Waste Generation and Composition

Information on waste quantity and composition is important in evaluating alternatives in terms of equipment, systems, plans and management programmes. For example, if wastes generated at a commercial facility consist of only paper products, the appropriate equipment are shredders and balers. Similarly, on the basis of quantity generated, we can plan appropriate means for separation, collection and recycling programmes. That is to say, the success of SWM depends on the appropriate assessment of quantity of wastes generated.

Brief Description of the Sector

Thousands of tons of solid waste are generated daily in Africa. Most of it ends up in open dumps and wetlands, contaminating surface and ground water and posing major health hazards. Generation rates, available only for select cities and regions, are approximately 0.5 kilograms per person per day—in some cases reaching as high as 0.8 kilograms per person per day. While this may seem modest compared to the1–2 kg per person per day generated in developed countries, most waste in Africa is not collected by municipal collection systems because of poor management, fiscal irresponsibility or malfeasance, equipment failure, or inadequate waste management budgets.

Though high- and low-value recyclables are typically recovered and reused, these make up only a small proportion of the total waste stream. The great majority of the waste (~70 percent) is organic. In theory, this waste could be converted to compost or used to generate biogas, but in situations where rudimentary solid waste management systems barely function, it is difficult to promote innovation, even when it is potentially cost-effective to do so. In addition, hazardous and infectious materials are discarded along with general waste throughout the continent. This is an especially dangerous condition that complicates the waste management problem.

Throughout most of sub-Saharan Africa solid waste generation exceeds collection capacity. This is in part due to rapid urban population growth: while only 35 percent of the sub-Saharan population lives in urban areas, the urban population grew by 150 percent between 1970 and 1990. But the problem of growing demand is compounded by broken-down collection trucks and poor program management and design. In West African cities, as many as 70 percent of trucks are always out of service at any one time, and in 1999 the City of Harare failed to collect refuse

from nearly all of its residents because only 7 of its 90 trucks were operational.

For health reasons, waste in tropical regions should actually be collected daily. This makes the challenges and costs of solid waste management in much of Africa even more daunting. It is generally the city center and the wealthier neighborhoods that receive service when it is available. In poorer areas, uncollected wastes accumulate at roadsides, are burned by residents, or are disposed of in illegal dumps which blight neighborhoods and harm public health. Where present, manual street sweeping by municipal employees or shopkeepers may help reduce these effects in the most public areas. Nonetheless, roadside accumulation in many cities has reached levels resembling those that spawned epidemics in European cities 500 years ago. Unless more effective urban waste management programs and public water supply systems are put in place, outbreaks of cholera, typhoid and plague may become increasingly common.

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. The larger dumps are located on the edges of cities, towns, and villages, sometimes in ecologically sensitive areas, or areas where groundwater supplies are threatened. They serve as breeding grounds for rats, flies, birds and other organisms that serve as disease vectors. Smoke from burning refuse may be damaging to the health of nearby residents and the smell degrades their quality of life.

While the recovery and reuse of materials is generally for personal use, there are also many professional waste pickers. They are seriously threatened by disease organisms, sharp objects and other hazards in the waste, especially since they generally lack protective equipment. The high level of reuse of non-organic waste reflects the extent of poverty in the region.

Separation and treatment of organic waste is very rare. Municipal composting programs exist in some South African cities, but the few large-scale composting facilities built elsewhere are no longer operating. Anaerobic digestion to produce methane is not widely applied, and then usually uses manure, not organic waste.

While solid waste collection is generally a municipal function, some countries and municipalities are now experimenting with limited privatization of these services, with some success. Because of the poor levels of collection, many residents—from impoverished to wealthy—pay for private collection of their wastes where these services are legalized.

Municipal waste incinerators are too expensive for most communities and are not used. In any case, they are generally not practical, since most paper that can be reused from the waste stream is removed, leaving behind an organic waste that is too wet to burn. Some hospitals and municipalities have incinerators for medical waste, but these are often not operated correctly. The HIV/AIDs epidemic has raised concerns about reuse of syringes, and efforts are being made to construct low-cost,

high-temperature two-chamber incinerators to destroy syringes along with other medical wastes.

Potential Environmental Impacts from Solid Waste Management Activities

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

An open refuse dump in downtown Segou, Mali. During the rainy season part of the dump is submerged in water, threatening the health and water supply of the surrounding area.

- **Increase disease transmission or otherwise threaten public health.** Rotting organic materials pose great public health risks, including, as mentioned above, serving as breeding grounds for disease vectors. Waste handlers and waste pickers are especially vulnerable and may also become vectors, contracting and transmitting diseases when human or animal excreta or medical wastes are in the waste stream. (See the discussion on medical wastes below and the separate section on "Healthcare Waste: Generation, Handling, Treatment, and Disposal" in this volume.) Risks of poisoning, cancer, birth defects, and other ailments are also high.
- **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; it is composed of rotted organic waste, liquid wastes, infiltrated rainwater and extracts of soluble material.) If the landfill is unlined, this runoff can contaminate ground or surface water, depending on the drainage system and the composition of the underlying soils.

Many toxic materials, once placed in the general solid waste stream, can be treated or removed only with expensive advanced technologies. Currently, these are generally not feasible in Africa. 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 gas with 21 times the effect of carbon dioxide in trapping heat in the atmosphere.

  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 aquatic habitats and harm native plants and animals. The high nutrient content in organic wastes can deplete dissolved oxygen in water bodies, denying oxygen to fish and other aquatic life form. Solids can cause sedimentation and change stream 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.

- **Injure people and property**. In locations where shantytowns or slums exist near open dumps or near badly designed or operated landfills, landslides or fires can destroy homes and injure or kill residents. The accumulation of waste along streets may present physical hazards, clog drains and cause localized flooding.

- **Discourages tourism and other business**. The unpleasant odor and unattractive appearance of piles of uncollected solid waste along streets and in fields, forests and other natural areas, can discourage tourism and the establishment and/or maintenance of businesses.

Sector Design—Some Specific Guidance

Experience and study of solid waste collection programs in various parts of the developing world have identified a set of program elements and common pitfalls as well as a number of operations strategies to meet operational requirements and avoid commonn problems. Successful program:

- Apply an integrated holistic approach that takes into account key factors affecting waste generation, storage, and final disposition;
- Securing or establish stable financing and ensure funds are used appropriately;
- Carefully design, develop and implement privatization schemes after weighing the potential costs and benefits;
- Involve the community in waste-management decision making; and
- Build capacity of administrative and technical staff in government, NGOs and/or the private sector.

An illegal dump site south of Sumbe, Angola. A well-designed waste management plan can minimize illegal dumping and mitigate severe environmental damage.

Integrated waste management

The adverse impacts of waste management are best addressed by establishing integrated programs where all types of waste and all facets of the waste management process are considered together. Despite their importance, limited resources may prevent these programs from being 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.

Whether pursuing a 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 the following key questions will help achieve 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 be 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 *Conceptual Framework for Municipal Solid Waste Management in Low-Income Countries* listed under references in this document.

Financing

Sources of Funding

Possible sources of funding for construction and operations are:

- Communal or municipal funds.
- Taxes. Problem: Incorporation within local tax systemsInclusion in local taxes will not work if tax collection is deficient, or if the transfer to management committees is not secured. This form of general taxation method also dissociates waste management costs and revenues.
    - User charges (flat or graded rate). Block rate pricing could be used in solid waste— too: a low rate for a basic amount of garbage (the poor usually produce less waste) and higher rates for subsequent blocks.
    - Mixed systems and water or electricity metering provides opportunities for cross-subsidies. Water metering can be compared to measuring the amount of solid waste produced (in volume or weight). Because electricity consumption is closely correlated with waste generation, fees for waste collection can be tied to electricity use and integrated into the electrical bill. The utility company may charge an administrative fee for handling such billing.
    - Vending arrangements, such as:
        - Shared private connections and sanitary blocks serving clusters of households. In this system, users pay in cash for each use. This system combines well with garbage collection depots.
        - Metered group connections paid for by a user group with its own group committee. This system is comparable to

a community or group paying a private operator to collect solid waste in its area. In this case, the group is sold service from the municipal government at a bulk rate and determines its own systems for distribution and fee collection. The municipality can offer additional benefits—, for example, like exemption from certain local taxes, or a subsidy to buy equipment.

  - Concession system. A system where local private operators of solid waste collection systems (micro-enterprises) obtain a license or concession from the local government. This may or may not involve community management.

- Local revolving funds or credit circles. However, voluntary funds, however, often do not generate enough money for effective solid waste management. Other communal funds that require a communal production base may not be effective in cities.
- Lotteries and auctions.
- Raffles, bazaars, or entertainment (such as movie showings).
- Donations from prominent individuals.
- Launching community-based organizations.

Fee Collection

Willingness to pay, combined with ability to manage, are good measures to assess the feasibility of a community-based project. A service is considered affordable when a community perceives it as valuable. While this strategy will lead to the desired level of service, is not necessarily the simplest or cheapest approach from an operator perspective.

Ways to generate more revenue from fee collection include:

- Change way of payment.
- Change tariff system to reflect:
  - Level of service. Different rates could be used for collection from communal collection points, curbside or house-to-house collection..
  - Type of users (domestic, institutional, commercial, industrial and gender). If men and women have their own sources of income and take part in financing arrangements as individuals, programs should avoid askingthat the same contribution from women as is asked from men and women..
  - Income level.

  - Property value or characteristics.
  - Amount of waste to dispose (measured by size or weight of bin).
- Educate people on benefits and financial obligations. Use community meetings to review billing rate, fee collection plan, and encourage regular payment.
- Give fee collectors more personal benefit.
- Establish/enforce sanctions for non-payment.
- Fee collection by operators or respected community members rather than by government officials. Small user groups or operators can collect fees via house-to-house collection, via community meetings, via deposits on bank accounts, at government offices, or through payment in cash directly at waste disposal location. For women, payment at central places may be culturally less appropriate than home collection of fees. Payment on a savings account is also an effective strategy because women can make small deposits and poor people can join projects that require larger deposits or tariffs.
- Set fees with the assistance of community organizations. (See section on community based management of solid waste.)

Accountability and Reporting

Accountability and reporting are also aspects of financing a solid waste management project. Means of improving accountability are reporting include:

- Provide bookkeeping training, account books, water fee collection cards, etc., and employ teachers or women as treasurers.
- Avoid misuse of funds by requiring two or three committee member signatures of committee members, or one signature from someone with of the assisting NGO, to withdraw money from the bank.
- Sign a contract between the management committee and the community detailing rights and responsibilities, including reporting, for both parties. (See section on community- based management of solid waste.)
- Communicate financial reports through
  - Bulletins distributed to households.
  - Oral reports given by the treasurer at community meetings followed by questions and answers.

  - Written reports on large sheets of paper and posted on walls in public places, particularly where people come to pay their bills.
  - Waste committee meetings dealing with financial matters and open to the community.

- Provide training in accountability to
  - Treasurers, on how to make simple summaries of costs and expenditures, and how to present these to committee and general user assemblies.
  - Committees, on how to account to the users for their performance.
  - Users, on their rights and how they can arrange for accountability (e.g., through statutory annual meetings and an independent audit committee for checking the books.))

Privatization

Privatization is the gradual process of disassociating state-owned enterprises or state-provided services from government control and subsidies, and replacing them with market-driven entities. In the context of municipal services, privatization generally implies reducing local government activity within a given sector by:

- involving participation from the private sector; or
- reducing government ownership, through divestiture of enterprises to unregulated private ownership, and commercialization of local government agencies.

Private sector participation leaves municipal resources available for urban infrastructure and equipment. Privatization of urban services also can reduce the cost of public services to consumers; relieve the financial and administrative burden on the government; increase productivity and efficiency by promoting competition; stimulate the adoption of innovation and new technology; improve the maintenance of equipment; and create greater responsiveness to cost control measures.

There are five basic modes of privatization:

1. **Concessions:** a contractual arrangement whereby a private operator is selected and awarded a license to provide specified services over a discrete period of time in return for a negotiated fee. The concession agreement sets out the rights and obligations of the service provider, who generally retains ownership of the principle assets. This method is well suited to enterprises which provide services that are economically and socially important and need significant improvement; are large and usually enjoy a monopoly position; are politically and/or practically difficult to sell; and are in need of investment capital, e.g., trucks and bins.

2. **Management contract:** a contract placing a municipal service under private management for a specified period of time, for which the contractor is paid a fee. The fee may be based partly on performance. The private manager has extensive autonomy, as set out in the contract.
3. **Commercialization:** a process in which the city authority forms a wholly owned subsidiary. Shares of the new company are restricted, and consumer representatives, the local government and other stakeholders make up the board of directors. The ownership of assets, regulation of tariffs and quality control remain at all times vested in the municipal authority. This method is suitable for managing water supplies.
4. **Franchise:** a process in which the city authority awards, through competition, a finite-term, zonal monopoly to a private firm for the delivery of service. The private firm pays a license fee to cover the government's costs of monitoring and recovers earned revenue through direct charges to households and the establishments served. The city authority provides control over the tariff charged to the consumer. This method is suitable for solid waste management.
5. **Private enterprise/entrepreneurship:** a mode whereby the city authority freely allows qualified private firms to compete for service delivery. Individual households and establishments make private arrangements with individuals firms who compete for business. Under such arrangements, city councils license, monitor, and (as needed), sanction the private firms. Private firms bill their customers directly.

Criteria for Privatization

In deciding whether to privatize a specific aspect or portion of its service, a government needs to weigh the risks—political manipulation, changing environmental regulations, government tariff regulation, currency devaluation, inflation, and unclear taxation systems—against the economic benefits of private sector efficiency. The following criteria may be helpful in considering private sector involvement in solid waste management services (adapted from Cointreau-Levine, 1994):

- **Ease of defining outputs.** Ensure that defined, measurable outputs of the proposed service are incorporated in written performance specifications to clearly establish public and private sector deliverables. The government must have the resources and capabilities to monitor service levels and enforce penalties for noncompliant behaviors.
- **Efficiency.** Consider reasons for public and private sector inefficiencies, including cost accountability, labor tenure, government wage scales, restrictive labor practices, personnel benefits, inflexible work arrangements, bureaucratic procurement procedures, political limitations, and hiring and

firing procedures. Assess options for reducing or removing these barriers. Give preference to plans offering economies of scale.

- **Capability.** Ensure that adequate government capacity exists for planning, design, construction, operation, maintenance and oversight. Evaluate both the public and private sectors for technical and financial resources, including expertise, skills and access to capital. Private companies must possess required facilities and equipment, or have a business plan that covers them. Governments must have both the capability to monitor performance and the political will to enforce contractual or license agreements.
- **Competition.** Ideally, a privatization plan will allow for competition between a number of private firms or between the government and a few private firms. Consider possible barriers to market entry and exit, as well as economies of scale that might limit competition. Determine if financial incentives or technical assistance would result in better performance from private firms. Ensure the government's ability and commitment to conducting a competitive procurement process.
- **Duplication.** Ensure that the government has the political will to cut personnel and assets when services are privatized. Balance the cost savings from reduced staff with new monitoring and enforcement costs.
- **Risk.** In some developing countries, commercial lenders and private companies do not want to risk their money on long-term or large-scale investments that rely on government payments. Regulatory framework must exist to protect the private sector against risks such as environmental damage, currency adjustments, inflation and political changes. Local governments must be able to generate enough revenue to meet contractual agreements with the private sector and protect against economic instabilities. Plans should include provisions for loss due to corruption (kickbacks, bribes and favors).
- **Accountability.** Ensure that private sector participation will not disproportionally benefit wealthy classes. Market openings should be made available to small- and medium-size enterprises, helping to redistribute income. Government must guarantee a fair minimum wage and safe working conditions. Government should also make provisions for displaced workers, including job training and employment networking.
- **Costs.** The costs for public waste collection services must be well understood. Cost factors should be analyzed separately for the different components of solid waste service—collection, cleansing, disposal and transfer. Government must have detailed accounting information to determine whether private sector participation would be more cost-effective. A strategic planning and feasibility study should be conducted to know whether the

technology offered by the private sector would result in lower costs.

These criteria help to determine the extent to which a society is open or closed to competitive market forces, whether the procurement process is straightforward or opaque, how interrelated and transparent taxation and subsidies are, and the extent to which corruption skews the system. Moving public services to the private sector will be efficient only where competition, performance monitoring and accountability exist.

Wastes Requiring Special Attention

Certain wastes merit special handling and disposal because of their dangers or volume. The best option is to minimize or eliminate the generation of these wastes by encouraging users to apply cleaner production approaches and substitute materials or change processes (see "Environmental Guidelines for Activities with Micro- and Small Enterprises" in this volume). Those that are generated should be collected and disposed of separately from one another and away from the rest of the solid waste stream.

Hazardous waste. Wastes pose a wide range of risks. They may be chronically and acutely toxic, cause cancer, trigger birth defects, explode, corrode many materials, and cut, puncture, crush, burn and infect people and animals. Hazardous wastes endanger many different classes of people, placing waste producers, collectors, landfill workers, waste pickers, and nearby residents at risk. The leachate from a landfill may be dangerous as well; its level of toxicity is directly related to the quantity and toxicity of hazardous materials mixed in with other solid waste.

Management of hazardous wastes needs urgent attention in Africa. The variety and classes of materials and sources—from households to industrial and medical facilities—makes this particularly challenging. Action is constrained by limited financial resources to deal with these problems and ignorance or unwillingness to acknowledge the risks.

Sound management of hazardous materials includes four elements: waste reduction, segregation, safe handling, and disposal. The best solution is to not generate this waste in the first place. When this is not possible, every effort should be made to minimize generation, and generated wastes should be handled cautiously to reduce risks. Producers 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:

- *Providing technical assistance and training* to educate decision-makers, system operators, and the public. These efforts should strengthen stakeholders' capacity to identify cost-effective waste reduction measures, and to help design and to put in place practical hazardous waste management plans. (See the Cleaner Production approach described in the "Small and Micro Enterprises" section of these guidelines.)
- *Establish incentives, disincentives, or regulations* to promote waste reduction where it is not otherwise cost-effective.
- *Establish dedicated hazardous waste recycling and disposal facilities*. Few countries in Africa operate hazardous waste treatment and disposal facilities. Thus, much of the hazardous waste generated

continues to be disposed of in dumps and landfills without any provisions for segregation, containment or treatment.

- *Develop systems 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" (a sequence of required documents) 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.*

Medical waste. Wastes from health posts, clinics, hospitals, and other medical facilities pose serious and urgent problems in the Africa region. (A detailed discussion of impacts and appropriate mitigating measures can be found in the "Healthcare Waste: Generation, Handling, Treatment and Disposal" section of this volume.)

These wastes can contain highly infectious organisms, sharp objects, hazardous pharmaceuticals and chemicals, and even radioactive materials. Since the various forms of healthcare waste require different types of treatment, they should be segregated at the source. General waste should be segregated from hazardous material to reduce volume: sharps should be placed in puncture-proof containers, infectious waste separated for sterilization, and hazardous chemicals and pharmaceuticals segregated into separate bins.

Unfortunately, all of the available disposal options are imperfect. The most immediate threat comes from highly infectious waste. On-site treatment is generally preferred to reduce the risk of disease transmission to waste handlers, wastepickers and others. Suggested mitigation measures include:

- In rural areas, burn infectious waste in a single-chamber incinerator, if possible. This kills >99 percent of the organisms and is the best option for minimal facilities.

- In urban areas, burning is not advisable, as the fly ash, toxic gases and acidic gases pose a much greater health threat in more densely populated urban environments than in rural areas. Thus larger facilities should autoclave infectious waste. While high-temperature incineration is theoretically the best option in urban environments, in practice the equipment is rarely operated properly and disposal is highly polluting.

- In some large cities, off-site wet thermal, microwave or chemical treatment options may be available.

- The least expensive option is land disposal. If waste is to be disposed of in a dump or landfill, it should be packaged to minimize exposure, placed in a hollow dug below the working face of the landfill, and immediately covered with 2 m of mature landfill waste. Alternatively, it may be placed in a 2 m deep pit

and covered in the same manner. Waste-picking must then be prevented.

Tires, oil, and batteries. These three common automotive wastes cause difficulties throughout the continent:

- 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 Africa.
- 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 of different waste materials 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 allowance for return of construction material.* This ensures that unused materials will not be 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.

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