction and demolition debris. Most adverse environmental impacts of solid waste management are rooted in inadequate or incomplete collection, or in inappropriate siting, design, operation, or maintenance of dumps or landfills. Improper waste management activities can:

Increase disease transmission or otherwise threaten public health. Putrefying organic materials pose great public health risks. They can become breeding grounds for disease vectors such as rats and flies. Waste-handlers and waste-pickers risk contracting and transmitting diseases, especially if human or

animal excreta or medical waste is in the waste stream. Populations are also at an increased risk for poisoning, cancer, birth defects, and other ailments (see Section B~Medical Waste in this chapter).

Contaminate ground and surface water. Municipal solid waste streams can bleed toxic materials and pathogenic organisms into the leachate of dumps and landfills. (Leachate is the liquid discharge of dumps and landfills caused by decomposed organic waste, infiltration of rainwater, mixing of liquid wastes, and extraction of soluble material.) If the landfill is unlined, depending on the drainage system and the composition of the underlying soils, this runoff can contaminate ground or surface water. When leachate from sanitary landfills is discharged into surface water it will similarly contaminate these bodies.

Many toxic materials can only be treated or removed with expensive advanced technologies. These are generally not feasible in Latin America. Even after organic and biological elements are treated, the final product remains harmful.

Create greenhouse gas emissions and other air pollutants. When organic wastes are disposed of in deep dumps or landfills they undergo anaerobic degradation and become significant sources of methane, a greenhouse gas that is much more powerful than carbon dioxide.

Garbage is often burned in residential areas and in landfills to reduce volume and uncover metals. Burning creates thick smoke that contains carbon monoxide, soot, and nitrogen oxide, all of which are hazardous to human health and degrade urban air quality. Combustion of polyvinyl chlorides (PVCs) generates highly carcinogenic dioxins.

Damage ecosystems. When solid waste is dumped into rivers or streams it can alter the aquatic habitat and harm native plants and animals. High nutrient contents can deplete dissolved oxygen in the body of water, and solids can cause sedimentation and change the stream s flow and bottom habitat. Siting dumps or landfills in sensitive ecosystems may destroy or significantly damage these valuable natural resources and the services they provide.

For more information

These guidelines are intended to be a starting point for solid waste project developers and managers and are designed to highlight key issues, questions to consider, and technical options. More detailed resources are cited at the end of this document. Solid waste project developers and managers should pay particular attention to *The International Source Book on Environmentally Sound Technologies for Municipal Solid Waste Management,* produced by the International Environmental Technology Centre of the United Nations Environment Programme. This comprehensive resource discusses environmental issues and options for municipal solid waste management.

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Cause flooding. The accumulation of waste along streets can clog drains and cause localized flooding.

Injure people and property. In locations where shantytowns have been built near open dumps or badly designed or operated landfills, landslides can destroy homes and injure or kill residents.

PREVENTING POLLUTION IN PUERTO BARRIOS, GUATEMALA: MAKING CITIES WORK PARTNERSHIP FUND

With nearly half of the population in Central America living in urban areas and an annual urban growth rate of 4 percent, the environmental degradation caused by urban pollution is one of the main problems jeopardizing sustainable development in the region. Local governments usually lead and direct efforts to solve air and water pollution, solid waste collection and management, and water and sewage treatment. However, in Central America, most local governments and private sector groups lack the knowledge and infrastructure to properly address environmental problems.

Puerto Barrios is a international commercial seaport on the Caribbean coast of Guatemala. However, uncontrolled waste disposal and the discharge of untreated waste into nearby water bodies (the Atlantic Ocean and the Escondido and Zapatero Rivers) are threatening the port s viability. Open dumps produce a wide range of public health problems, creating breeding grounds for disease vectors such as rats, cockroaches, and flies, contaminating surface and groundwater, and contributing to air pollution through uncontrolled burning of waste. Disposal of untreated hospital waste and gas explosions present further hazards.

USAID s Regional Urban Development Office for Latin America and the Caribbean, in cooperation with the USAID/G-CAP funded Local Environmental Policy and Program Initiative (LEPPI), is working in Puerto Barrios on a pilot project to reduce environmental pollution. This project addresses the management and disposal of solid waste and the reduction of contamination caused by the discharge of wastewater into rivers. The Making Cities Work Grant involves the organization of a local Environmental Steering Committee that has coordinated the development of an environmental action plan and a feasibility study on solid waste. As a result, the city is moving toward a more efficient and rational solid waste collection system by:

- Constructing transfer stations and a material recovery facility for handling recyclables and providing training and technical support to the Municipal Board and to the local Environmental Steering Committee to operate the facility.
- Designing a sanitary landfill; planning collection routes.
- Establishing an environmental education program for schools and residents.

In addition, LEPPI supports efforts to organize individuals who are collecting reusables and recyclables from the municipal dump into a recycling and composting microenterprise. The experience of Puerto Barrios demonstrates how a participatory planning approach can effectively identify local resources and address community issues in an integrated manner.

Sector Design--Some Specific Guidance

Failure to effectively collect waste from all waste generators and properly site, design, and operate landfills is the most serious fault commonly identified in solid waste management in the developing world.

Integrated Waste Management

The adverse impacts of waste management are best addressed by developing and implementing integrated programs where all types of waste and all facets of the waste management process are considered together. Despite its importance, limited resources may prevent such an integrated program from being fully implemented, and only a piecemeal solution may be possible. However, the long-term goal should be to develop an integrated waste management system and build the technical, financial, and administrative capacity to manage and sustain it.

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Whether pursuing an integrated, holistic approach or a piecemeal one, managers should ensure that the program is appropriately tailored to local conditions and that practical environmental, social, economic, and political needs and realities are balanced. Answering a few key questions will help greatly in achieving this goal:

- Are adequate financial and human resources available to implement the policy, program, or technology?
- Is this the most cost-effective option available?
- What are the environmental benefits and costs? Can the costs be mitigated?
- Is the policy, program, or technology socially acceptable?
- Will specific sectors of society by adversely affected? If so, what can be done to mitigate these impacts?

For a detailed discussion of key objectives and issues to be addressed in municipal solid waste management strategies, see the UNDP reference *Conceptual Framework for Municipal Solid Waste Management in Low-Income Countries.*

Capacity Building

Insufficient capacity is a fundamental impediment to sound solid waste management programs in much of the developing world. Operating an efficient, effective, environmentally sound municipal solid waste management program requires building administrative capacity for government and private sector play-

ers and technical capacity for designing, operating, maintaining, and monitoring each part of the process.

Often those people working in solid waste management--private sector companies, NGOs, and government entities--lack technical and financial knowledge of solid waste management. Training that builds human resource and institutional capacity for all stakeholder groups at appropriate levels should be a part of every waste management project. Peer-to-peer training for everyone from waste-pickers to local government officials has proven effective in extending and sustaining these programs.

Reducing the quantity of waste that must be transported and disposed of should be a primary goal of all municipal solid waste management programs.

Environmental Mitigation and Monitoring Issues

To operate in an environmentally sound manner, integrated solid waste management programs should strive to:

- Minimize the quantity of waste that must be placed in landfills through elimination, recovery, reuse, recycling, remanufacturing, composting, and similar methods.
- Manage non-hazardous wastes and special or hazardous wastes separately .
- Collect and transport all waste effectively and efficiently.
- Design sanitary landfills and ensure appropriate siting, operation, monitoring, and closure.

Waste Minimization

Reduce, reuse, recycle. Reducing the quantity of waste that must be transported and disposed of should be a primary goal of all municipal solid waste management programs. Waste should be recovered at the source, during transport, or at the disposal site. The earlier the separation, the cleaner the material, and, in the end, the higher the quality and value it will be to its users. Integrating and fostering the involvement of the informal sector--itinerant collectors, microenterprises, cooperatives--are the keys to improving waste minimization. Other tips on reducing waste include:

- ***Avoid curbside recycling.*** Brazil and Mexico have experimented with curbside collection of recyclables, but its economic viability has not proven favorable.
- ***Organize itinerant collectors and publicize prices.*** In cities throughout Latin America and the Caribbean, itinerant collectors recover high-value recyclable materials at residences and small industries. Go-betweens, who buy their

goods and resell them to manufacturers, often exploit these collectors. Organizing collectors can improve both their standard of living and the stability of the collection services. Publicizing prices can help mitigate possible exploitation by intermediaries.

- ***Set up collection centers.*** Centralized collection centers set up outside of supermarkets have been used with some success in Argentina, Brazil, Columbia, and Mexico.
- ***Offer incentives.*** Modest incentives have had promising results: in Curitiba, Brazil, people receive bus tickets and vegetables in exchange for recyclables.

FREQUENCY OF WASTE COLLECTION

Tropics	Daily
Temperate regions	
Summer	Every 2 days
Winter	Every 3 days
Cool climates	
Summer	Twice a week
Winter	Once a week

Source: IETC/UNDP 1996.

Facilitate separation at disposal site. When waste-pickers are allowed access to disposal sites, significant amounts of material can be recovered. However, because they interfere with efficient operation of dumps and landfills, waste-pickers are usually excluded from these sites, decreasing the level of recovery and causing them severe economic hardship. In Rio de Janeiro, waste-pickers were organized into a cooperative to recover recyclables from loads originating in high-income neighborhoods--and by 1997 they earned nearly four times Brazil s minimum wage.

Composting and anaerobic digestion. Organics make up 40-50 percent of the waste stream in Latin America and the Caribbean, though this varies with the incomes of the neighborhood, region, or country. If this part of the waste stream was recovered and processed for reuse through composting or anaerobic digestion, many adverse impacts of landfills would be significantly diminished. Landfills would require less space, last longer, and produce less leachate and methane. At this time, little organic recovery and processing are occurring.

Organics make up 40-50 percent of the waste stream in Latin America and the Caribbean

- ***Composting may not be the best option.*** Large centralized composting efforts, designed to separate the organic component from mixed waste, have almost always failed in Latin America and the Caribbean for reasons including poor, or absent, feasibility studies and subsequent failures to meet cost recovery expectations. Small composting enterprises have fared only somewhat better. Even the higher-quality compost produced from source-separated waste cannot command prices high enough to support operations, causing these businesses to struggle. If composting is to become a part of integrated waste management, greater urban demand or subsidies may be necessary. Municipalities, for example, could compensate small composting operations by the ton of material that is diverted from landfills and base that compensation on avoided disposal costs.

- ***Promote vermiculture treatment of vegetable food waste.*** Small earthworm composting farms, operated by 5-6 people, have proven more successful than traditional composting facilities, though they are not yet in widespread use. Vermiculture benefits from better quality control and the perception that the worm excrement is derived from clean vegetable waste, whereas compost is derived from garbage. The excrement is also more nutrient-rich than compost.
- ***Investigate anaerobic digestion.*** Pilot projects using anaerobic digestion in biogas reactors have been technically successful, but they have not yet proven cost-effective. Anaerobic digestion can generate a nutrient-rich slurry to be used on soil and a methane-rich biogas to be used for fuel.

Reaching the goal of universal collection at the recommended frequency requires implementation of best practices and careful consideration of the characteristics of the city, climate, and culture.

Collection and Transfer

In most cities in Latin America and the Caribbean, a significant proportion of people do not have regular waste collection or access to disposal services. Affluence usually determines the collection frequency. Reaching the goal of universal collection at the recommended frequency requires implementation of best practices and careful consideration of the characteristics of the city, climate, and culture. The following general insights from international experience may be valuable:

Use appropriate technology--regular trucks and alternative vehicles. Compacting provides little advantage, considering the density of the waste currently produced in most of the region. Specialized compaction trucks are very expensive, difficult to repair and are often out of service. Regular trucks require less capital investment and are easier to maintain. They may also be better adapted for poor road conditions and can be used for alternative purposes if the municipality or company decides to transfer collection responsibility to others. For waste collection in hard-to-reach areas--very narrow streets, alleys, deteriorated roads--consider alternative collection vehicles, such as semi-motorized carts, front-loaded tricycles, donkey carts, and handcarts.

Integrate the informal sector. Cooperatives and microenterprises are the primary users of smaller collection vehicles and can effectively collect waste from hard-to-reach areas at a low cost. Municipalities in some countries--Bolivia, Columbia, Costa Rica, Guatemala, Peru--integrate recyclable and solid waste collection with microenterprise and cooperative associations through concessions, contracts, or informal arrangements. Community members willingness to pay generally increases when collection methods are flexible and inexpensive features are best delivered by the informal sector.

Build on the existing system. Radical changes are often difficult to achieve, especially with limited political support, administrative and technical capacity, or financial resources. Develop current structures and processes as part of a strategy of incremental improvement.

Introduce transfer activities. Transfer activities often increase efficiency, for both small- and large-scale systems. In small-scale transfer, microenterprises or cooperatives bring waste to a centralized area for pick up by private or municipal trucks. At large-scale stations, waste is transferred from a compactor or small truck to larger trailer trucks. Both types of transfer activities save fuel and reduce both wear-and-tear on trucks and the amount of time spent traveling to and from the landfill. The farther the landfill is from the city, the greater the benefits of large-scale transfer.

Develop dependable revenue collection systems. Non-payment or unwillingness to pay for independent service reduce operating budgets and jeopardize systems economic viability. Consider using linked billing, a strategy that has proven effective in a number of countries in the region. Electricity consumption is closely correlated with waste generation, so fees for waste collection can be tied to electricity use and integrated into the electrical bill. After charging a small administrative fee, the utility passes the payments to the municipal solid waste department.

Landfills

Much of the waste disposal in Latin America and the Caribbean occurs in open or controlled dumps that are environmentally unsound. Even using the best waste minimization practices at all stages, some non-recoverable waste will remain and landfills will be needed. The ultimate goal for land disposal should be separate disposal of hazardous and non-hazardous materials and construction of clean and properly sited landfills with diligent management, including leachate and methane controls, during operation and after closure. When these conditions are met the landfill becomes a sanitary landfill. The transition from open or controlled dumps to sanitary landfills should be made incrementally as follows:

Open dumps. If open dumps are currently being used, initial upgrades can be made with little capital investment and minimal ongoing costs. Take the following initial steps:

1. Construct perimeter drains to catch runoff and leachate.

SITING GUIDELINES FOR LANDFILLS

Do not site landfills:

- In wetlands or areas with a high water table
- In floodplains
- Near drinking water supplies
- Along geological faults or seismically active regions
- Within two kilometers of an airport

Do site landfills:

- Above clay soils or igneous rock
- With active public involvement
- In areas with sufficient capacity
- Where they will be easily accessible for waste delivery

Source: IETC/UNDP 1996.

2. Minimize leaching through soil by grading the fill and repeating periodically (bi-monthly is often sufficient). Manual labor or heavy equipment may be used (renting heavy equipment is often the least expensive option).
3. Protect the health of waste-pickers and landfill staff by providing soap and water.
4. Regularly test ground water for contamination by contaminants such as bacteria, heavy metals, and toxic organic chemicals.
5. Conduct a formal environmental assessment of the current site before making further upgrades. If it is environmentally sound and has adequate additional capacity, it can be converted directly to a controlled dump. Otherwise an appropriate alternative site for a controlled dump or sanitary landfill must be located.
6. Engage the public in decision-making. Public involvement in upgrades, siting decisions, and subsequent planning is essential. Otherwise, strong opposition may develop that delays or halts the project.

Sanitary landfills are the only land disposal option that enables control and effective mitigation of potential surface and ground water contamination, health and physical threats to waste-pickers and sanitation workers, and methane emissions.

Controlled dumps. To transform an open dump into a controlled dump the following procedures are recommended:

1. Fence in the active face of the landfill and hire staff to monitor and control dumping.
2. Track how much waste is delivered.
3. Compact waste before or after dumping.
4. Schedule monitoring of gas production, landfill composition, and surface and ground water conditions.
5. Develop closure and post-closure plan.
6. Seal and cover when the dump s capacity is exhausted.
7. Maintain scheduled monitoring until sampling indicates it is no longer necessary--possibly 30 years or more.

Sanitary landfills. Sanitary landfills are the only land disposal option that enables control and effective mitigation of potential surface and ground water contamination, health and physical threats to waste-pickers and sanitation workers, and methane emissions. Sanitary landfills require much greater initial investment and have higher operating costs than controlled dumps. Full community involvement throughout the life cycle of the project is essential. Proper design, operation and closure also require a much higher level of technical capacity.

Siting. Siting is possibly the most difficult stage in landfill development.

1. Carry out an environmental impact assessment that addresses all siting criteria.
2. Organize full community involvement. This is especially important given the greater expense and often greater size of sanitary landfills.

Design. To mitigate environmental impacts, sanitary landfill designs should include:

1. An impermeable or low-permeability lining (compacted clay and polyethylene are most common in Latin America, geo-polymers and asphalt are prevalent in the developed world).
2. Leachate collection, monitoring, and treatment.
3. Gas monitoring, extraction, and treatment.
4. Fencing to control access.
5. Provisions for closure and post-closure monitoring and maintenance.

The impact of leachate can be controlled only by lined landfills.

Leachate management. The impact of leachate can be controlled only by lined landfills.

1. Install collection systems to retrieve leachate from the bottom of the landfill.
2. Treat leachate physically, chemically, or biologically through:
   a. *An off-site sewage treatment plant* (adequate sewage treatment facilities are readily available in only some parts of Latin America and the Caribbean) or in a dedicated on-site treatment plant.
   b. *Recirculation that sprays leachate from the bottom of the landfill onto its surface.* This is a popular landfill management practice in the region that reduces leachate volume by increasing evaporation, stores remaining leachate in the body of the landfill, and may accelerate degradation and extend the life of the site. However, recirculation is a new technique whose long-term effects are not yet known. In Bogota, Columbia, it is believed to have contributed to the massive collapse and slide of a landfill.
   c. *Evaporation of leachate through a series of open ponds.* This method requires pumping and some means for disposing of possibly toxic residues. Ponds should be designed with enough capacity to accommodate increased volume during the rainy season.
3. Monitor ground and surface water regularly, both down-gradient and up-gradient of the landfill. Monitoring should at least include indicators on

core contaminants--chemical oxygen demand, biological oxygen demand, and total nitrogen and chloride levels.

4. Landfill gas should be recovered and used as fuel, or, if this is not economical, it should be vented and flared. Currently recovery and processing systems are both expensive and difficult to operate. These systems are economical only when the landfill generates large quantities of gas, where local or regional demand exists, or where the price for natural gas or other substitutes is high. At a minimum, buried perforated pipes should be installed that can safely vent gas and a flaring system added to reduce global warming effects by converting methane to carbon dioxide.

Without proper controls, incinerators can be highly polluting, generating dioxins and depositing toxic heavy metals into water bodies.

5. Fence in landfills to prevent waste-pickers from accessing the site. This enables landfill personnel to work efficiently and protects waste-pickers from exposure to harmful substances--but it also deprives them of their livelihood. Take steps to integrate waste-pickers into formal collection or disposal operations by, for instance, organizing a cooperative and offering structured access at the landfill gates, as is done Rio de Janeiro. Another option may be to incorporate them into earlier stages of the collection process, as in Porto Alegre, Brazil, where waste-pickers were integrated into the curbside recycling program that serves 80 percent of the city. In Columbia, waste-pickers who were excluded from a landfill were organized into a cooperative that collects recyclables from industry.

6. Implement the activities specified in closure and post-closure plans that were developed during design. These should include sealing and application of final cover (including vegetation), land use restrictions, and long-term gas, leachate, surface water, and ground water monitoring.

Incinerators

Do not construct incinerators. Incineration of municipal solid waste is rarely economically feasible for developing countries and is virtually non-existent in Latin America and the Caribbean. The high humidity of waste often requires the addition of supplemental fuel, and the great diversity of waste composition between neighborhoods makes consistent and optimal operation difficult to achieve. Without proper controls, incinerators can be highly polluting, generating dioxins and depositing toxic heavy metals into water bodies. The proprietary technologies involved require very large capital investments and have high maintenance costs.

Special Wastes

Certain wastes merit special attention because of their dangers or volume. All should be collected and disposed of separately from one another and away from the rest of the solid waste stream. Separate collection of some special wastes is common practice in many parts of Latin America, but separate disposal occurs less often. (For medical waste, see section B of this chapter.)

Hazardous waste. Chronically and acutely toxic, cancer-causing, teratogenic,[1] explosive, and corrosive materials are concentrated hazards. Generators of solid waste, collectors, landfill workers, waste-pickers, and nearby residents are all at risk of exposure. The level of a landfill s leachate toxicity is directly related to the quantity and toxicity of hazardous materials mixed in with other solid waste. The many types of materials and sources--from households to industrial and medical facilities--makes this particularly challenging. Contributing factors include limited financial resources to deal with these problems and ignorance or unwillingness to acknowledge the risks.

Sound management of hazardous materials has four components: waste reduction, segregation, safe handling, and disposal.

Sound management of hazardous materials has four components: waste reduction, segregation, safe handling, and disposal. While the best solution is to not generate the waste in the first place, when this is not possible every effort should be made to minimize generation, and wastes that are generated should be handled to minimize the risks. Generators of hazardous waste should segregate different types of materials to make recycling easier and prevent chemical reactions or explosions. Suggested best practices for accomplishing these goals in the developing world include:

Sound management of hazardous materials has four components: waste reduction, segregation, safe handling, and disposal.

- ***Providing technical assistance and training*** to educate decision makers, system operators, and the public and to identify cost effective waste reduction measures (see Chapter 4: Micro and Small Enterprises in this manual).
- ***Establish incentives, disincentives, or regulations*** to promote waste reduction where it is not otherwise cost effective.
- ***Establish dedicated hazardous waste recycling and disposal facilities.*** Many countries in Latin America and the Caribbean operate hazardous waste treatment and disposal facilities. However, much of the hazardous waste generated continues to be disposed of in dumps and landfills without any provisions for segregation, containment, or treatment.

[1] Teratogenic substances cause toxification, cancer, genetic mutations, and birth defects. They are also called genotoxic.

Table 5.1 Examples of Hazardous Waste Facilities in Latin America and the Caribbean

Country	Facilities
Argentina	• Several hazardous waste treatment and disposal facilities exist. A complete list can be obtained from the Dirección Nacional de Ordenamiento Ambiental-Unidad Registro. Online: www.medioambiente.gov.ar
Brazil	• There are several licensed landfills for urban and common wastes, as well as for hazardous and industrial wastes. There are also licensed incineration facilities. A detailed list of these facilities can be obtained from the Directorate of Environmental Control of the Brazilian Institute of Environmental and Renewable Natural Resources (IBAMA). Online: www.ibama.gov.br
Chile	• The Hazardous Waste Treatment and Disposal Facility is located at: Hidronor S.A. Vizcaia #260, Santiago, Tel: (56-2) 640-9364
Colombia	• The Executive Unit for Public Utilities in Bogotá maintains a security cell for hospital wastes at the Dona Juana Landfill. The government is in the process of bidding the design and construction of hazardous wastes cells in Bogotá. Under the auspices of the Ministry of the Environment, there are a number of initiatives for recycling, regeneration, and reuse of hazardous wastes.
Ecuador	• The Guayaquil Municipality operates a landfill (Relleno Sanitario Las Iguanas) that has segregated areas for depositing hazardous waste. In addition, the Ecuadorian telephone and water company collects and stores used oils.
El Salvador	• The San Salvador Metropolitan Area Landfill has facilities for autoclaving infectious biological wastes, and several private sector entities also recover, reuse, and recycle hazardous waste. These include Baterías de El Salvador (for recycling of lead acid batteries and use of spent oil as fuel) and Cementos Cessa (for use of spent oil for fuel).
Mexico	• Mexico has two large licensed hazardous waste treatment and disposal facilities and is in the process of constructing a third facility.
Panama	• The Cerro Patacon Sanitary Landfill also handles hazardous waste. The following companies have recovery, recycling, or reuse facilities: The Panama Refiner, Eco-Klean (for processing spent oil), Derivados de Petróleo S.A., and Proceso y Análisis Metálicos.
Peru	• The following landfills in Peru have segregated areas for disposal of hazardous waste: Portillo Grande, Lurin, Relima; Zapalla, Puente Piedra, Relima; and Huaycoloro, Huarochiri, Petramas. In addition, these private sector entities have facilities for recycling, reuse, and recovery of hazardous waste: Corporación Aceros Arequipa and Tecnofil.

- ***Develop systems that attempt to ensure that waste is not illegally dumped.*** One model that provides checks on illegal dumping is the hazardous waste manifest system in the United States, where a paper trail is generated to prove that the material reached its intended final destination.
- ***Explore options for contracting private sector firms*** that specialize in the handling and disposal of hazardous wastes.

Tires, oil, and batteries. Stockpiled tires can spontaneously combust, producing prolonged polluting fires. Reuse or retreading are the best alternatives available for reducing tire waste in developing and industrializing countries. Used motor oil from auto shops is often burned as fuel, contributing to air pollution. Re-refining this oil is the best alternative, but this alternative is neither readily available nor commercially feasible in most of Latin America and the Caribbean. Lead acid batteries should not be placed in landfills--the lead is toxic, the acid corrosive and contaminated. Lead acid batteries are often recycled in small-scale foundries that are highly polluting and located in residential areas. Recycling in large facilities that have emission and environmental controls is preferable, if this option is available.

Construction and demolition debris. Prevent disposal of construction and demolition debris in dumps or landfills, as this will greatly reduce the life of the facility. Residual lead paint, mercury switches, asbestos and PCBs can also make this debris toxic. Arrange for the return of unused construction materials, recovery of all reusable or recyclable materials, and on-site separation to simplify reuse. The UN Environment Programme s *International Sourcebook on Environmentally Sound Technology for Municipal Solid Waste Management* recommends the following best practices for construction and demolition debris:

- ***Inventory control and return allowances for construction material.*** This ensures that unused materials will not get disposed of unnecessarily.
- ***Selective demolition.*** This involves dismantling, often for recovery, selected parts of buildings to be demolished before the wrecking process is initiated.
- ***On-site separation systems.*** Use multiple smaller containers instead of a single roll-off or compactor.
- ***Crushing, milling, and reusing secondary stone and concrete materials.*** There can be a tie-in to approved road construction material specifications.

RECOMMENDATIONS FOR THE LATIN AMERICA AND CARIBBEAN REGION

To improve solid waste management disposal practices, the following recommendations may be adopted:

1 ***Technical and institutional guidance.*** At the national level, Latin American and Caribbean countries need guidance on siting of landfills with regard to conventional and unconventional environmental protection measures. In particular, the climatic and hydro-geological aspects of leachate management need to be incorporated into landfill policies.

2 ***Development of the full concept of leachate management.*** First, countries need to improve the criteria for liners and leachate collection systems to assure appropriate technology investments. The use of the entombment concept, questioned in the scientific community as unsustainable, should be carefully considered and re-assessed. In addition, the region must advance the concept of recirculation, including the benefits and risks, the principles of simple treatment methods and their functions, and education of the principle of attenuation and dispersion. The benefits from evaporation should also be further developed in some countries.

3 ***Re-assessment of passive gas-ventilation systems.*** Passive ventilation must be compared with the option of flaring landfill gas in order to reduce methane emissions. The possibilities for recovery of landfill gas for electric power production or utilization of the gas for industrial purposes should be followed up.

4 ***Re-evaluation of daily cover use.*** Most landfills in the region use clay materials that may prevent proper recirculation of leachate. Moreover, soil is often used in excessive quantities, constituting up to half of the operating budget for landfills in some countries.

5 ***General knowledge of environmental monitoring.*** Many countries have introduced monitoring of leachate and groundwater but selected parameters are too many yet indicators are inadequate. Simple approaches with a few important indicator parameters may yield better results. For instance, monitoring chemical oxygen demand, biological oxygen demand, total nitrogen, and chloride levels may increase understanding of the pollution potential in the landfills and provide an early warning for groundwater contamination.

6 ***Assessing the real costs of tipping fees.*** The actual costs associated with landfilling waste in the region are unknown. To assess a comprehensive fee table for depositing waste, costs should include investment, depreciation, operational, and long-term aftercare costs.

Source: Johannessen and Boyer 1999.

References

Reports

IETC (International Environmental Technology Centre) and UNEP (United Nations Environmental Program). 1996. *International Source Book on Environmentally Sound Technologies for Municipal Solid Waste Management.*

Directed toward NGOs, community-based organizations, and municipal solid waste management decision-makers in developing countries and countries in transition, the sourcebook is designed to serve as a general reference. It provides a list of information sources and overviews of world practices in environmentally sound management of municipal solid waste--waste reduction, collection and transfer, composting, incineration, landfills, special wastes, waste characterization, management and planning, training, public education, and financing. Most of the book is available online: http://www.unep.or.jp/ietc/ESTdir/pub/MSW/.

Lardinois, Inge. 1996. *Solid Waste: Micro and Small Enterprises and Cooperatives in Latin America.* The Global Development Research Center.

This paper describes the nature, type, origins, economics, and institutional relationships of micro- and small enterprises and cooperatives providing solid waste collection in Bolivia, Brazil, Colombia, Costa Rica, El Salvador, Guatemala, and Peru, based on research carried out in January-May 1996. Online: http://www.gdrc.org/uem/waste/swm-waste.html. (Digital copy included.)

Johannessen, Lars Mikkel, and Gabriela Boyer. 1999. *Observations of Solid Waste Landfills in Developing Countries: Africa, Asia, and Latin America.* World Bank, Washington, DC.

A survey of landfills in Asia, Africa, and Latin America. The Latin America section discusses recommendations, landfill operations (gas and leachate management), waste-pickers, and private sector participation. The report reviews environmental impacts and offers recommendations for improvements in World Bank projects that have solid waste components. Online: http://www.worldbank.org/html/fpd/urban/publicat/landfilloverview.pdf.

Partridge, William. 2000. Latin America and the Caribbean Update. *Environment Matters at the World Bank, Annual Review.* World Bank, Washington, DC.

Books and Other Resources

ERM (Environmental Resources Management). 2000. *Strategic Planning Guide for Municipal Solid Waste Management.* CD-ROM prepared for the World Bank, SDC, and DFID, Waste-Aware, London.

ERM offers a new set of tools for strategic solid waste planning field tested in Peru, the Philippines, and Vietnam. To request a copy, email Urban Help at urbanhelp@worldbank.org.

Pugh, Michael, and Philip Rushbrook, eds. 1999. *Landfills in Middle and Lower-Income Countries-A Technical Guide to Planning, Design and Operation.* The World Bank, SDC, World Health Organization, and SKAT.

Targeted at senior waste management staff in local authorities, this guide is intended to be a practical tool for waste managers to make gradual short-term improvements by upgrading waste disposal at modest cost, while still providing acceptable levels of environmental protection in different climatic, cultural, and political regimes. Guidance is also provided on siting, developing, and operating full sanitary landfills along with comprehensive policies and programs to reduce waste generation and increase recycling. Online: http://publications.worldbank.org/ecommerce/catalog/product?item_id=210054.

B. Medical Waste

Brief Description of the Sector

Healthcare activities--urban clinics, hospitals, rural posts, immunization posts, reproductive posts, mobile and emergency programs--provide important, and often critical, services to individuals and communities that would otherwise have little or no access to such services. They are the front line of defense against epidemics such as AIDS, cholera, and malaria and a key component of any comprehensive development program. The medical and health services they provide improve family planning, nurture child and adult health, prevent disease, cure debilitating illnesses, and alleviate the suffering of the dying.

Healthcare activities are the front line of defense against epidemics such as AIDS, cholera, and malaria.

Currently, little or no management of medical waste occurs in small-scale facilities in Latin America and the Caribbean. Training and supplies are minimal. Common practice in urban areas is to dispose of medical waste along with the general solid waste. In peri-urban and rural areas, waste is buried without treatment in unlined pits. In some cities small hospitals incinerate waste in dedicated on-site incinerators but do not operate the incinerators with necessary safeguards. Unwanted pharmaceuticals and chemicals may be dumped directly into the local sewage system, septic tank, or latrine.

Potential Environmental Impacts

Although small-scale healthcare activities provide important benefits to communities, they may also unintentionally do great harm through poor design and operation of waste management systems. Medical waste is dangerous. If improperly handled, treated, or disposed of it can spread disease, poisoning people, livestock, wild animals, plants, and entire ecosystems.

Medical wastes generally fall into three categories (table 5.2):

- ***General medical waste,*** similar to domestic waste, includes materials such as packaging or unwanted paper--75-90 percent of waste generated by healthcare facilities falls into this category. It is generally harmless and requires no special handling.
- ***Hazardous medical waste*** includes all infectious waste (except sharps), small quantities of chemicals and pharmaceuticals, and non-recyclable pressurized containers.

- ***Highly hazardous medical waste*** includes sharps, highly infectious non-sharp waste, bodily fluids of patients with highly infectious diseases, large quantities of expired or unwanted pharmaceuticals and hazardous chemicals, and radioactive or teratogenic wastes.

Disease transmission. Transmission of disease through infectious waste is the greatest and most immediate threat from medical waste. If waste is not treated

Table 5.2 Types of Hazardous and Highly Hazardous Medical Waste

Hazardous Waste		Highly Hazardous Waste	
Infectious	Wastes thought to contain low concentrations of infectious agents, such as disease-causing bacteria, viruses, parasites, and fungi, that could spread the disease Examples: tissues, swabs, wash water, materials or equipment that have been in contact with infected patients, human excretions such as puss, feces, and vomit	Sharps	Sharp objects that can easily cut or injure a handler. Used hypodermic needles are the most common and dangerous as they are often contaminated with highly infectious blood Examples: needles, scalpels, knives, infusion sets, broken glass
Pathological	Tissue or body fluids from humans or animals Examples: blood, body parts, organs, carcasses	Highly infectious (non-sharps)	Contain high concentrations of infectious agents and pose an extreme health hazard Examples: body fluids, such as blood from patients with highly infectious diseases; microbial cultures; and carcasses of inoculated laboratory animals
Chemical (small quantities)	Waste containing purified chemical substances that are toxic, corrosive, flammable, reactive, and explosive Examples: unwanted disinfectant, solvents, film developer, laboratory reagents	Chemical, pharmaceutical, and heavy metal (large quantities)	The same pharmaceuticals and chemicals that are only hazardous in small quantities may be highly hazardous in large quantities Examples: rechargeable batteries, mercury from broken thermometers or blood-pressure gauges, some medical equipment batteries
Pharmaceutical (small quantities)	Waste containing pharmaceuticals Examples: bottles/boxes of expired or unwanted medications	Teratogenic	Wastes containing substances that can cause mutations, birth defects, and cancer. Facilities with laboratory facilities might stock some teratogenic chemicals Examples: chemotherapy drugs
Pressurized containers	Examples: gas cylinders, gas cartridges, aerosol cans	Radioactive	Waste containing radioactive substances not likely to be used by small-scale healthcare facilities. Examples: some laboratory wastes, wastes associated with radiation therapy

in a way that destroys the pathogenic organisms, dangerous amounts of microscopic disease-causing agents--viruses, bacteria, parasites, fungi--will be present in the waste. These agents can enter the body through punctures in the skin or mucous membranes in the mouth and by being inhaled, swallowed, or transmitted by a vector organism. People who come in direct contact with waste--healthcare workers, cleaning staff, patients, visitors, waste collectors, disposal site staff, waste-pickers, drug addicts, and those who recycle contaminated syringes--are at greatest risk.

Although sharps pose the inherent physical hazard of cuts and punctures, the much greater threat comes from sharps from syringes or needles used on infected patients, which can infect people with HIV/AIDS and the hepatitis B and C viruses through accidental pricks.

Chemical and pharmaceutical wastes, especially in large quantities, can be a threat to the environment and human health.

Chemical and pharmaceutical wastes, especially in large quantities, can be a threat to the environment and human health. Since these wastes may be toxic, corrosive, flammable, reactive, or explosive, they can harm people who touch, inhale, or are in close proximity to them. If burned, chemical wastes may explode or produce toxic fumes.

Contamination of water supplies from untreated medical waste can also have devastating effects. Since most sewage is not treated in Latin America and the Caribbean, infectious stools or bodily fluids flushed into the sewer system can create and extend epidemics. The absence of proper sterilization procedures may have increased the severity of cholera epidemics in the region during the last decade. When chemical and pharmaceutical waste is disposed of in unlined landfills or pits, the leachate can contaminate ground or surface water, threatening people who use the water for drinking, bathing, and cooking and damaging local plants and animals.

Designers and managers of healthcare facilities should take an incremental approach to improving waste management.

Burning or incinerating medical waste, while often a better option than disposing of it in an unlined pit, may create additional problems. Toxic air pollutants--acid gases, nitrogen oxide, particulates, dioxins, heavy metals--may be produced and distributed over a wide area. Dioxins and heavy metals are of particular concern. Dioxins, believed to be potent cancer-causing agents, do not biodegrade and accumulate in progressively higher concentrations as they move up the food chain. Heavy metals, such mercury and cadmium, are toxic and can cause birth defects, even in small quantities. Disposable pressurized containers pose another hazard for incineration, as they can explode if burned.

Sector Design--Some Specific Guidance

Minimum Elements of a Complete Waste Management Program

Healthcare facilities require a sound medical waste management system to minimize adverse health and environmental impacts caused by their waste. A comprehensive minimal program to manage medical waste includes the following practices:

1. A waste management plan should be written describing all of the practices for handling, storing, treating, and disposing of hazardous and non-hazardous waste, as well as the types of worker training required. This plan is usually drawn up after doing a comprehensive assessment of waste handling at the facility.
2. Staff responsibilities should be clearly assigned to make workers feel accountable for how well tasks are completed and ensure that no step in the process is overlooked.
3. Formalized internal rules for waste generation, handling, storage, treatment, and disposal must be maintained.
4. Training in safe handling, storage, treatment, and disposal will ensure that staff are aware of all hazards they might encounter and that they are practicing good hygiene, safely handling sharps, properly using protective clothing, and safely packaging, labeling, and storing waste. Training helps ensure correct responses to spills, injury, and exposure.
5. Protective clothing--surgical masks and gloves, aprons, boots--should be readily available to protect workers when moving and treating collected infectious waste.
6. Good hygiene practices prevent worker sicknesses. Many infectious agents must enter the mouth or be swallowed to cause disease, but even if protective clothing is worn, some organisms can get on workers hands and faces. Workers should wash their hands and faces regularly with soap and warm water.
7. Worker vaccinations guard against potentially deadly hepatitis B and tetanus infections.

8. Temporary storage containers and designated locations should be used to store hazardous wastes, and only for short periods of time–less than 24 hours in warm climates. Hazardous wastes should be stored in labeled, covered containers in the designated location, away from patients or food.

9. Minimization, reuse, and recycling procedures ensure that less waste is generated so there is less waste to manage. Unnecessary disposal of valuable chemicals and pharmaceuticals can be avoided through good inventory practices–using the oldest batch first, never opening a new container before the last one is finished, preventing products from being thrown out during cleaning, and checking delivery to make sure materials are not about to expire. Where possible and safe, use reusable syringes and needles. This generates less waste (0.5-2 percent of disposables), and costs 5-15 times less. Minimize use of products containing PVC plastics. Competitively priced substitutes for PVC plastic are available that perform equally well.

10. A waste segregation system both reduces the volume of waste and enables different kinds of materials to be handled appropriately. Two-thirds of the waste produced by small-scale facilities is general waste. Separating hazardous waste from general wastes reduces the amount that must be treated by 75-90 percent. The dangers of sharps waste can be minimized when sharps are collected in separate puncture-proof containers. Other elements that can be segregated include hazardous liquids, chemicals, pharmaceuticals, PVC plastic, and materials containing heavy metals.

11. Treatments for hazardous and highly hazardous waste available to small-scale facilities are limited (see table 5.3). High concentrations of infectious agents makes these wastes dangerous, and the risks associated with current methods for managing healthcare waste exist because little is done to reduce concentrations before disposal. The most important function of treatment is disinfection. For rural facilities, burning in the open air in a single-chamber incinerator or drum or brick incinerator, preferably combined with good waste segregation practices, is the recommended option.

12. Autoclaving infectious waste and encapsulating sharps may be the best option for urban facilities since the air pollution produced by burning poses a greater hazard in urban areas. If a larger hospital with more advanced treatment and disposal systems is located nearby, small facilities could investigate piggy-backing on those systems, though precautions will need to be taken to reduce risks from transporting the waste.

13. A final disposal site must be available where residues from treated waste and waste that cannot be treated can be disposed of properly. Small facilities should bury waste on site, ideally in a pit lined with clay or other imperme-

A healthcare facility does not need to do everything at once. Implementing just a few key practices can dramatically reduce risk and improve health and safety.

able material. But most urban facilities lack the space for this, and disposal in a public landfill may be the only option. Precautions must be taken to protect handlers and waste-pickers from infection. Sharps should be encapsulated to prevent accidental sticks and reuse.

14. A schedule for review of the adherence to and effectiveness of the plan must be established for regular follow-up to ensure planned practices are in place, being carried out correctly, and are minimizing risk, damage, and disease. Maintenance of good waste management practices is a process of continuous improvement.

First Steps

A healthcare facility does not need to do everything at once. Implementing just a few key practices can dramatically reduce risk and improve the health and safety of facility personnel, patients, and the surrounding community. If a facility does nothing else, it should, at a minimum, take the following four steps:

1. Burn or incinerate medical waste on site (rural facilities). Ideally, burning should be conducted in a single-chamber incinerator. Second in desirability is burning in a drum or brick incinerator. If no other option is available, burning may be conducted in open pits (see table 5.3).

   Autoclave infectious waste and encapsulate sharps (urban and peri-urban facilities). Then bury on site or dispose of in a sanitary landfill.

2. Segregate the waste. Begin with sharps. If possible, separate hazardous and general waste.

3. Motivate managers and other staff to follow new practices.

4. Give workers minimal training in how to handle hazardous waste, including:

   Personal hygiene--ensure that soap and water are readily available.

   Sharps handling--especially how to avoid being pricked with needles that could transmit blood-borne diseases.

   Protective clothing--provide thick gloves and aprons for staff handling healthcare waste.

These four steps are the best way for facilities with limited resources to begin working toward a complete minimal medical waste management program.

Questions to Help Guide the Development of Medical Waste Management

General facility information

1. How many employees will the facility have?
2. How many patients will the facility serve on a daily basis? How many beds will the facility have, and what is the expected occupancy rate?
3. How broad a range of health services will the facility offer? Family planning or HIV testing services only? Mother and infant health support? General primary care? What kinds of resources will these services require: Distribution of pharmaceuticals? Laboratory facilities for testing? Food preparation? Bathing? Laundry?

Handling of waste

1. How much and what types of medical waste (such as sharps) will be generated routinely? What materials are used and stored that could at some point become waste (such as expired pharmaceuticals)?
2. How much of the waste will be hazardous or highly hazardous?
3. How and where will the facility s waste be stored before collection and treatment?
4. How much segregation of waste is feasible? Sharps from other? Sharps and hazardous from general waste? Separate collection of sharps and hazardous and highly hazardous wastes?
5. What will happen to bath water? Water from laundry operations?
6. Where will patient urine and excreta be disposed of?

Treatment and disposal of waste

1. How will waste be treated? If it will be burned, how will the remaining ash and materials be handled and disposed of?
2. If waste is to be transported off site, how will this be done? How will the waste be packaged? What types of vehicles will be used to transport the waste? What precautions will be taken to protect handlers and bystanders?
3. Will any of the waste be taken to a dump or landfill site? If so, how will it be handled at this facility? Will it be buried immediately after arriving at the dump? Will it be burned on site? Is it likely to be left unattended at any time after being unloaded?
4. If there is open access to the dump, will waste-pickers, children, or others be at risk?
5. Is there potential danger of well or groundwater contamination from wastewater, or patient excreta or urine? How can these potential effects be mitigated?

Management issues

1. Who will be responsible for waste management at the healthcare facility?
2. What are the current operational standards for medical waste, and what are the applicable national, regional, and local policies?

Environmental Mitigation and Monitoring Issues

Designers and managers of healthcare facilities should take an incremental approach to improving waste management. The first priority involves actions and procedures that will be most effective at reducing risk at the lowest cost. The ultimate goal is to develop a complete program The following two subsections outline the minimum elements of a complete medical waste management program for a small-scale facility. They indicate which elements will result in the most significant improvements at least cost (and should therefore be introduced first) and what questions to ask when developing a medical waste management program for a small-scale facility.

Table 5.3 Treatment and Disposal Options for Healthcare Facilities

Treatment/ disposal method	Description	Effective for	Advantages	Disadvantages
Single-chamber incineration	A permanent simple furnace of solid construction, such as concrete. Waste is placed on a fixed grate. Burning is maintained by the natural flow of air. Operating temperature reaches 300°C. May need to add kerosene or similar fuel to maintain combustion. Incinerator ash is disposed of as solid waste, preferably by burying on site using safe techniques.	• Infectious waste • Sharps waste • Pathological waste	• Disinfects effectively • Reduces waste volume by ~80%; burning efficiency of 90 95% • Low investment and operating costs	• Polluting emissions such as fly ash, acid gases, and some toxins • May produce odors (can be limited by not burning PVC plastics) • Sharps in ashes pose physical hazard • Inappropriate for most pharmaceutical or chemical waste
Drum or brick incinerator	A simple furnace with less mass and insulating value than a single chamber incinerator. Constructed out of an empty oil drum or a short chimney of bricks placed over a metal grate and covered with a fine screen. Operating temperature reaches 200°C. May need to add kerosene or similar fuel to maintain combustion. Incinerator ash is disposed of as solid waste, preferably by burying on site using safe techniques.	• Infectious waste • Sharps waste • Pathological waste	• Disinfects reasonably well, destroying 99% of microorganisms· Burning efficiency of 80 90%	• Emissions of black smoke, fly ash, acid gases, and some toxins. • May produce odors (can be limited by not burning PVC) • Sharps in ashes pose physical hazard • Inappropriate for most pharmaceutical or chemical waste

Treatment/ disposal method	Description	Effective for	Advantages	Disadvantages
Open-air burning	Burning of wastes in or next to pit where they will be buried. May need to add kerosene or similar fuel to maintain combustion. Not recommended as a permanent solution, but better than burying untreated on site.	• Infectious waste • Sharps waste	• Similar to drum or brick incinerator	• Burning may be incomplete and residues still infectious, and more hazardous to staff • Greater risk of scavenging by waste-pickers or transfer of pathogens by vectors including insects or animals • Even if disinfected, sharps in ash pose physical hazard • Ineffective for pathological waste and inappropriate for most pharmaceutical or chemical waste
Autoclaving	Steam treating waste at high temperature and pressure to sterilize. Usually used for sterilizing reusable equipment. Steam must be able to penetrate the waste. Autoclaved waste is disposed of as solid waste, preferably burying on site using safe techniques.	• Highly infectious wastes	• Efficient at disinfecting • No significant environmental adverse impacts • Relatively low investment and operating costs	• Requires qualified operators • Cannot be used on pathological, pharmaceutical, and chemical waste • Autoclaves designed to sterilize equipment have a limited capacity
Encapsulation	Containers are filled three-quarters full with hazardous waste. Material such as cement mortar, clay, bituminous sand, or plastic foam is used to fill the container. When capping material is dry the container is buried or placed in a landfill.	• Sharps waste • Small amounts of chemical and pharm. waste	• Simple and safe • Low cost	• Ineffective for non-sharps infectious waste
Safe burying	Burial of waste in a pit on site. Access to site should be limited and the pit lined with clay, if available. To extend useful life pit should be used only for hazardous waste and less than 1 kg buried at a time. Each layer is covered with a layer of earth.	• Infectious waste • Sharps waste • Small amounts of chemical and pharm. waste	• Provides some human health and environ-mental pro-tection by making waste inaccessible • Organic materials will eventually biodegrade	• Soil can become polluted if permeable • Difficult to prevent scavenging

Treatment/ disposal method	Description	Effective for	Advantages	Disadvantages
The methods below are more likely available for larger urban facilities.				
Wet thermal treatment	Similar to autoclaving. Waste is shredded and exposed to high-pressure, high-temperature steam. Waste is disposed of in a sanitary landfill (see below).	• Infectious wastes	• Efficient disinfection • No significant environmental impacts • High capacity • Low investment, operating costs	• Shredder liable to mechanical failure • May require off-site transport • Cannot be used on pathological, pharmaceutical, and chemical waste • Requires qualified operators
Microwave irradiation	Waste is shredded, humidified, and irradiated with microwaves. Heat destroys microorganisms. Thermal treated waste is disposed of in a sanitary landfill (see below).	• Infectious wastes	• Efficient disinfection • Environmentally sound • Shredding reduces waste volume	• Relatively high capital an operating costs • Shedder liable to mechanical failure • May require off site transport • Cannot be used on pathological, pharmaceutical, and chemical waste • Requires qualified operators
Sanitary landfill	Waste is packaged to minimize exposure and placed in a shallow hollow dug below the working face. Waste is then immediately covered with 2 m of mature waste. Alternatively, packaged waste is placed in a 2 m deep pit in mature waste and covered immediately. Waste-picking must be prevented.	• Infectious waste • Sharps waste • Small amounts of chemical and pharm. waste	• Low-cost option • Organic materials may eventually biodegrade	• Requires access to sanitary landfill • Transportation to site creates opportunities for exposure • Improper leachate handling can cause water pollution and public health risks • May be difficult to prevent scavenging

Source: Adapted from Prüss et al. 1999.

Table 5.4 Best Management Options for Healthcare Facilities

Type of Waste	Management Options	Comments
Solid infectious waste	• Autoclave, incinerate/burn, or bury.	Autoclaving is ineffective for pathological waste such as body parts.
Excreta from patients with cholera or other forms of diarrhea	• Isolate patients if possible and capture excreta in a bucket. • Disinfect excreta by adding chlorine oxide powder, dehydrated lime oxide (CaO), bleach (sodium hypochlorite), or another disinfectant. • In case of epidemic, disinfect all hospital sewage. • Pour treated stools into sewage system, or pit where they will be filtered by the soil but will not contaminate drinking water.	
Blood and other infectious bodily fluids	• Disinfect by adding chlorine oxide powder, dehydrated lime oxide (CaO), bleach (sodium hypochlorite), or another disinfectant. • Pour treated fluids into a pit where they will be filtered by the soil but will not contaminate drinking water.	
Sharps	• Separate from other waste • Immediately after use put in plastic, metal, or cardboard container that will keep liquid from leaking. Cardboard containers should be lined with plastic bags • If possible, containers should be yellow and marked Infectious waste, Dangerous, or something similar in all relevant languages • Burn or encapsulate sharps when containers are 75% full • If container is to be reused, sterilize first with bleach or other disinfectant	
Pharmaceutical waste small quantities	• In general, bury • If collected together with infectious waste, small quantities of pharmaceutical waste can be treated as infectious waste follow the same procedures of incineration and safe burial. Note: crush ampules and bury; they can explode if burned • If collected separately, encapsulate semi-solids	For more information see: *Guidelines for Safe Disposal of Unwanted Pharmaceuticals in and after Emergencies,* World Health Organization 1999, Chapter 4.

Type of Waste	Management Options	Comments
Pharmaceutical waste large quantities	◆ Return to supplier ◆ Subcontract for incineration in a double chamber incinerator that operates at more than 900°C, if available ◆ Mild, water-soluble pharmaceuticals, such as vitamin solutions, cough syrups, intravenous solutions, and eye drops, may be diluted with large amounts of water and discharged to fast flowing watercourses ◆ Other options are available for some subcategories ◆ If no other option is available, waste can be encapsulated	Acceptable options are neither cheap nor easy and are not likely to be readily available to small-scale facilities leaving no safe way to dispose of these materials. It is therefore critical to minimize the amount of pharmaceutical waste generated.
Chemical waste small quantities	◆ In general, bury ◆ If collected with infectious waste, small quantities of chemical waste can be treated as infectious waste follow the same procedures of incineration and safe burial	
Chemical waste large quantities	◆ Return to supplier ◆ Subcontract for incineration in a double-chamber incinerator that operates at more than 900°C, if available ◆ Export to a location with adequate facilities for safe disposal ◆ Other options are available for some subcategories	Acceptable options are neither cheap nor easy and are not likely to be readily available to small-scale facilities leaving no safe way to dispose of these materials. It is therefore critical to minimize the amount of chemical waste generated.
PVC plastic and other halogenated materials	◆ Bury	DO NOT BURN. Burning will create highly toxic pollutants that will spread over a wide area.
Materials containing heavy metals	◆ Capture mercury from broken thermometers and reuse or recycle via local cottage industry, if available. Batteries may also be locally recyclable via cottage industry	DO NOT BURN. Burning will create highly toxic pollutants that will spread over a wide area.
Pressurized containers	◆ Return undamaged containers to supplier ◆ Empty damaged containers completely and recycle via local cottage industries ◆ Small cans can be buried with ash, residues, and other waste on site	DO NOT BURN. There is a high risk of explosion.
Wash water and sewage	◆ Treat using best available system (see Chapter 2: Section B Water Supply and Sanitation in this manual) ◆ If sewage will not be treated, disinfect wash water by adding chlorine oxide powder, dehydrated lime oxide (CaO), bleach (sodium hypochlorite), or another disinfectant ◆ Pour treated liquid in a pit where it will be filtered by the soil but will not contaminate drinking water	
Incinerator ash and burning residues	◆ Bury in pit on site	

References

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A study reviewing and documenting key issues in the management and disposal of healthcare wastes in relation to the urban poor. This is done through a review of the current literature and secondly by undertaking two short field studies in Pakistan and Bangladesh to identify good practice. A select bibliography, which includes contact details, is provided. Online: http://www.lboro.ac.uk/orgs/well/resources/well-studies/full-reports-htm/task0326-full%20report.htm. (Digital copy included.)

Johannessen, Lars M., et al. 2000. *Healthcare Waste Management Guidance Note.* Waste Management HNP Anchor Team, World Bank.

A working document that attempts to synthesize available knowledge and information in healthcare waste management, the Guidance Note complements WHO s guidelines and provides information necessary for World Bank projects. It addresses management and policy issues and gives technical background on issues in greater detail than the WHO guidelines. Online: http://wbln0018.worldbank.org/hdnet/hddocs.nsf/c0d65c5ea6fcb4688525670c004d14c2/0d87e869807f2f69852568d20054e66b. (Digital copy included.)

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This comprehensive handbook recommends safe, efficient and sustainable methods for the handling, treatment, and disposal of healthcare waste. It addresses technical options, as well as organizational and policy issues. The handbook is targeted at public health professionals, regulators, and hospital managers and administrators. French and Spanish versions are in preparation. Online: http://www.who.int/water_sanitation_health/Environmental_sanit/MHCWHanbook.htm. (Digital copy included.)

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A quick but thorough introduction to healthcare waste hazards and practices to minimize those hazards. Designed to be used in conjunction with Prüss et al. 1999. Emphasizes an incremental approach to healthcare waste management at small-scale facilities. Designed to address the practices most predominant in Africa. (Note: Does not yet exist online.)

WHO (World Health Organization). 1999. *Guidelines for Safe Disposal of Unwanted Pharmaceuticals in and after Emergencies.* WHO: Geneva.

This manual offers practical guidance on the disposal of drugs in difficult situations in or after emergencies, armed conflicts, and natural disasters. In such situations, unwanted drugs may accumulate due to mismanagement of stocks and inappropriate donations. The guidance consists of simple and low-cost measures and is addressed to local authorities, healthcare personnel, or other professionals confronted with these kinds of problems. Online: http://whqlibdoc.who.int/hq/1999/WHO_EDM_PAR_99.2.pdf. (Digital copy included.)