

Community Participation – Solid Waste Management in Low–Income Housing Projects: The Scope for Community Participation

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Community Participation – Solid Waste Management in Low–Income Housing Projects: The Scope for Community Participation

United Nations Centre for Human Settlements (Habitat)
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Guidelines for the instructor

This module has been prepared as a general introduction to community participation in waste management. It provides background information on the facilities and systems used in urban–waste collection and disposal, on storage and transport facilities and on waste–disposal methods. As local conditions of city management and settlement development determine the relevant options, the final choice of community involvement depends on community–specific factors. The instructor should, therefore, collect information on specific local practices. The instructor must collect, beforehand, the answers to the specified questions.

Target group

Project staff (project managers, engineers, community development officers).

Number of participants

10 –20 people

Duration

Five days

Location

Easy access to low–income community, dump site and, if relevant, small industrial area (informal–sector recycling).

Equipment

Chalkboard, slide projector, overhead projector. A set of overhead sheets, based on the drawings in this module, can be obtained from the United Nations Centre for Human Settlements (Habitat).

Films

“Garbage Boy”, a television film on life on a municipal refuse dump (Bangkok, Asian Institute of Technology, Human Settlements Division, Information Project 808).

Preparation

- (a) A local case study analysing conditions in residential areas is essential to put the module's material in local perspective.
- (b) Basic information about the actual performance and cost of municipal service is equally important. This should include data on the social and political aspects of waste collection in low–income and high–income areas, as mentioned in the module.
- (c) Information on attitudes towards waste management in communities is essential for the discussion on community involvement.

Introduction

The urbanization of developing countries and the growth of spontaneous settlements are taking place on such a scale that national and local governments cannot cope with the demand for decent shelter conditions. At the city level, this is most noticeable in the sphere of infrastructure. Services often fail to reach new low-income areas, while existing municipal services rapidly deteriorate.

A municipal service that seems to fail most strikingly is waste collection. This is likely to be seen as a problem of inadequate means of transport, as far as the municipality is concerned. This training module aims at showing that a reorganization of waste-management procedures, including community participation, is more likely to provide durable solutions than purely technical approaches.

Many municipalities see solid-waste management as a problem of equipment: how to obtain and maintain technologically advanced compactor trucks, hydraulic-compressor containers, transportable containers and transport vehicles. In developing countries, with insufficient technical services, spare parts and maintenance budgets, when such technically sophisticated equipment breaks down the entire system fails.

Waste-management systems which include community participation and do not require high technology and inappropriate machinery might prove to be sustainable at the community level, since income-generating waste-management systems can be maintained by low-income communities. This manual will show the possible scope of community participation in solid-waste management.

Considerations of community participation In waste management

Waste disposal

Waste disposal is often seen as simply removing waste from human settlements. Nowadays, waste is also seen as a resource that should benefit the community: resource recovery (reuse or recycling) is a basic element in waste management. This factor plays an important role in the planning of waste-disposal systems. The main benefit that waste management will yield is a clean environment, but other benefits can be:

- The production of fertilizer through composting;
- The recovery of energy through biogas or incineration;
- Recycling of the various materials in waste;
- Land reclamation.

Since the largest cost factors in waste disposal are transport and collection, reduction of the quantities, through early separation and recycling, is a very effective means for achieving savings. Reductions in the volume of waste and decentralized processing are some of the approaches which could be followed and from which an organized community could benefit.

Community participation in waste disposal can be a catalyst in community-development work, because it gives residents a feeling of self-esteem. It can lead to the possibility of income generation through recycling which will also reduce the quantities of material that have to be transported for disposal.

Solid-waste disposal follows several steps:

The **waste-production** cycle is inside the house, market, industry etc. Easy separation can be made at the source where the waste is not yet mixed (bottles, paper, food remains, plastics, metals etc.).

The **primary-collection** cycle is at the community level where wastes of the same sort are collected.

The **secondary-collection cycle** is at city level where dumping at a communal depot or recycling takes place.

Community-managed waste disposal consists of the following elements:

1. Primary waste collection (neighbourhood – wide collection and storage);
2. A waste-management system, administering and financing the primary collection system;

3. Planned co-operation with municipal service agencies, to ensure a reliable transfer of waste from the primary to the secondary collection cycle;
4. The development of recycling activities within the community;
5. The development of income-generation activities, through processing and upgrading of waste material and development of local industries.

Example

A university in Europe held a competition to design the best waste-management system. Most entries were highly complicated machines to separate the waste and sort out the different materials in order to recycle them by type. One entrant, however, presented a system with five different small containers for paper, plastics, glass, metals and organic materials, respectively. Apparently, all other systems were based on mixing everything first, compacting it and, then, trying to separate it again. The system with the five containers proved to be the least expensive but required community organization.

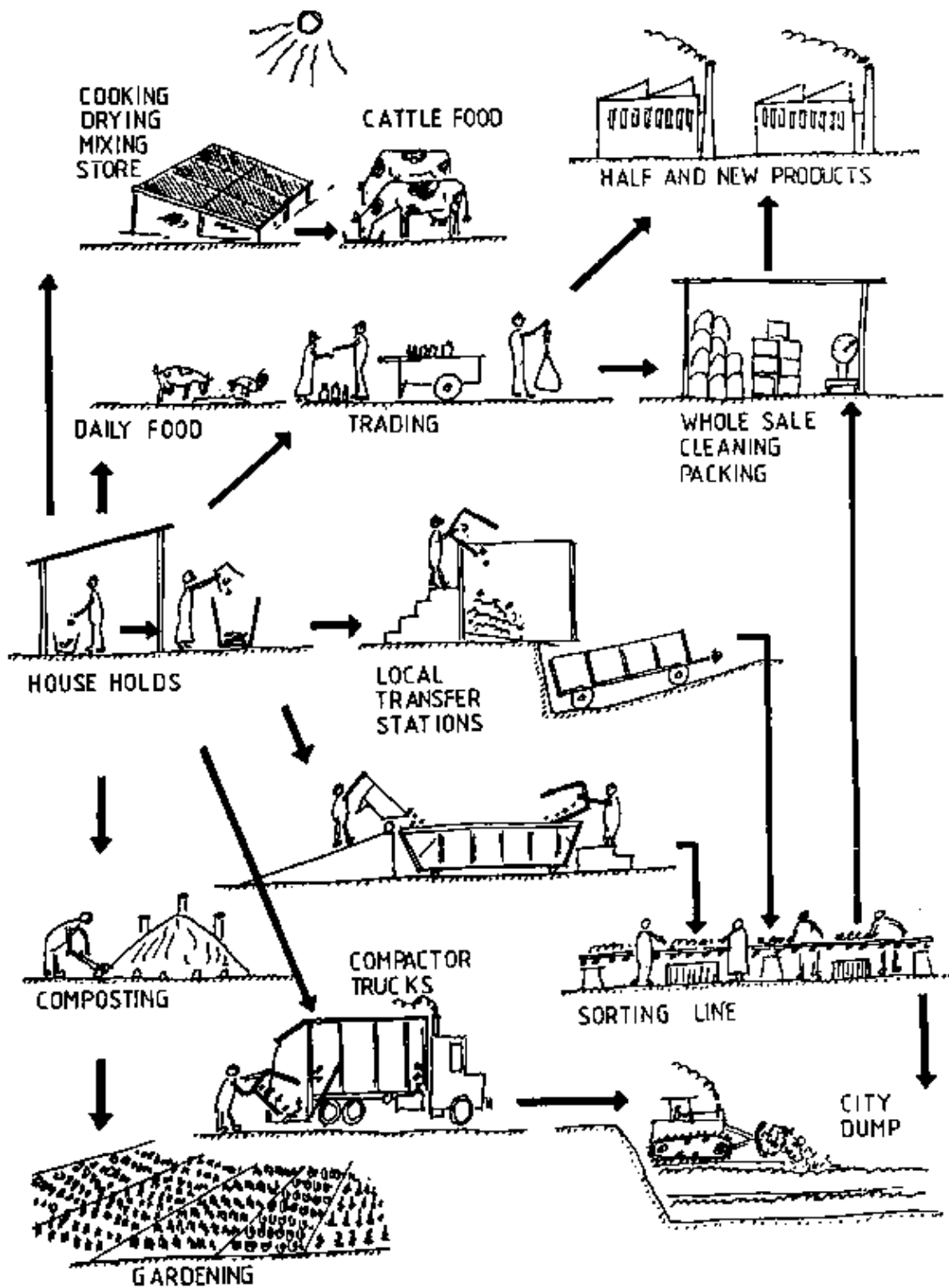
Community participation in the field of waste disposal does not come easily, and much consciousness-raising is required in order to create a feeling of responsibility. It is not uncommon for slum-dwellers to keep their own houses very clean and, yet, throw all waste on the nearest street. In some countries, there is a tradition of caring for areas around and between dwellings, whilst, in others, this is not the case. Such general attitudes affect the willingness to participate locally.

Low-income versus high-income

The amount of waste produced per inhabitant in high-income areas is a multiple of the amount of waste produced by low-income households. Yet, it can be observed that, while it seems possible to keep high-income areas clean, low-income areas remain unclean. There are two factors which contribute to this common situation:

- Registered households in high-income areas pay sewerage taxes, waste-collection taxes and, possibly, land taxes, all sources for financing municipal services. Households in low-income areas are often not registered and do not pay these taxes.
- Senior governmental officials, diplomats and politicians and their acquaintances tend to inform and pressurize the municipality when, in their residential areas, excessive waste accumulation occurs. In low-income areas, communities often do not have the influence.

Community participation is essential in the choice of methods, in co-operation, in storage and in decisions about separation and recovery of resources, as will be explained later.



THE SOLID WASTE CYCLE

Forms of In primary waste-collection, community participation in waste management may be distinguished in two main forms:

1. The efforts of the community to collect and transport waste to a few central places, where the municipal refuse-collection service will remove it for final disposal elsewhere;
2. The efforts of the community to extract certain materials from the waste for commercial or manufacturing purposes (recycling).

The first type requires co-operation from the whole community and special tasks for a few individuals. The choice of collection system influences the transporting of household waste to collection points. Every individual household is involved in this. The second type also requires separate storage of certain items

(glass, paper and kitchen waste), so that these materials can be recycled with the least possible soiling. Here, some people may be paid for their work in sorting, recycling and remanufacturing.

In the secondary waste-collection cycle, large tasks, such as the emptying of communal containers and transporting waste to depots, are often given to paid workers. Management is vital for planning and co-ordinating community efforts. In the absence of efficient municipal services, this means considerable work by the residents which should be rewarded.

Most recycling activities in developing countries are organized outside the community on a commercial basis. In some countries, recycling is highly organized and very profitable; in others, it hardly exists. The establishment of efficient recycling and remanufacturing options in low-income areas provides a firm basis for developing community-based waste-disposal management.

TASKS:

1. How is waste-collection organized at present in your town?
 - (a) Is it a centralized or decentralized system?
 - (b) What type of equipment is used?
 - (c) What are the major shortcomings of the present system?
2. What waste materials are at present recycled in your town?

I. Waste management in human settlements

The waste generated by a community reflects its way of life, its wealth and its culture. Some communities use and discard great quantities of paper, others throw organic materials away. Restaurants dispose of quantities of food that is still fresh but can no longer be sold for human consumption. However, it might be very valuable to the owner of animals. Thus, what is waste to one person might be a valuable resource for others.

If unmanaged, waste becomes a source of contamination and disease. Not only health and environmental hazards necessitate waste disposal but also economic considerations. The latter is more often the stimulus for action.

Poor service

Urban waste management in most developing countries is a very poor service, because municipal provision is dependent on vehicles, fuel and spare parts, while the service often has no source of income but only a flow of expenditures. Lack of access roads into low-income areas and difficulties in organizing an efficient primary-collection system in communities add to these problems.

Collective demand

With informal collectors or organized collection systems by residents, municipal services are often easy to keep up, because of short collection routes. Community participation of this kind can also lead to an efficient municipal response, because of the collective demands that residents can make on the public service if it fails. As easily as high-income dwellers can inform the authorities, low-income representatives can do the same, but with more reason, because of the larger number of people involved who suffer from non-collected waste.

Shared benefits

Co-operation between the community and the public service might require the community to collect waste locally and concentrate it at set times at easy pick-up points. This will reduce collection time for the municipality and help to reduce nuisance for the community. In this way, both efficiency and environmental health are improved.

Key factors

Community participation requires an understanding of the key factors in waste management:

- Collection options;
- Transport choices;
- Storage requirements;
- Recycling;
- Financing.

Local *transport* possibilities will have to be explored, and the routes and equipment worked out.

Storage should be arranged, to reduce nuisance and fly-breeding and to facilitate easy secondary collection.

Organized *recycling* and separation avoid unorganized scavengers interfering in collection and storage.

Financing of the collection, transport, storage and recycling of waste can be done through taxation, cross-subsidy or sale of recycled source materials.

All these factors concern choices that the community has to make and should discuss with the municipality.

Technical issues

There are three basic elements in waste disposal that should be known to the community members who plan participation:

- The speed at which material decays:
- The danger of leachate (see glossary):
- How flies breed in refuse.

Waste material decays, and the great bulk of waste in developing countries consists of organic material. Rot or decay is the decomposition of organic material into simple components, such as gases and minerals. It is during this process that waste produces unpleasant gases and liquids. During this process, it also attracts insects that might become carriers of diseases.

Fly-breeding

The attraction that rotting waste has for flies to breed is one of the key considerations in urban waste management. The smell attracts flies, and the heat generated by decaying waste offers a fine breeding environment. Flies are, together with dirty water, the most effective transmitters of diseases in human settlements. In tropical countries, it takes about a week for flies' eggs to hatch. Hence, collection and storage should not take more time than one week before waste is hauled away to a safe disposal site. However, even during this one-week period, the eggs are developing into maggots which can escape from the containers. Storage of one week should, therefore, be in closed containers. If open storage (e.g., in baskets) is chosen, haulage should be undertaken no less frequently than every two days.

Leachate

Leachate is another problem related to the storage of waste: the fluids that seep out might contain poison and acids. This could be especially the case in industrial and high-income areas. Containers that keep waste longer than a few days should have a proper drainage arrangement that prevents the leachate from entering the ground and, then, groundwater sources.

Cairo

Waste collection in Cairo, a city with an estimated 10 million inhabitants, is entirely in private hands and largely financed by the recovery of materials from waste products. Street-sweeping is a municipal service, but the collection of household refuse and its disposal are undertaken by two private groups – the neighbourhood collection administrators (wahis) and the haulers and recycling workers (zabbaleen).

The transport system is based on donkey carts which take the waste from all neighbourhoods to six zabbaleen settlements around Cairo. Together, the wahis and zabbaleen load the donkey carts. The donkey carts can enter narrow streets where modern trucks cannot enter. During the loading, a primary selection is made. The zabbaleen have found markets for practically all waste materials and discard only 15 per cent of the original waste volume on their dump sites.

Their system is organized around family sorting compounds where the waste is divided into some 15 marketable items. Pigs and goat pens use most of the organic material, and the zabbaleen have become skilled in the composting of non-edible remains. There is a good market in Egypt for compost which is used to improve the desert land for agriculture. The effective sorting of recyclable materials by the zabbaleen has promoted the development of a commercial and industrial network based on the supply of raw materials extracted from waste. One zabbaleen settlement, Manchiet Nasser, has about 8000 people handling a daily waste volume of 1000 tons on a land area of about 30 hectares.

Since the municipality of Cairo only finances the street-sweepers, it has the lowest cost for waste collection per inhabitant in the world.

II. Waste collection

Collection systems

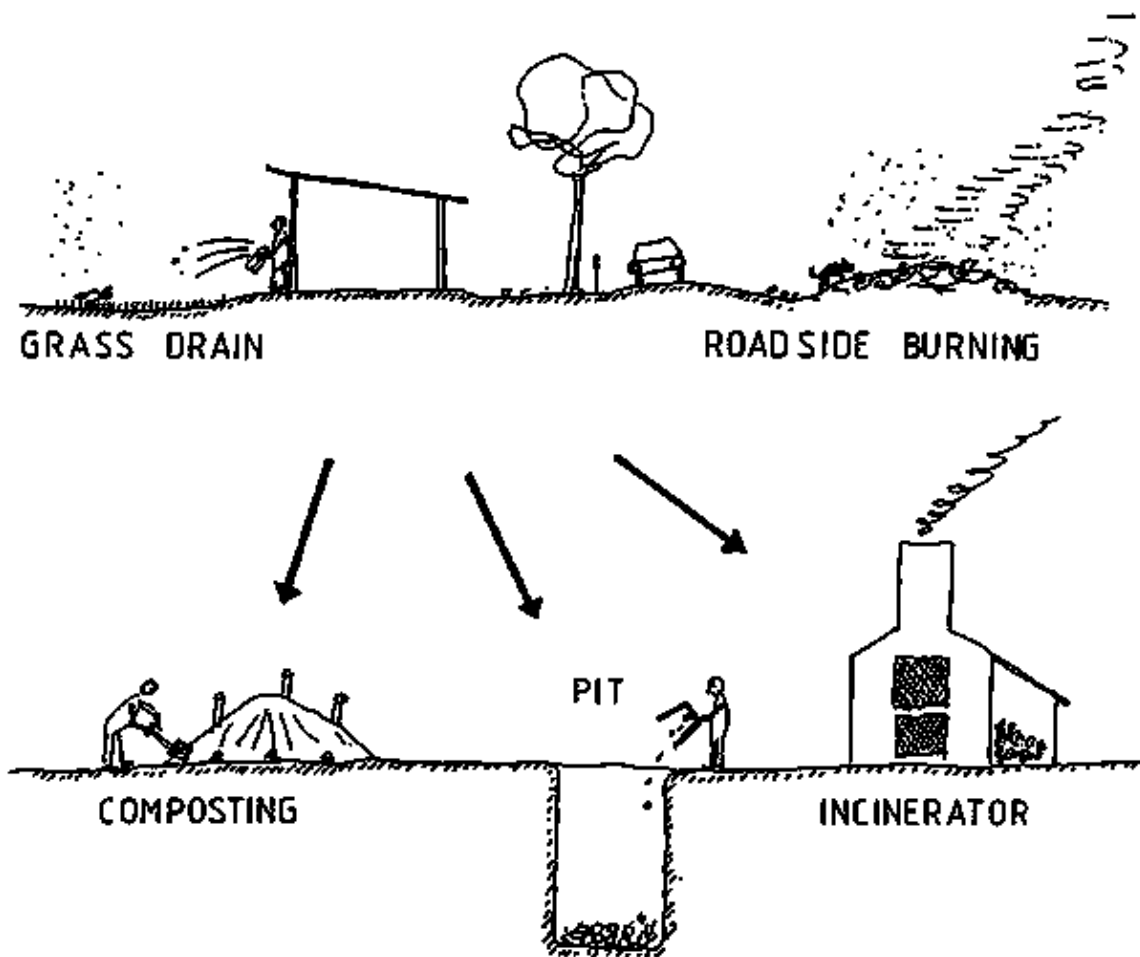
Community waste disposal is mostly concerned with primary collection, and the choice between different collection systems at this level determines the main costs to the community in effort and money. Ultimately, all costs of waste disposal are paid for by residents in one form or another, and this choice is, therefore, of special interest to the community. The choice of systems at the primary-collection level can vary considerably, depending on the amount of labour, the level of community participation and the transport systems used.

The following collection systems are common:

- No collection;
- Door-to-door collection;
- Kerbside collection;
- Block collection;
- Communal depots.

No collection

No collection is a common system used in low-density housing areas. The community throws the waste 20 to 50 metres away from the house and leaves it there. Chickens, goats, ants and pigs eat the digestible parts from the waste the same day. Rotting becomes minimal, and fly or larvae breeding is reduced, owing to the chicken eatings the larvae. In dry countries, the sun dries the remains, and virtually no gases are emitted. The remaining small quantities are occasionally burnt.



Two problems remain with this system:

- Flies still feed on the waste and can transmit disease;
- In wet seasons, humidity turns the waste into a vast breeding ground for insects, and decomposition spreads smells of rotting.

Since, during the dry season, no organized collection is established, it is not likely to be organized during the wet season. No collection is the largest incentive for community action; hence, to reduce cost in certain suburbs, a municipality can deliberately choose the option of no collection.

TASK:

Discuss this option in your town situation and think of the sort of actions the people might take.

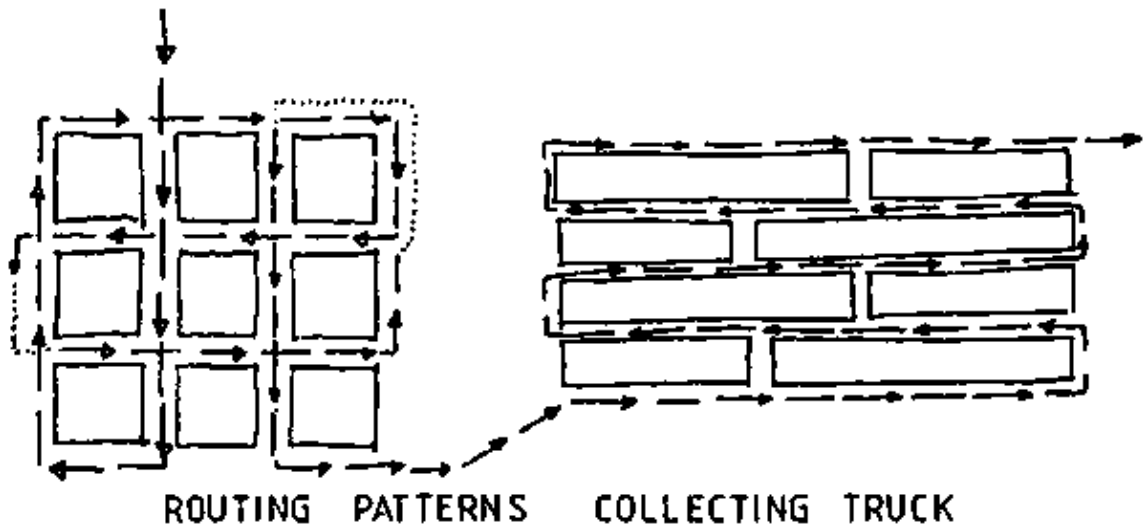
Door-to-door collection

With this method, the collection vehicle stops as close as possible to the entrance of the house, and the individual household container is picked up by a collector and emptied into the truck. The individual household is only required to put a small container outside which is emptied and returned by the collection staff to the house.

One individual in a group of households can be responsible for the door-to-door collection and the emptying of small household containers into a communal block depot. This is an especially feasible solution in very dense areas or in small compounds where vehicles cannot enter.

Kerbside collection

Here, each household places its waste container at the edge of the pavement where the collection vehicle passes at a set time and the collection staff empties it into collection vehicles. Standardized refuse bins are supplied to individual households. These have often been designed to fit the lifting devices of the truck.

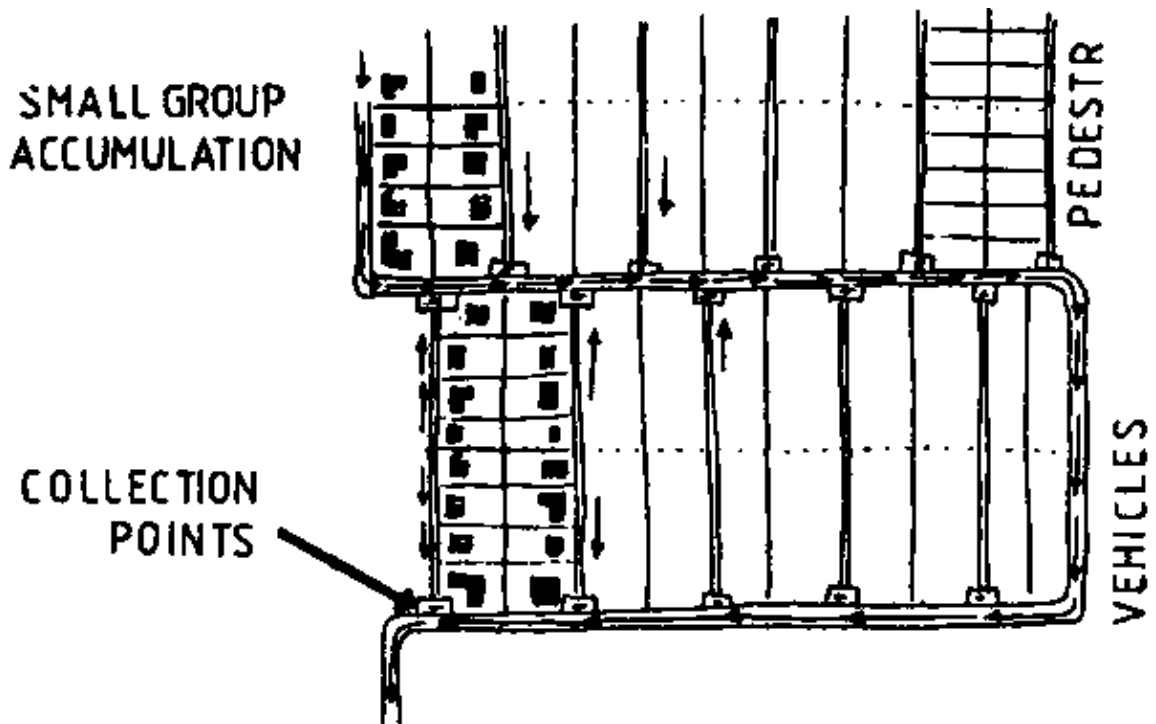


The following questions have to be answered:

- How far does any one family want to walk?
- For how long are the bins to remain at the kerbside?
- Are the bins safe from theft (recognizable)?
- What size should the bins be?
- Do they require wheels?
- How often should they be emptied?

Block collection

Block collection reduces stops for the collection vehicle which comes at a set time, place and date, to collect waste from dwellers who bring their dustbins to empty directly into the vehicle. The system requires co-ordination between the people and the collection service, because the refuse is not left at the roadside to be picked up by the collection staff but requires the dwellers themselves to go to the collection point, empty the dustbin and take the empty container home again.



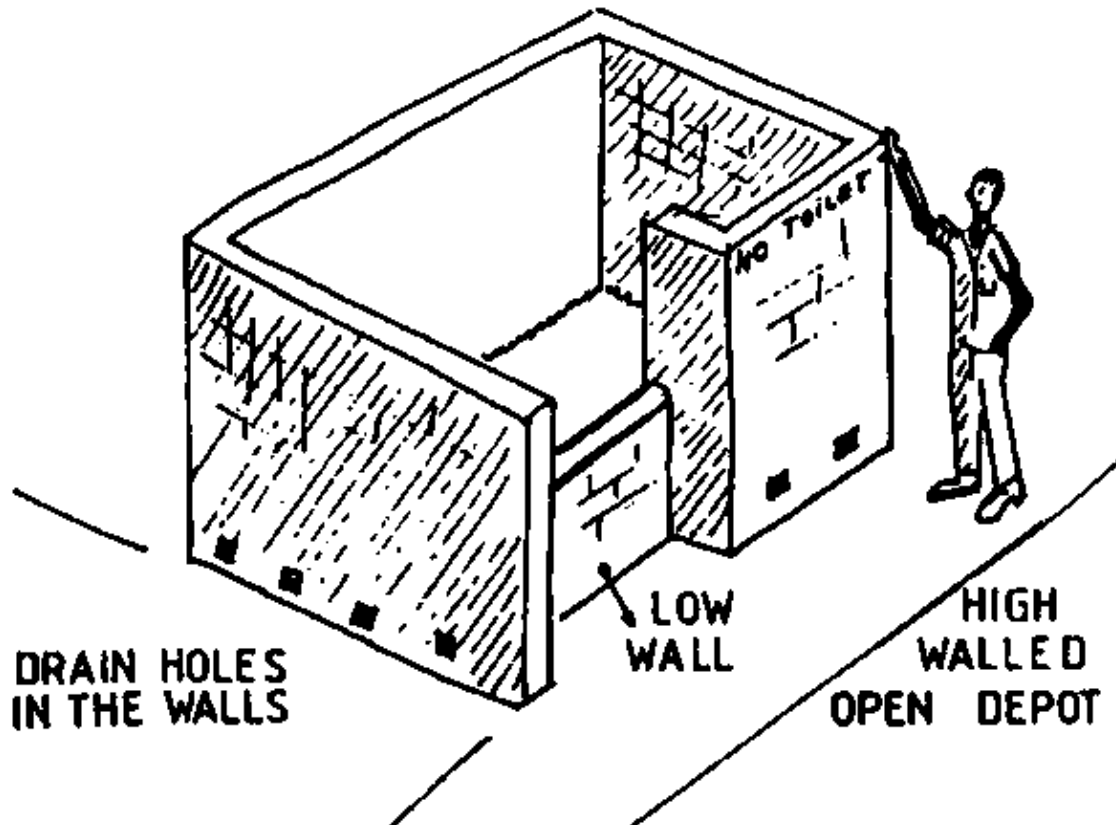
The advantages of this system are that:

- Bins are not lost;
- Different items can be sorted out on the collection truck;

- It reduces collection–staff members.

Communal depot

Communal depots again reduce the number of stops that the waste–collection vehicle has to make. There are a number of options that can be chosen which require different degrees of community participation. The use of depots has the advantage that the collection vehicles can take a full load by calling on a few depots only, while problems of access in narrow alleys can be avoided. Communal depots require local collection, since the willingness of the dwellers to carry their waste themselves to the depot diminishes rapidly as the distance increases. The heavy work of loading the collection vehicle at the depot is another disadvantage.



Four systems which reduce loading problems are in use:

Fixed depots: 1. Walled–in areas;

2. Split–level walled–in areas;

Containers: 3. Large containers (6 cubic metres);

4. Small containers (2 cubic metres).

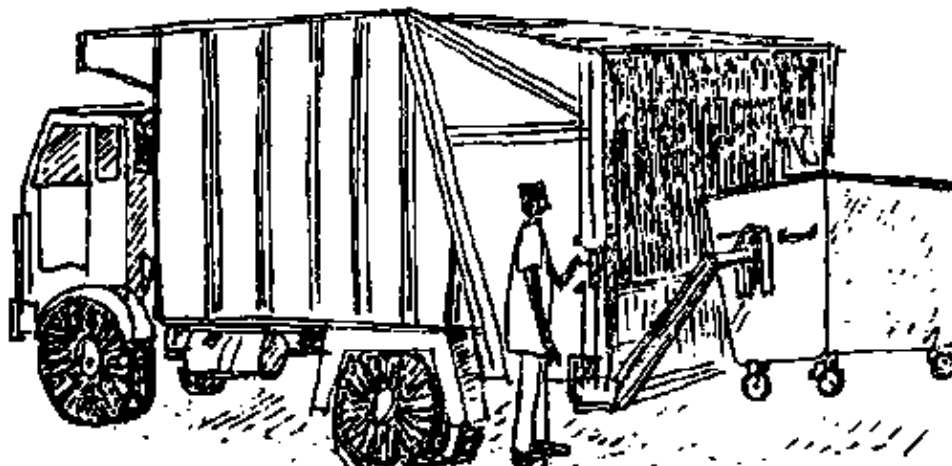
1. Communal depots can, in their simplest form, consist of simple walled areas or enclosures, allowing either the individual dwellers or paid waste collectors to bring the waste there.

2. Split–level depots allow truck loading by pushing the waste into the trucks without having to lift the waste. In recent slum–upgrading programmes, such split–level depots have been used in combination with a local collection system with hand or animal–drawn carts which can collect the waste from inaccessible locations using narrow footpaths.

3. Large (open) containers of about 5–6 cubic metres can be collected by tilt–frame trucks for direct haulage to the disposal site. The truck crew leaves an empty container when it removes the full one.

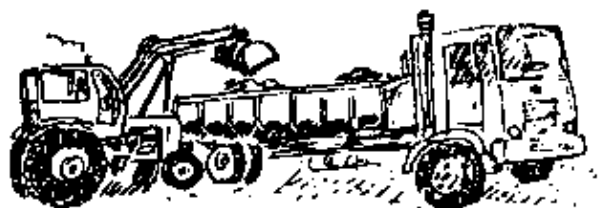
4. Small (closed) containers of about 2 cubic metres, with spring–loaded covers, can be hand–filled by the people, who have to walk from their door to reach the container. The truck collecting the waste from these containers is equipped with special lifting devices to empty the containers directly into it. The containers and the vehicles require a considerable

investment but allow for very swift collection of neighbourhood waste and transport to disposal sites without further transfers. These small containers are appropriate for large buildings in city centres, offices and high-density multistorey housing.

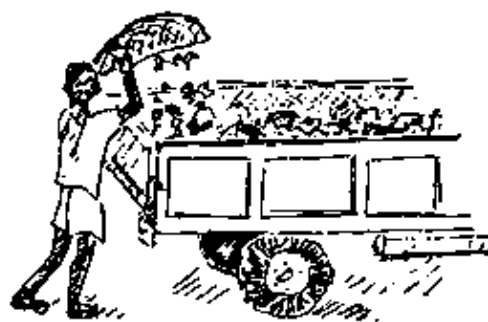


COMPACTION REFUSE COLLECTION TRUCK WITH HYDRAULICALLY LIFTED CONTAINER

Communal depots need constant supervision, to avoid unhygienic conditions developing, but also offer natural sites for the extraction of many recyclable materials by scavengers. Generally, fixed open depots are not recommended as scavengers will litter waste on the site, leading to people emptying their bins on the ground nearby rather than in the depots. All depots, especially open ones, require workers who will clean the whole site every time they empty the communal depot or remove it. In one country, the designers of a street-side depot feared that the depot would be used as a latrine; hence, they built a small wall at the front opening, with the result that the depots could not be properly emptied. Also, after rainwater had collected in the depot, holes at ground level had to be made.



MECHANICAL LOADING



EMPTYING OF LARGE DEPOT
SWEEPING OF AREA

All four collection systems described here require different tasks and responsibilities for the municipality and the communities. Financially, this has some consequences and the system will have to be selected in close consultation with the community. Systems in which the community plays a limited role require more collection work and a longer collection time for the collection vehicle than other systems. If the primary collection has been well organized and the waste is brought to a few depots, the collection vehicle just loads the waste and

hauls it away and will have a far higher haulage ratio (tons per hour) than trucks that need to make many stops for small loads.

The choice of system thus determines:

- The type of haulage vehicle;
- The storage system in the neighbourhood;
- The means of transport of refuse within the neighbourhood;
- The efforts that the community and community collectors must make, to enable the system to work.

Collection vehicles

The collection of waste can require many different kinds of vehicles depending on the quantities involved and the distances waste has to be transported.

Design

There are some general criteria for the design of collection vehicles:

- The vehicle must be able to reach the waste-reception points – at house, kerbside, depots etc.;
- The load should not be blown off by wind, so a vehicle travelling at high speed or in areas with wind should be covered or well-screened;
- Loading heights from the standing position to the container on the vehicles should not be more than 1.5 m for ease of hand-loading;
- Tipping for fast emptying should be possible, unless portable containers are used:
- Transfers between vehicles or between depots and vehicles should not involve dumping the waste on the ground but should involve split-level transfer arrangements.

Primary-collection vehicles

Primary collection can cover areas up to 2,000 households per transfer station or community depot, from where heavy vehicles take it to the ultimate waste-disposal site. In warm climates, the decay of waste is much faster than in cold climates and the frequency of waste collection, therefore, depends on climate: high temperatures require two or three collections per week. Primary collection offers the greatest participation possibilities, and the choice of vehicles at this level is important.

Choices are:

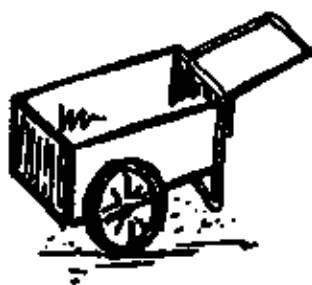
Handcarts. These are suitable for high-density areas with only small amounts of waste per inhabitant, high-density waste and low labour costs. The use of handcarts is linked to small neighbourhoods, as the radius is limited to a distance of about 1 kilometre. It is, therefore, often a community-controlled activity. This direct contact improves the efficiency of the work and the co-operation between the households and the collection service. One collector with a handcart can service about 200 dwellings per day.

A handcart has the great advantage that it can reach otherwise inaccessible parts of the area (narrow roads). It also facilitates separation at the source of different materials for recycling. It can be designed with separate containers for various types of waste, such as glass or paper, and can even be used in special collection rounds for specific types of waste.

The disadvantages are:

- Difficult in hilly areas;
- Difficult in areas with soft soils;
- Limited total weight (200 kg for unpaved roads or 400 kg for flat paved roads).

There are two types of handcart – those which transport bins or drums and others that just carry waste in bulk. The former allow easy transfer into the container or the truck taking the waste to the disposal site but requires much more investment than cage-type or box-type carts. Empty oil drums are not useful, since they cannot be man-lifted once they are full.



DOOR-TO-DOOR COLLECTION (300 upto 500 litres)



TWO BIN HANDCART, ROUND OR SQUARE (120 upto 200 litres)



6-BIN HANDCART, SORTING POSSIBLE (300 upto 500 litres)



DONKEYS (1 – 2 m³)

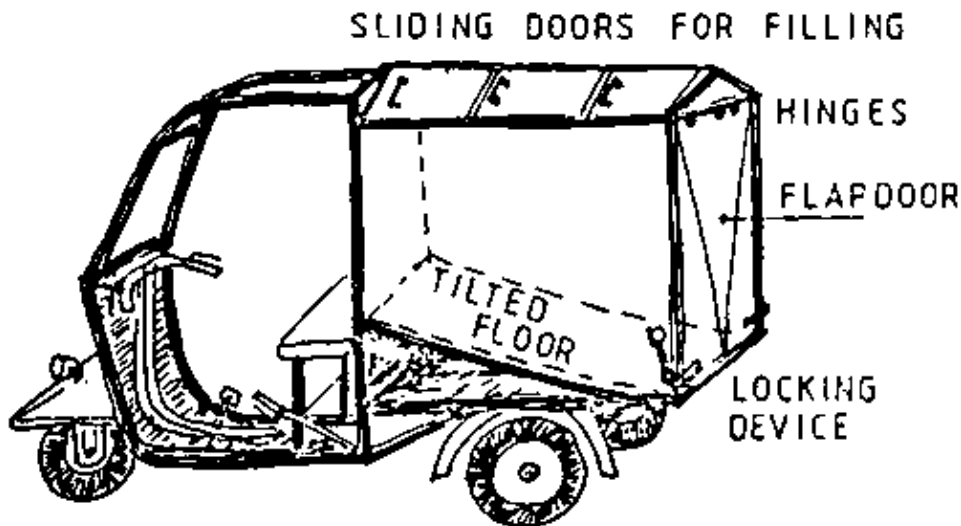
Open handcarts are boxes on wheels, with a capacity of 300–500 litres. These carts pick up waste from individual houses, often by alerting the dwellers with a bell. In some cases, the collectors load the handcarts from kerbside waste-bins or from masonry containers. Loading might take a few minutes per house, and carts, therefore, cover 200– 250 dwellings per day, collecting 400–600 kg of waste. Two trips per day to the communal or central dumping area might be required, one in the morning and one in the afternoon. The cans should allow easy tipping for rapid emptying.

Handcarts with bins reduce transfer labour and time, and allow separation of the household waste at an early stage. The transfer station, however, has to be designed with special handling facilities for the waste transfer to trucks – either split – level arrangements for tipping and emptying the bins or lifting devices for this purpose.

Mombasa

In Mombasa, Kenya, single oil drums (200 l.) on carts are used to collect waste in public places, such as markets. They are carried directly to trucks with a lifting crane. The carts simply lift the drums with a hook through a hole punched near the top of the drum and have a round fork that fits around the base of the drum. The two-wheel cart is very manoeuvrable and easy to push.

Oil drums are also used in two-drum carts. However, because of the weight, these require paved roads. Handcarts for four or six bins usually take 50-litre refuse bins made from strong plastic or galvanized sheeting. This gives a total load of 200–300 litres per cart, which is considerably less than the capacity of open box-type carts.



Pedicarts. In several South-East Asian countries, pedicarts are used for primary waste collection. They can cater to about 200 dwellings a day and are especially useful in low-density areas but require good roads and flat terrain. These vehicles are much more expensive than hand-drawn carts but can cover larger areas. They also reduce the physical stress on the collector.

Animal-drawn carts. Carts drawn by horses, donkeys and bullocks are used in many cities for neighbourhood refuse collection. The accessibility of these vehicles is different from that of handcarts, but animal-drawn carts have a far greater capacity (1–2 cu m) and operating radius than handcarts. Accessibility, in some respects, is lowered because of required increased load width but is, in some respects, increased because of the possibility of using them on slopes. Animal-drawn carts can be used in combination with split-level transfer stations, where the cart simply dumps the waste on to a loading floor for sorting or into trucks parked in the lower loading bay. The use of animal-drawn carts reduces the number of transfer stations or depots in an area, since the operating radius is double that of hand-drawn carts, i.e., 2–3 km.

Cairo

Animal-drawn carts do not have to deliver the refuse to transfer stations but can take it directly to the disposal site. This is the case in Cairo, but the distances travelled between the suburb of collection and the dump site are well over 5 km. Collection is done at night, so as not to interfere with motorized transport. The donkeys are largely fed with collected food remains.

Secondary-collection vehicles

Although secondary collection is usually the responsibility of the municipality, it is intimately linked with the choice of primary-collection system and equipment. Thus, it is essential that early consultations with the municipal waste-disposal service is arranged. The key to the linking is the transfer system that is used. This can be:

- (a) Vehicle – depot – vehicle;
- (b) Bin – depot – vehicle;
- (c) Vehicle – vehicle.



FLAT CONTAINERS WITH TRACTOR HAULAGE

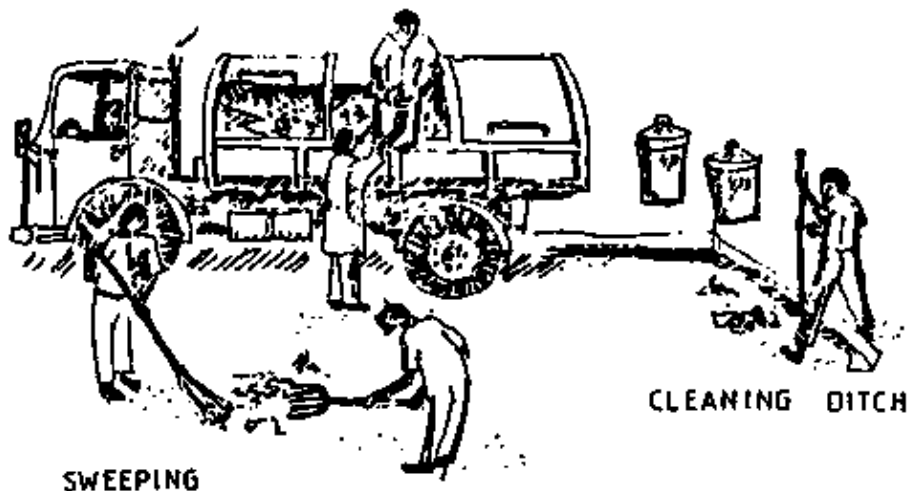
Trailers and containers

Trailers and containers are, at the same time, local depots and haulage equipment. They are stationed as open depots in the area and are filled by the dwellers and collectors, and then hauled away. Trailers are tugged behind a tractor to the dumping site, while containers or skips are lifted by hoist on to a vehicle and carried to the dumping site. An empty trailer or container is brought by the vehicle which collects the full container. The empty container is offloaded, the full container is removed, and the site is cleaned.

Since trailers and containers function as uncovered depots, open to rain, birds and scavenging, the surroundings will be easily littered. The haulage arrangement should, therefore, include the cleaning of the communal depot every time a container is exchanged.

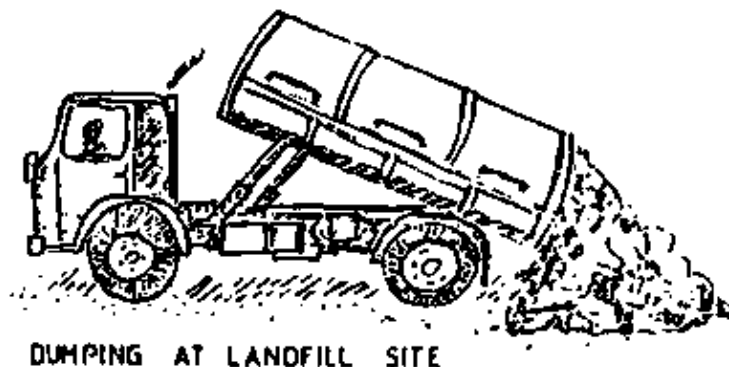
Waste-collection truck

Waste trucks are usually ordinary lorries of 5–7 tons, with some special facilities for loading and unloading and for increasing the total capacity of the vehicle. The truck must be able to drive on a dumping site, and is cheap compared to automatic hydraulic-compactor trucks.



SWEEPING

CLEANING DITCH



DUMPING AT LANDFILL SITE

Hydraulic-compactor trucks are often used in high-income areas where the density of waste is low, owing to empty cartons, glass and plastic containers loose paper. In low-income areas, the need for compaction is small. Because of their high purchase-cost, compactor trucks are not justified for low-income areas or developing countries.

TASK:

Divide the students into four groups. Each group takes one of the four systems and writes down the primary–collection system and the secondary–collection system. A map of the suburb is required for proper planning. The following issues should be indicated:

- The number of metres from each household;
- The routing of the vehicles;
- The frequency of collection;
- The volume of the containers and total waste;
- The number of workhours required by the:

- (a) Household;
- (b) Community;
- (c) Municipality.

- The salary payments required.

TASK:

Take the previous task and fill in the equipment required for the proposed system.

- Estimate the number of vehicles;
- Estimate the cost of purchase;
- Estimate the cost of running;
- Estimate the cost of maintenance.

III. Storage of waste

Waste disposal requires:

- Primary collection;
- Secondary collection;
- Transport;
- Storage;
- Treatment;
- Final disposal.

Removal of waste from the individual household to the municipal dump is not undertaken in one step. In between, there may be many other processes, such as sorting and treatment. One function of storage facilities is to keep the refuse temporarily under hygienic and aesthetically satisfactory conditions until it is collected and transported again. There are two points that require particular attention: the storage facility should prevent the breeding and spreading of flies; and it should control leachate.

Household storage

The average volume of refuse generated by a six–member low–income urban household is between four and eight litres a day, equivalent to 1 to 2 kg in weight. If collection is arranged twice a week, the household container needs to be 20 litres in volume. This container, should have a lid.

Communal depots

The collection of small quantities of household waste is very time–consuming and costly for a truck. Community depots or containers are, therefore, commonly used as intermediate storage and collection points.

All depots tend to become unhygienic, because no communal responsibility exists for cleaning them. Concrete pipes (1 m in diameter) are popular, because they are available and easy to install: emptying, however, is gruelling and uncomfortable work. Full oil drums can just be lifted by two people, but loading on to a truck is often done by first emptying the drum on the street. Drums are easily stolen, and if waste is burned in them, oil drums are rapidly destroyed. Masonry block containers, when not emptied, become burning sites. All depots expose the refuse to rain and are difficult to keep clean. Containers soon become filthy, and the surrounding is similarly affected.

The use of large open steel containers, that are hauled away by tilt-frame trucks or trailers, is another solution. Such containers, which might measure 2.0 x 5.0 metres (10–15 cu m) are common for temporary use on construction and demolition sites. They save labour by reducing loading operations but are quite expensive. The open storage of waste in these containers, moreover, leaves it unprotected against rain, insects and rodents. Open storage has, however the advantage that the total volume of waste is reduced by scavengers who took for materials to be recycled, if this option is preferred.

Through community participation, a house to house collection of reusable materials can be organized by which:

- There is no primary mixture with non-reusable waste materials;
- The recyclable materials are kept clean;
- Households can earn money;
- Scavengers have a clean job;
- Open depots can be reduced;
- Communal cleaning of open depots is reduced;
- The quantity of waste is reduced.

In high-density cities, there are advantages in building fixed or container depots which do not serve households directly but rely on collection by community waste-workers using simple handcarts. Such depots might have a capacity of 10 to 15 cubic metres and serve a population of about 12,000 households. The depots can be containers, simple enclosures or closed structures with inlets through the roof for deposit and side flaps to allow refuse to be raked out.

Open enclosures

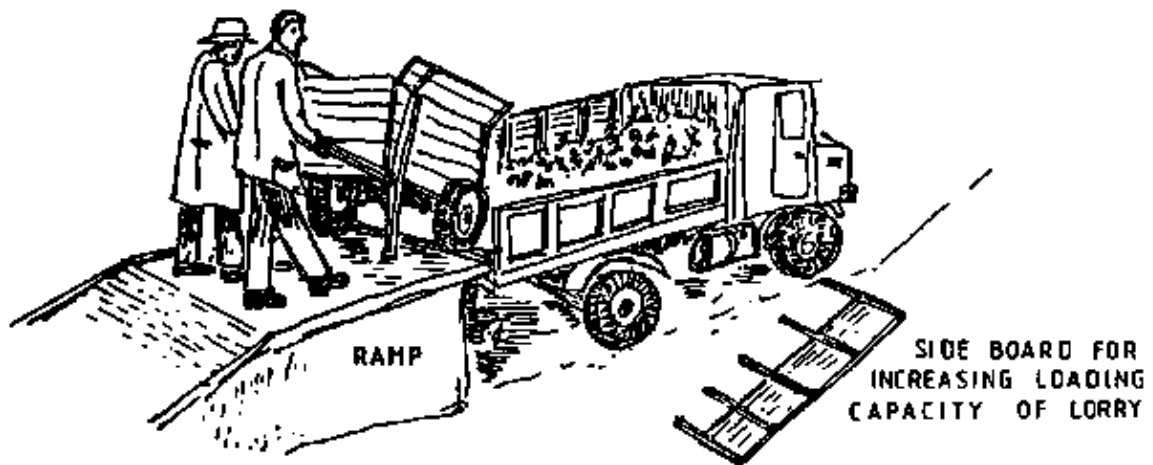
Open enclosures are difficult to keep clean, and rain, flies and rats have free access to them. Loading and unloading are tiring and messy. If such depots are served frequently by collectors, and dealers are motivated to use the depot frequently, open enclosures offer a cheap solution and become the natural first point for resource sorting and recovery. It is recommended that the enclosure be given a light roof against rain.

Closed depots

Closed depots have the advantage of providing environmental control, since the protection from rain and sun reduces the chances of fly-breeding, rapid decay and leachate.

Design

It is a great advantage if the depot can be raised above street level to allow for easy loading by just shovelling the refuse on to the collection truck without lifting it. The easy and fast loading justifies the extra expenditure needed for such split-level provisions. Similarly, operation and maintenance are facilitated if the depot is filled from inlets in the roof so that the incoming refuse can be tipped into the depot from handcarts pulled up to the roof. Paving of the surroundings will improve cleaning possibilities.



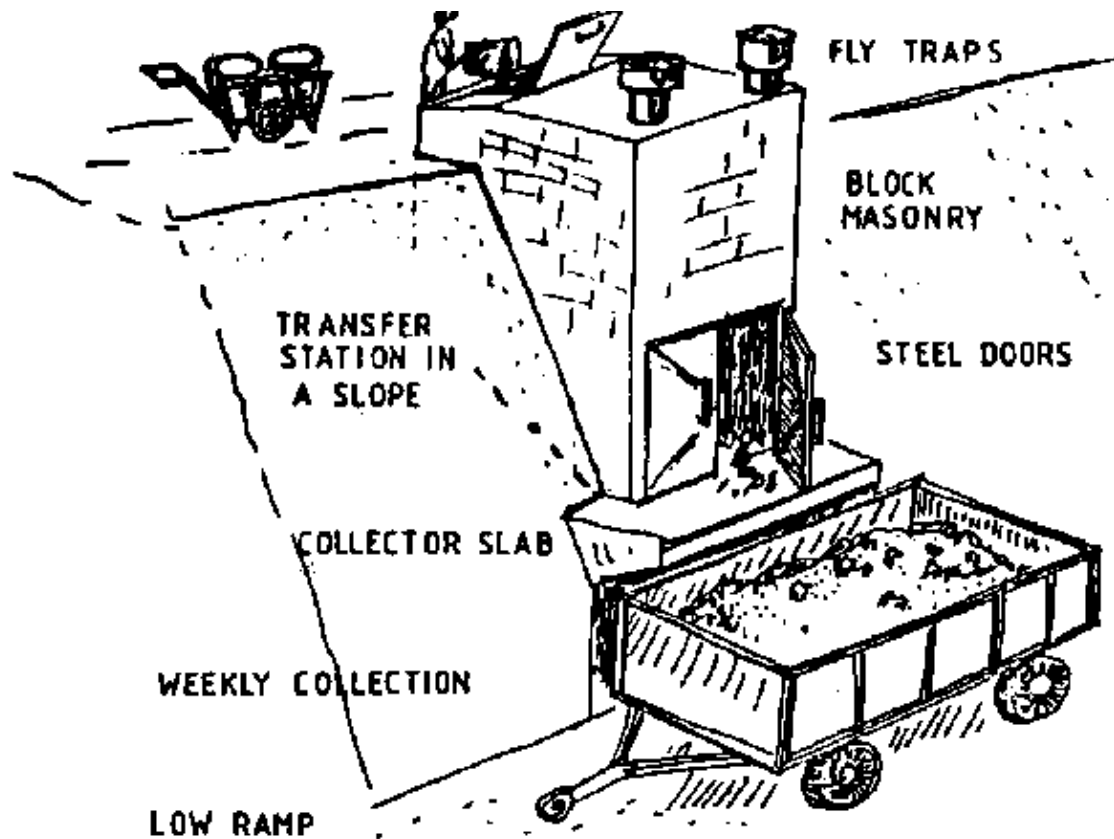
EMPTYING OF CART AT TRANSFER STATION

Transfer stations Transfer stations connect the primary local-collection system to the secondary haulage

system taking large quantities of waste from the neighbourhood to disposal sites. Small containers of 100–200 litres are used for collection and brought to the transfer station, to wait for trucks to remove the refuse. The containers are usually oil drums or large plastic drums which are reusable. They can be stationed throughout an area at fixed points or circulated on small hand-drawn carts pulled by waste collectors who serve all households and deliver the full containers to the transfer station.

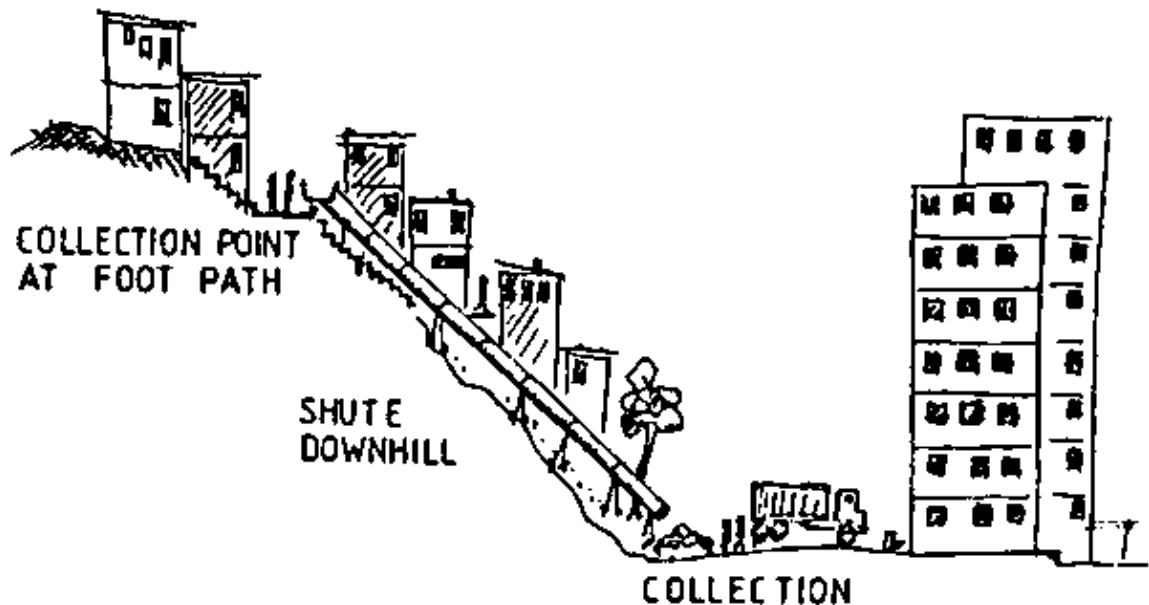
Transfer stations or depots between the primary-collection cycle and the secondary-collection cycle can be used as collection points and storage points for all materials to be recycled. Small stores and weighing facilities can be set up, as well as baling facilities for sorted paper etc. Special metal containers can be placed at the transfer station for clear or coloured glass, as well as a selling and buying point for empty bottles. In many cities these buying and selling points are considered illegal and are, some times, removed by the police.

Furthermore, the transfer stations could serve as maintenance points for the vehicles used in the primary-collection cycle.



The chute

In a hillside suburb in Caracas, municipal lorries cannot drive on the footpath between the houses. A chute, made of oil drums, brings all the waste from the houses beside the footpath to a collection point where the municipal trucks have access



QUESTIONS:

1. What management steps do you recommend, to ensure that proper environmental conditions exist at storage sites?
2. Would cost-recovery be possible for project expenditures in storage facilities? How?

TASK:

Continue with the two previous tasks from chapter II. Design a transfer station and show:

- Floor layout;
- Access and departure layout for vehicles;
- Arrangement for stores and selling/buying points;
- Design of repair/maintenance shop for vehicles.

TASK:

In a community, the municipal waste collection is a mess, and some people have taken up the idea of composting household waste; some individuals do so already, and their places look clean, and their gardens flourish. Negotiations have been carried out with the municipality, and, as a prototype project, it is prepared to finance a house-to-house collector. The Church has a plot available for composting. A scavenger already collects glass bottles and plastic containers.

Make an operational plan of action and write a letter or pamphlet to all the families (2000) in the suburb, to ask for their participation. Think about what might interest the residents – money, cleanliness, status etc.

IV. Waste disposal-methods

There are four methods of disposing of household waste:

- Land application (dumping);
- Composting;
- Incineration;
- Resource recovery (see chapter V).

These options are all practiced by low-income residents. Community participation in waste disposal is, therefore, first a question of organization and motivation and, only secondly, a matter of knowledge. In slum areas where no waste-disposal service exists, individual households often bury waste in small pits in the garden, while others burn their waste regularly on the plot. Composting occurs especially where agricultural

plots are found. Finally, many recoverable materials are collected by scavengers and waste dealers in every city.

The sharp contrast between the tidiness of individual houses and the untidiness of their surroundings is very common in squatter areas and often reflects the lack of co-ordination and co-operation between dwellers. A collective neighbourhood clean-up campaign can have a dramatic effect, because the results are so visible and pleasant. It might persuade residents that collective responsibility for the environment is worthwhile, and this would provide a natural basis for co-operation between the neighbourhood and the authorities, if the municipality can be persuaded to remove collected waste.

Alternatively, the possibilities of resource recovery can be a first incentive to participate in a waste-collection system. Separation of certain materials at source, such as glass, paper and kitchen refuse, requires co-operation from residents and gives a start to the sharing of responsibility.

Land-fill applications

Controlled dumping of municipal waste is a safe and efficient method of waste disposal that, in the long run, renders the waste harmless and allows the land to be used again for other purposes. Controlled dumping prevents harmful environmental effects and is a relatively cheap method of waste disposal. However, it requires a great deal of land located at some distance from settlements, and this might be difficult to find. It also demands great quantities of soil to cover the dumped waste.

The following requirements for landfill should be looked into:

- Site conditions;

Preferably a big existing excavation, quarry site or a shallow waterlogged area which has to be filled. Avoid soils with good natural drainage.

- Soil requirements;

A lot of soil is required to be spread over each layer of 2–3 metres of waste (soil amount is 10 per cent (20–30 cm) of waste amount).

- Hazardous waste;

Leachate of industrial or other poisonous material must be avoided. Production of anaerobic gas might occur after some years in wet material;

- Future use;

The future bearing capacity for construction may be rather low. Natural compacting will continue for years. Filled land cannot be used for agriculture but sometimes for forestry of parks.

Despite the simplicity of the approach, it is applied in very few cities in developing countries. What takes place instead is indiscriminate and uncontrolled dumping. This is very harmful environmentally as the waste may include dangerous chemical products, and leaching occurs with risks to groundwater. Since such dumps usually also become the homes of a large scavenger-community, the health implications are serious.

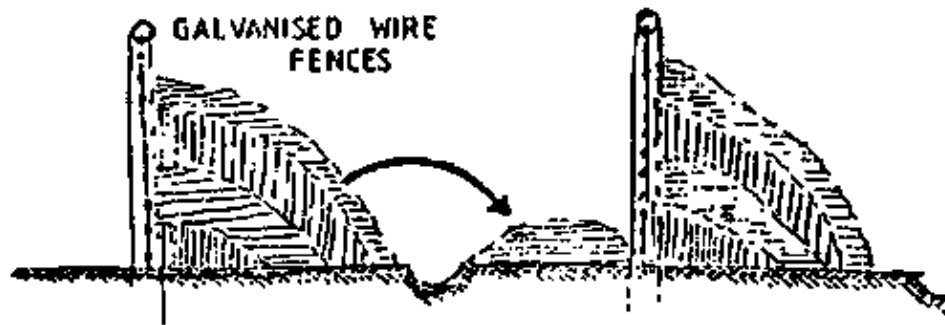
In certain areas (e.g., Guayaquil in Ecuador) landfill is used to make seashore/swamps habitable. Roads require, however, large deposits of sand, so as to attain the necessary stability.

Composting

Composting has long been used in agriculture, but its application to the digestion of urban waste has only recently been developed. It is essentially a process by which organic matter (food, leather, wood, paper etc.) decays. Inorganic matter, such as sand, metal and glass, does not decay and is, therefore, unaffected by composting. In low-income housing areas, as much as 90 per cent of waste might be compostable.

Composting can be done in small quantities and is, therefore, a waste-disposal method that is possible even at the neighbourhood level or at the transfer-depot site. The composting process might take a month, and

composting can be turned into a profitable business for holders of small vegetable plots and nurseries for potted and garden plants. Composting needs air, humidity and warmth. Stacked waste with lots of kitchen waste needs to be turned regularly, in order to allow the air to reach the micro-organisms which digest the organic matter and break it down into harmless components. When the waste pile or ridge is turned every week, this might be sufficient in a warm climate. With sufficient air access, the smells will be minimal.



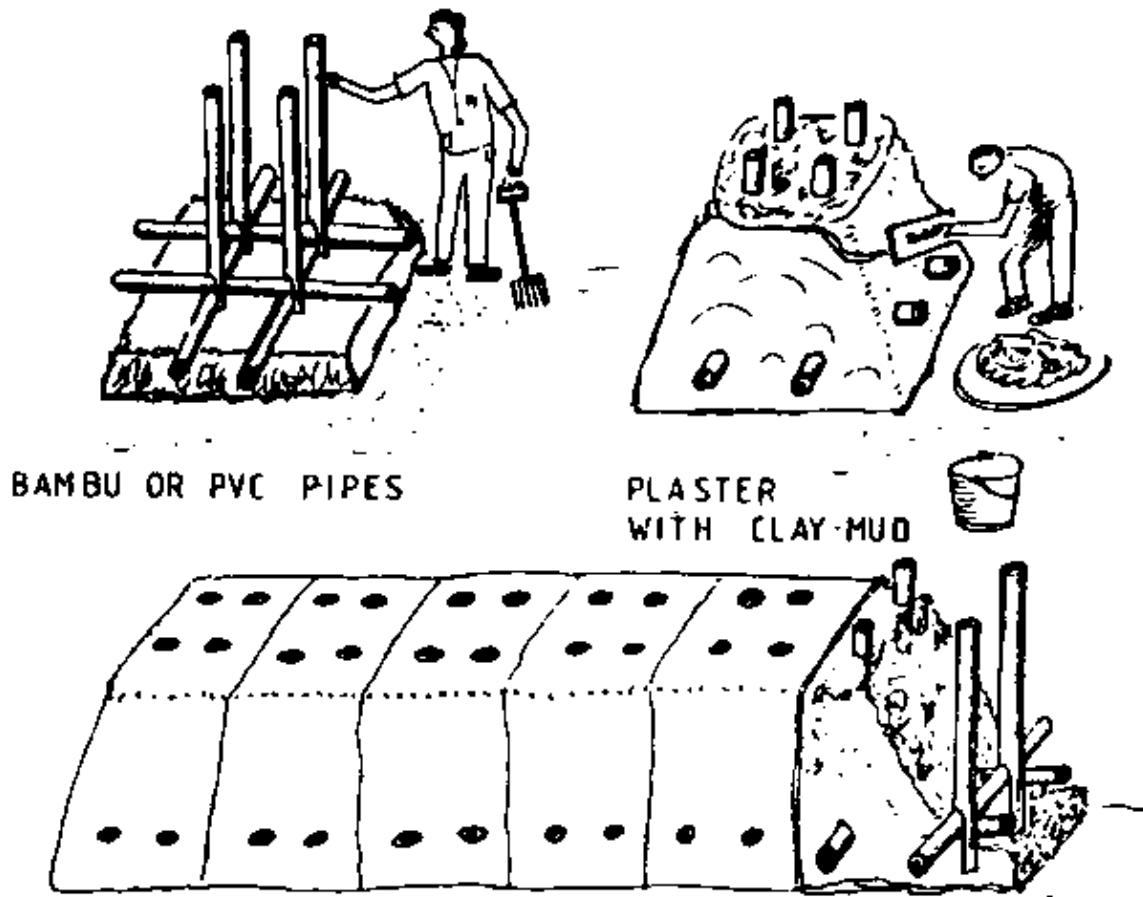
COMPOSTING: WEEKLY MOVING OF RIDGE



The Chinese aerobic-composting system consists of a 2 x 2 m pile, with bamboo or PVC pipes at the bottom of the pile in both directions. Where those pipes cross, vertical (chimney) pipes are placed. When the pile is 1.7 metres high, the outside is plastered with mud, and all pipes are extracted (see drawings). After two months, the pile can be dismantled, and inorganic and large parts can be separated, before the residue is used as compost.

Incineration

Generally speaking, refuse contains 25–60 per cent water and 15–50 per cent combustible material, such as plastic, plant material and wood. The rest is non-combustible (sand, stone, metal, glass etc). During burning, hot gas is produced, containing carbon dioxide and a great number of acid gases. Some materials, such as paint, plastics, rubber and synthetic textiles, produce toxic fumes. All of these are harmful and constitute air pollution. Ashes will correspond to 15–30 per cent of the original weight of the refuse.



BAMBU OR PVC PIPES

PLASTER WITH CLAY MUD

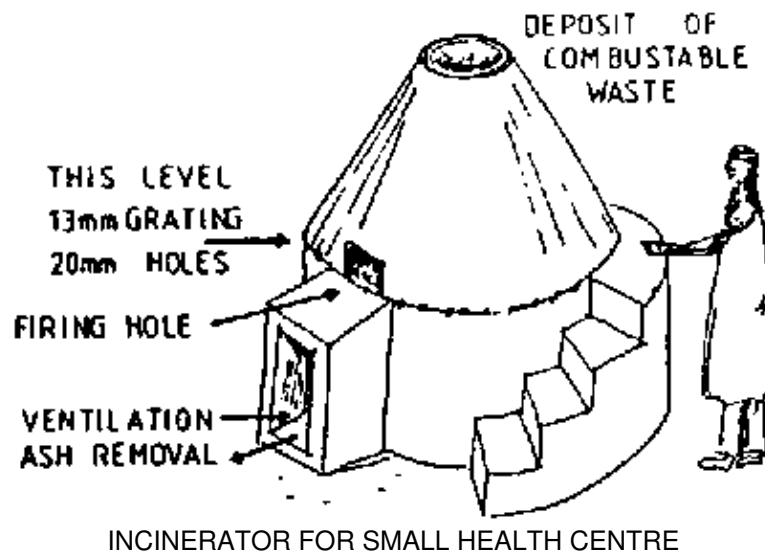
CHINESE AEROBIC COMPOSTING SYSTEM 3 MONTHS MATURING PERIOD

The burning or incineration of waste is commonly done for sites where no collection is done or is possible. In the case of small hospitals or clinics, burning is advisable, for destroying bandages and other septic remains. The burning has to be done in a proper incinerator, to ensure complete combustion. The burning is achieved by the use of paper, cardboard and timber remnants.

For household incinerators, sufficient quantities of dry paper, cardboard and timber are required, and wet materials that can be composted should, therefore, not be placed in the incinerator. The burning of waste in bins or masonry receptacles in the backyard are examples.

What about neighbourhood incinerators to get rid of some of the waste in dense residential areas? The following aspects must be taken into consideration.

- Burning dry materials (filling in the incinerator);
- Composting wet materials (separation);
- Possibility to remove ashes (special tools, gratings etc.);
- Air inlet and smoke outlet (rainy season function);
- Avoid flying ashes in regions with thatched roofs or dry grass areas;
- Plastics and paints produce poisonous fumes when burnt at low temperatures.



Resource recovery

The final option, resource recovery, is of great potential for developing countries and can be practiced at the community level. This approach is, therefore, explained in detail in the following chapter.

QUESTIONS:

1. In the disposal of refuse, what should the community undertake in co-operation with the municipality and what can it solve alone?

2. If municipalities will have towered costs and reduced volume in waste disposal, owing to community participation, what can the community demand in return?

- Expenses of transfer depots;
- Sorting equipment;
- Market skills and selling points;
- Cleaning of depots;
- Supply of dustbins/vehicles;
- Wages of collectors, cleaners, transporters;
- Price guarantees for recycled materials;
- Elimination of taxes;
- Land for commercial waste-related activities.

TASK:

Design a composting area in an urban context. Calculate the amount of organic matter and allow for a two-month composting period, using:

- (a) The Chinese method;
- (b) The ridge method.

Include transport, storage, sieving, packing etc.

QUESTIONS:

1. What will be the economic incentive for the population to separate waste at the household level?

2. What would be the best location of the transfer depot in the settlement area?

3. If selling/buying depots are set up in a settlement, how would it be possible to discourage or incorporate freelance scavengers whose operations would otherwise reduce the economy of the selling/buying points?

V. Resource recovery: handling and dealing in waste

The recovery of usable materials or energy from waste is called resource recovery. The less processing needed before the reclaimed material can be re-used, the more attractive it is economically. Waste paper from offices, for example, can be used for paper pulp without any further treatment, while newspapers will need de-inking. Similarly, clean transparent plastic can be used directly for the production of bags, while soiled and coloured plastics have to be cleaned and sorted before use and can only be used for cheap products.

Recycling in Asia

Plastic recycling on dumps has become fairly common in developing countries. In the Republic of Korea and Thailand, plastics recycling involves six processing phases by different groups of scavengers, each purchasing the plastic from the previous group, adding value by sorting, cutting, pelletizing and bulking or baling the material. The value of the dirty, unsorted plastic extracted from the dumping grounds increases five-fold by the time it is cleaned and sold in pelletized form or in standardized sheets to plastic industries.

Recovery methods

The simplest and most economical recovery method is separation. In the case of household waste, this requires a great deal of co-operation from residents. The recovery of glass bottles, paper and used textiles is a common example of this. In a few countries, kitchen waste for cattle feed is also collected in this way. For many other materials, however, it is not realistic to expect all the extra work and planning needed from individual households to separate and recover materials (e.g., metal, plastics, wood).

Waste from industry and commerce can be recovered in great quantities of uniform quality by specialized dealers. Hotels, restaurants and markets generate large quantities of kitchen and food waste that can be used as animal feed with little processing. Garages discard oil products and metals, printing shops reject cuttings and misprints. These institutional sources of waste are naturally attractive sources of specialized materials, because of the quantities involved and the uniformity of the material.

Combined separate collection

Separation at source is based on co-operation or financial arrangements between the collector of the material and the waste producer. This is "combined separate collection". This is common in the collection of bottles, paper and textiles from individual households. Similar arrangements are made between industrial and commercial enterprises and waste dealers. This type of resource recovery requires a high degree of co-operation and co-ordination. It is also the most profitable form of waste handling.

Community involvement

On a community organization basis in low-income housing areas, the separation of waste on a household level is very profitable. Door-to-door collection of usable materials can be organized, or, alternatively, households can bring their collected paper, glass and plastic bottles to the transfer depot where dealers might have their shops or market stands. The organization of a small processing plant for animal fodder, based on kitchen waste, adds to the general resource-recovery options, while it, in itself, easily becomes an economically viable undertaking.

Recovery from mixed waste

This method involves the separation of various materials from general waste. Scavenging is the most common form; composting and the production of fertilizer and soil conditioner is another way.

In developing countries, there is an increased awareness of the usefulness of scavenging at different stages in the disposal process. In general, the earlier the scavenger can collect the material the more profitable and successful the work is. Recovery from household containers and neighbourhood depots is far preferable to scavenging on a dump, because there is little soiling and breakage. In the transport and compacting process, much value is being lost.

Chemical separation

Chemical separation is the industrial recovery process used to recover specific raw materials from composite products. The de-tinning of tin cans is an example. The removal of ink from printed paper and the cleaning of scrap metal before melting for steelmaking are other examples.

Separation

The separation of recoverable materials requires a well-protected and well-organized area. The advantage of such neighbourhood depots is that separation takes place under controlled conditions, keeping the level of pollution and disturbance to a minimum.

Experiences in industrialized countries

In Europe, resource recovery is receiving increasing attention for both economic and environmental reasons. The economics of waste disposal concerns the municipality, whilst the economics of recovery interests the population in the settlement. The Netherlands, which is a very small country with a high population density and a severe shortage of land, has been leading the attempts to achieve efficient resource recovery. However, one must consider that the general context in Europe is different from non-industrialized countries. This must be realized in order to avoid mistakes when making a choice of method.

Differences are based on economic aspects such as the total quantity and market value of the recovered materials and the labour and equipment costs for sorting and processing. Also affecting waste handling are social or cultural considerations.

Indonesia

The Bandung Urban Development project is an example of blind and wrong application of foreign technology. A team of foreign experts focused on the transport aspects of waste disposal and introduced expensive compaction trucks which picked up the waste from transfer stations, where it had been brought by handcarts. The compaction did not reduce the waste volume very much, since waste densities in developing countries are already nearly as high as the compaction truck achieves in developed countries. What the compaction truck did, however, was to crush the glass, so that manual waste-separation became almost impossible.

Separation at source: the Netherlands

All municipalities in the Netherlands have introduced containers for collecting glass in many neighbourhoods near bottle stores and supermarkets. Glass-collection containers have become a very common part of life.

Paper (newspaper) consumption is very high, and almost all families pile their used newspapers in cardboard boxes which are collected monthly from door-to-door by different charitable organizations and clubs who, with the income thus collected, do social or welfare work. Paper is pre-sorted into three categories: newspapers, magazines and cardboard. About 75 per cent of the cardboard and packaging industries in the Netherlands obtain their source materials from recycled paper. Similar practices can be found in developing countries as informal and, often, semi-legal activities.

Separation at dumps: scavenging

Dump scavenging has practically disappeared in industrialized countries and has been replaced by industrial methods. Scavenging on dump sites is common in developing countries, but it is the least attractive of the resource-recovery routes, since separation at source or at the neighbourhood level can be organized with much less pollution and fewer health risks than is now found at the dump sites. Waste at the dump is soiled, damaged and thoroughly mixed, giving it a low value.

Value and value-added of waste material In developing countries

There are two elements that directly affect profitability of recovery of material – the scale of the operation and the point from which the material is extracted. The question of scale is related to the quantities that it is economical to handle, process and sell to manufacturers. It is only when the material is handled in tons, rather than in kilograms, that recovery becomes a viable enterprise. The point from which the material is obtained often determines the need for additional processing, especially separation and cleaning.

Organizing community-based resource recovery should, therefore, select some materials to be separated at source which are of enough value and discarded in sufficient quantity to justify separate collection. Since the

willingness of households is related to convenience and financial incentives, only a few materials can be obtained this way – old clothes, paper, plastic bags, kitchen waste, bottles and, possibly, metals. Other materials will have to be extracted from mixed wastes. The further down the transport route between the household and the dump, the more labour is involved and the less valuable the materials because of damage, soiling and transport costs. The best solution is, therefore, to combine “combined separate collection” at the household level with recovery from mixed waste in neighbourhood depots. This means that the primary–collection system delivers the waste to a transfer and separation station where a large proportion of the recoverable materials will be separated for commercial purposes, and only the residue will be collected by the municipal trucks for disposal.

Extraction from urban waste requires a great deal of labour and little technology. For example, with \$100/ton spent on processing, scrap iron can be sold for \$150/ton to big iron plants. The chart shows the values of other processed waste.

Communities have the possibility of organizing their own primary waste–collection cycles, resource–recovery and refuse depots, as part of a settlement–upgrading programme, and this has the triple advantage of:

- Income generation;
- Organizational–capacity development that is essential in participatory work;
- Environmental improvement.

These factors together might persuade the community that collective efforts are meaningful in settlement upgrading.

Scavenging

In most cities in developing countries, scavenging occurs on dump sites. Most of the workers concern themselves with the extraction of a single material, in order to collect salable quantities. The purchasers of the materials are wholesale dealers. It is not unusual for the traders not only to control the prices offered to the scavengers but also to act as controllers and masters of the dump.

Scavenging involves many occupational hazards – exposure to poisonous materials, high risks of injury from glass and metal, dirty working conditions with much dust and grime – but scavengers often earn incomes that compare well with those of other unskilled jobs. Much of their vulnerability is related to the low level of organization of the scavengers and their lack of knowledge about the value of the materials they collect. If this were rectified, scavenging could be a profitable and worthwhile activity for low–income residents.

COMPARISON OF RECOGNIZED COST OF RECOVERY WITH VALUE OF RECLAIMED MATERIAL: SOME EXAMPLES

Form of reclaimed material	Approximate cost of recovery (\$/ton)	Nature of material for which reclaimed material is a substitute	Approximate value of reclaimed material as a substitute (\$/ton)	Profit (\$/ton)
METALS:				
Scrap for steel–making and de–tinning	50–100+	Pig iron	150	50–100
Scrap copper/aluminium	100	Copper/aluminium	1000	900
PAPER:				
Pulp for newsprint	50–200	Virgin pulp	300	100–200
GLASS:				
Containers for re–use	50–150	New glass	200	50–150
PLASTICS:				
Scrap for recycling	300–500	New thermoplastics resin	600	100–300
Various plastics	5–30	Wood, concrete etc.	15–100	10–70
RUBBER:				
Tires to “crumb”	75–100	Virgin plastic or rubber	600–800	500–700

TEXTILES:				
Rags for recycling or various fabrics	50–150	Virgin wool fibre	4000	3800
		Virgin cotton	1500	1200

Source: N.N. Lohani. *Urban Solid Waste: Recovery and Recycling* (Dakar, ENDA, 1982).

There is, therefore, ample scope for improving the efficiency and working conditions of scavenging. In several cities, attempts have been made by the authorities to improve conditions. In the Philippines, a policy was accepted that would stimulate resource recovery as early as possible in the collection chain, so as to increase the raw-material flow and decrease the transport and disposal task for the municipality.

Manila

It has become a part of local government policy to accept a partnership between informal-sector activities and municipal services. Recycling takes place at three levels with formal or tacit approval:–

1. Separation at source

Recycling, as commercial co-operation between households and traders, is encouraged, and can be supported by government-sponsored campaigns. Six materials fall into this category – paper, bottles, tin cans, iron, plastics and clothes.

2. Recycling during collection

Waste collectors are allowed to scavenge during their rounds, for supplementary income. This reduces collection efficiency but gives very good returns to collectors.

3. Dump scavenging

This is widely practiced, with an extensive network of dealers.

Manila

The Manila City Government calculates that this informal arrangement returns 30 per cent of the total waste volume to the Industrial raw-material supply stream and, thus, reduces the disposal volume accordingly. The development of an official policy that recognizes the usefulness of resource recovery is a critical step towards an integrated waste-management and income-generation development.

Nairobi

In Nairobi, in the city centre, a high degree of paper collection exists. Scavengers have fixed places (street corners, parking lots) to which office people bring used paper. Officially, it is not allowed, with the effect that regularly the police remove the people, and, therefore, paper is not collected or sold. Legalization of the collection points will not only improve the collection but allow small shelters to be erected against sun or rain, so that working conditions may improve. Other items can then be collected at these stands.

Bandung

The University of Bandung has supported a local scavenger community in developing an integrated operation. The community established a co-operative to co-ordinate all activities which included collection, sorting, waste dealing, utilization of edibles for animal husbandry and composting of organic material for vegetable gardens and fish ponds. The project offers technical advice and develops means of transport and processing, but emphasises, above all, the organizational aspects of the operation. The co-operative could offer its collection service to some neighbouring areas and suggest collection routines that facilitate resource separation. The project tries to avoid the extra transport and poor environmental conditions that scavenging on dump sites constitutes. It has, also, demonstrated its importance in income generation.

The support of outside institutions can help scavengers create their own organizational capacity and develop their activities in an integrated community-development effort. The establishment of a scavengers' association is a precondition for obtaining advice and support necessary for the improvement of working and living conditions.

Waste handling

Site organization

Waste handling consists of various operations which need to be kept separated; unloading and storage areas for unsorted, incoming materials, a processing area, and a well-planned traffic space for the transport equipment to dispatch or collect individual materials. Each area should be clearly marked for both workers and outsiders delivering to the site. This avoids accidents and increases speed and efficiency.

The main hazards on waste sites are:

- Injury from sharp objects – e.g., broken glass, nails protruding from timber and sharp metal edges;
- Fire – paper, rubber, plastics and oils should be stored with proper consideration of their fire risks;
- Leachate – wet, unsorted refuse might discharge offensive liquids on the surrounding ground;
- Insects and rodents – small watertight objects, such as broken bottles and tires, can offer chances for mosquito breeding; food remains attract rodents and encourage fly-breeding;
- Collapsing stacks – material piled up carelessly can start sliding or rolling.

All these hazards are easily controlled, if the danger is recognized. A well-planned and well-kept storage area is not only safe but is helpful for administrative purposes. Storage of paper and textiles under a roof will avoid wetting by rain and eventual rot. Storage of food remains in the shade will avoid early deterioration and maintain nutritive value.

Sorting

In most waste-handling areas, sorting operations should be at different levels.

In the first place, a general sorting of the incoming refuse into 10 or 12 categories is needed. In the Egyptian *zabbaleen* courtyards, this is done by taking the waste in loads from the donkey carts and dividing it into 10 heaps which are laid out in a circle around the cart. After the cart has been emptied, the small heaps are then carried off to the storage areas of each material.

For working with particularly heavy material, the issue of heavy boots with steel toecaps can be considered as well as visors protecting eyes and face. Waste handling and sorting require frequent loading and shifting work, and this can be efficient if hand trolleys, wheelbarrows and handcarts are available. The site should also have one hoist. The possibility of lifting heavy loads, such as a bale of paper, on to a cart or truck is indispensable for the waste dealer.

Dangerous materials

Refuse might contain dangerous materials that will have to be handled with special care. There might be containers with dangerous liquids, gas, inflammable materials or poisonous objects. The waste-storage area, therefore, needs to have an enclosed section where such material can be kept separately. Some metals will need special handling, others must just be kept in storage to be hauled away by the authorities. Special waste, such as used batteries, which is considered as environmentally hazardous can be extracted and collected.

Fire equipment

Fire extinguishers, buckets with sand and alarm bells at several locations on the site should be placed in very visible locations, preferably suspended from posts. The staff should be trained in handling emergencies, such as fires, explosions or the sliding of high storage stacks.

Hygiene

Serious attention should be paid to personal hygiene. Sanitation workers need to have good access to washing facilities. A drum of clean water and some buckets behind a screen will help workers control the worst of the untidiness, while a latrine on the site will prevent the spread of human waste through the collected material. It is also essential that there be a source of safe drinking water.

Packing and dispatching

The sorted and, sometimes, processed material will be hauled away in bulk. Since transport is the single largest expenditure for waste handlers, it is essential that this be undertaken in sufficient quantity to be economical. For many materials, this means that compacting and baling are necessary (e.g., textiles, scrap metal, paper, plastics and cartons). For some materials, such as cullet, special containers are needed. The quantities involved determine the price that the material will fetch, and, therefore, proper documentation is needed. This means that the loads will need proper identification or labelling – hence, adequate scales are necessary.

Waste handling is a commercial operation and it should be organized to maximize profits and minimize costs. This requires a clear businesslike mentality. From personnel management to security and marketing, the work has to be organized with intelligence and inventiveness. If this is the case, those involved will soon discover that waste handling is not only about disposal: it can give a very decent income and is, like any other work, dignified.

Dealing in waste

There is a need for specialization for each of the materials that are to be recovered and processed. The first aspect to investigate is the selling market and any special requirements of clients. Knowledge of the quantities that can be absorbed, delivery times, condition and possible processing of the material preferred by the client, frequency of delivery, preferred packing and the price that can be obtained is essential. Price can vary considerably in relation to the condition of the goods. Many manufacturers pay a high price, if the material has been sorted, cleaned and, even, processed. A glass dealer who returns empties to a large company should separate its particular bottles from the rest and does not need to clean them in advance, because the factory has special bottle-washing machines.

With some basic appropriate technology, material can be processed cheaply with a great increase in value. Processing reduces transport costs from the collection/processing site to the client significantly. The degree and type of processing will require different types of equipment and staff, and will also need space.

Usually the rewarding system which works best is based on piecework – that is, the scavenger or collector is paid for the quantity and quality collected.

Location

The degree of processing chosen determines the area needed for this work. The quantities of material that have to be stored, both incoming, unprocessed material and the processed material that will be sent to the client, and the work space for the processing itself all require space. To find a proper location is often difficult, because land is frequently scarce in urban areas, and few neighbours will be happy to find themselves next to a waste dealer. However, location might have a great impact on the profitability of the operation.

Incoming goods have to be collected in many small loads from neighbourhoods, while outgoing goods will usually have to be hauled away by truck. A poor location might increase transport costs noticeably, which a cramped site might increase production costs. Conflicts with neighbours always mean bad business. If the processed goods are stored at the very place where the truck will pick them up, considerable time is saved.

Transport

The collection vehicles should be able to reach the whole neighbourhood, be large enough to keep the number of trips low and, yet, be small enough to be easy to move. Outgoing goods usually have to be hauled away by truck.

Administration

The administrative side of waste collection is not different from other lines of business. Records of labour, transport, processing, and equipment operating costs as well as the normal depreciation calculations of the

assets of the firm are essential. The firm should have the usual bookkeeping, with two types of accounts with a bank – a current account and a savings account that bears interest. Dealings with clients should be business-like.

All this is self-evident for an outsider, but one who develops a waste business from scratch might lack self-esteem and become indifferent to social aspects of business. This, is a costly mistake. Dealing in waste is a very useful function in society and it is often a profitable one, but it will only be successful if the dealer acts as a business-person.

QUESTIONS:

1. There is much reluctance among the authorities of developing countries to allow scavenging and waste recovery in general; yet, in industrialized countries, it is gaining in importance. Do you think this reluctance needs to be overcome? If so, how? If not, why not?
2. Waste handling can be environmentally offensive. How can this be controlled?
3. Which resources do you think can be recovered and processed on a neighbourhood basis and which would require a city-wide operation?
4. Should waste dealing be an individual activity or community-based? Why?
5. Should your project promote waste dealing?
6. What kind of systems of payment would you prefer for:
 - House-to-house scavengers;
 - Selling/buying at transfer stations;
 - Sorting groups;
 - Upgrading groups;
 - Weighing and baling groups;
 - Transport;
 - Administrative personnel?

What influence on productivity can any type of payment have?

VI. Recycling examples

A. Glass

Glass is one of the easiest and most profitable resources that can be recovered from municipal and industrial waste, if handled in sufficient quantity. Most profitable is the recycling or re-use of discarded bottles. Beer and lemonade bottles are common examples. Empty spirits bottles of uniform size are often recycled for locally produced syrups, drinks or other liquids. Local factories provide the closing fixtures. For the production of high-quality glass, the cullet (scrap-glass) content can be as high as 40 per cent, while many small workshops use as much as 80–100 per cent of cullet as the raw material for production.

Collection

Glass recovery requires some sorting and processing, and this can usually take place within the community. In some cases, wholesale dealers will pay for glass bottles in bulk, without requiring sorting or cleaning of the bottles. Similarly, broken glass can be used for different recycling purposes, and clear glass is most valuable for this purpose. Sorting by colour, therefore, makes sense in most cases.

For clear glass, absolutely no coloured glass can be used. Clear glass should, therefore, be collected separately from coloured glass, so that it will fetch a high price. From mixed and coloured glass, brown beer or green wine bottles are manufactured.

It is useful to include non-household sources in the collection operation – shops, supermarkets, bars and factories. The inclusion of such suppliers helps to make a collecting system economical. A glass-collection service will need an enclosed area, with facilities for sorting, cleaning and storing the different types of material. Protective clothing, proper containers and transport facilities are also necessary.

Processing recycling

There are four types of recycling process that can be implemented at the community level. The first type is the sorting and cleaning workshop, where glass bottles and jars are sorted, cleaned, packed and resold to small industries. The second concerns the cutting and polishing of various types of glass to make ash trays, drinking glasses, tumblers, candle-holders and lampshades. This type of production unit can be very small and requires little investment. The third type concerns small glass workshops that produce various glass objects by melting and blowing objects. These objects can vary from clear-glass laboratory containers to artisans' work in different colours. Usually this type of workshop requires an oven, some additional source materials to produce glass that is blowable, and gas burners. It also requires cooling ovens. Since the produce of these shops is labour-intensive, it should concentrate on items which have a high retail value. The fourth type concerns large glass workshops that produce glass objects by melting cullet and moulding and blowing. This requires a good deal of expertise and a considerable investment. The workshop needs a high-temperature furnace for melting the material, and small-scale "pot" furnaces are common. When moulding large series of the same product, cooling, storage and packing spaces are commensurately large.

These workshops however cannot compete with the industrialized bottle-producing factories, and articles must be chosen which do not require standards or precision that are too high. Glass-jar containers or building elements might be feasible.

B. Paper

Paper requires a lot of energy in its production from new materials, and, hence, recycling means considerable savings. Paper recycling is the most common type of resource recovery and offers employment to great numbers of people in both developing and industrialized countries.

Paper collection

The collection system should make separate provision for various grades of paper and aim at avoiding a mix of different grades. Paper value is determined by quality and by weight. Since even a small mill uses considerable quantities of paper, transport is one of the main factors for the paper collector. Paper-collection operation is, therefore, based on proper grading for quality, baling and transport (unbaled paper is very difficult and uneconomical to store and transport). Recycled paper is directly used for the manufacture of paper for packing, cardboard and toilet paper.

Paper can be collected from households direct or scavenged from containers, depots and dumps, while special collections can be organized from enterprises that produce great quantities of paper waste. Printing shops, offices and newspapers all produce great quantities of paper of a very even quality. Warehouses, factories and shops usually have good quantities of cartons and other packing materials that can be recycled. Waste paper from households usually consists of two types – old newspapers, which might still be clean, and all other types of paper waste, often dirtied with other wastes and, therefore, only suitable as very-low-quality waste paper.

The following types of paper can be distinguished:

- Office stencils or photocopying paper;
- Newspaper (has to be de-inked);
- Magazines – not very useful because of the ink and glue;
- Cardboard boxes;
- Waxed or plasticized paper.

Collection from institutions and households is best organized in regular collection rounds at set times. The collection team should be equipped with a cart or vehicle that allows different grades to be placed in different compartments. It should also have facilities to receive rejected material, so as to avoid littering during collection. It might be advantageous to offer households an incentive to dispose of paper (in particular

newspapers) separately from other waste.

Paper production

Paper mills producing batches of as little as one ton can be profitable. Such a plant would employ 15–30 people and require equipment to a value of about \$35,000. Paper-making requires large quantities of water, and a good water supply as well as good drainage facilities are, therefore, essential.

Other uses of waste paper include paper bags and cartons from the 'raw' waste material. Paper shredding can be used as animal bedding, insulation material and packing material. Paper sheets with an asphalt coating, can be used as a cheap roofing material.

C. Plastics

Plastics have become common packing materials in developing countries, and, in recent years, the recycling of this material has emerged as a significant source of employment among scavengers. Recycling of plastic is not always economical, and recycled plastics will not have the same quality as the original material. There are two types of plastic found in quantity in municipal refuse – thermoplastics and thermosets.

Thermoplastics are materials that can be moulded after heating and that keep the desired shape at normal temperatures. Because of this property, thermoplastics are suitable for recycling. Two main types are distinguished by the scavengers – hard and soft plastics.

Thermosets (formica sheets, hard crockery plastics, many electrical fittings, etc.) cannot be recycled.

The materials discussed here are, thus, only thermoplastics, such as PVC, polypropylene and polyethylene. The burning of the different types of plastic must be discouraged, since it produces toxic gases.

Collection

The recycled value of plastics is low, and, therefore, households have no incentive to separate plastics from other waste. Consequently, plastics have to be extracted from waste and are, then, quite dirty. This, again, requires cleaning which decreases profitability. Plastics that are often recovered early in the disposal process are bottles and other containers which are fished out of bins and depots. Sheet plastic is usually only recovered at the dump.

Bandung

Recent studies of scavengers in Bandung have described the various steps in plastic recycling and the gradual increase in value of the material. One group might buy material, wash it and dry it. The next group might sort it, grade the sheets for size and thickness, and recover undamaged plastic bags which are bundled according to size and sold to hawkers and market-sellers. The next group might cut clean sheets into standard sizes and bale and sell them to producers of "new" bags, folders etc. (however, the production of new bags from used sheets after being "washed" is not recommended for foodstuffs). The residue will be sold to processors operating an extruder/pelletizer which partly melts the plastic and presses it out into strings which are then chopped into pellets. These are sold to the manufacturers of low-quality plastic objects, such as cups, dolls, toys and packing containers. The original colours of the plastics fed into the extruder affect the final product, and it is, therefore, an advantage to grade the plastics according to colour for the different batches that are to be pelletized. The less the colour, the higher the value of the pellets to the manufacturer.

When very large quantities of thermoplastics are available, and cleaning or pelletizing is expensive, building components can be manufactured from them by high-pressure (heating) moulds. During the process, the product is sterilized. In the Netherlands, all-weather and super-durable fence posts are manufactured in this manner.

D. Rubber

Collection

Little rubber can be collected from household refuse, but the collection of used tires is useful. These are mainly discarded by tire dealers, garages and scrap yards.

Recycling

Recycling of discarded rubber can concern the actual reclamation of rubber itself or the use of the rubber in its existing shape for the manufacture of other products.

Sandals and furniture straps are manufactured from used tires. Their running profile will be used for the soles of shoes, and the sides for straps and fittings. In some countries, these sandals are widely accepted because of their durability. In Nairobi, thousands of people find employment in the manufacturers and sale of these sandals.

Old tires with a good framework can be rasped off to form a smooth surface and then retreaded. The dust rasped off the tire is resold and can be used again in the tire-production process and is, therefore, sold at quite high prices.

Whole tires can also be re-used. Children's playgrounds offer a multitude of uses. Swings and boat bumpers are often made from old car tires. Rubber crumbs from car tires have found applications in road construction, as a filler in agricultural or human waste composting and as an ingredient for cement-based blocks. All of these can be produced in small workshops. Recent developments also show that small-scale manufacturing of moulded rubber products based on 100 per cent rubber crumb (old rubber powder) can achieve a good quality. The technology uses very fine rubber powder which is compressed and heated in steel moulds. Processing of very small objects from steel moulds heated in household ovens has been successfully reported, and the range of products that this method can manufacture includes battery boxes, dustbin covers, trolley wheels, shoe soles, moulded mats, floor tiles and car bumpers.

E. Metal cans

Like glass bottles, tin cans have a recycling value and constitute a nuisance if they remain mixed with refuse. De-tinning of tin plate is profitable because of the high price that pure tin fetches. The "scrape" of de-tinned steel plate is then suitable for melting. Aluminium cans from soft drinks and beers have very high retail value because of the high quality of aluminium used for the cans.

Collection

Cans are recovered from refuse depots or dumps by scavengers in the general sorting of refuse. The cans are quite soiled and awkward to handle, because of the sharp, jagged edges. There is not much point in trying to obtain collection at source, since the resale value of cans is low, and the quantities concerned would not justify the effort.

Processing

Sometimes whole tins are used to produce oil lamps, ashtrays and candlesticks, but, apart from such marginal uses, cans have to be pressed into small flat pieces of plate before being processed into goods.

In Egypt, scavengers use heavy-duty tin openers and scissors to remove the top, bottom and rim of the cans and to cut the remaining tube into rectangular pieces of sheeting which can easily be cleaned and bundled. The flat sheets can then be used to produce buttons, furniture fittings, boxes etc., while the rest goes for de-tinning and remelting.

Bottle tops can be stamped out of small pieces of tin plate, while decorative embossing can be made by hammering the plate on wooden or steel moulds. The recovery of tin plate, tin and iron from cans can form a regular source of income. It is, however necessary to have quite a large turnover for it to be profitable.

F. Kitchen waste

Kitchen waste and food leftovers are suitable animal feed until they decay. In Europe, kitchen waste from hotels etc. was collected daily in urban areas as pigfeed. The entire waste–collection system of Cairo was originally based on the same utilization of food remains for pig breeding.

The separation of suitable animal feed from other waste is difficult and messy. Basically, animal food is only advisable when it can be collected the same day (or night) from the source and does not contain meat and fish remains. Vegetable rejects from markets are the most suitable.

If separation at source is unsuccessful, several other options exist for kitchen–waste utilization. The first is the manual sorting of all waste and the separation of digestibles. In Ghana and Indonesia, experiments have been made to allow pigs and cattle to feed directly from fresh waste piles. There is, however, a considerable risk that the animals can be injured from sharp or poisonous objects or can swallow plastic sheets. Furthermore, in warm climates, disease development in kitchen waste is possible within days, and cattle might become infected. Hence, the feeding of kitchen waste to cattle without prior treatment, such as boiling or drying might cause ill effects. Chickens are less vulnerable than cattle.

In Indonesia, the digestion of organic material by worms has been tried; the worms would then be used in fish ponds.

Small–scale animal husbandry within the neighbourhood could profit from special collection of food–remains and kitchen waste at the source, but, if this proves difficult, it might be preferable to refrain from recovery for feed but use the waste as a component source only.

Collection

The collection of edibles for animals is dependent on the co–operation of households in storing them separately from other waste. This might be possible through a special animal–raising co–operative where the community identifies with this separate effort in waste handling. This type of waste decays more rapidly than others, and fly–breeding is closely associated with it. At the same time, the nutritional value declines rapidly with the time that elapses before it reaches the animals. Consequently, a very frequent collection is desirable (every two days).

The Egyptian waste–collection system is based on daily collection of unsorted waste which is immediately sorted in the waste compounds of the pig breeders. The separation process is effective, because the collection system in donkey carts does not damage the refuse much, while the separation takes place continuously, with meticulous separation of the various types of refuse. The production of dried animal feed from collected market or kitchen leftovers has the advantage that the dried feed can be kept for a few weeks, resold in bags and used as additional feed when grass is scarce. Sun–drying on black metal sheets and under glass gives off high temperatures which will kill off rodents and maggots.

A more elaborate form of processing feed remains is the boiling of the kitchen and market leftovers for a few minutes to sterilize the feed. Boiling and stirring will also reduce the water content of the food, and rapid drying in solar heaters will further sterilize the feed. The processed and dried feed can be stored for months, creating feed reserves when other feed supply is low. This feed can be improved by adding minerals, to create standard–quality animal feed. The process requires energy, but, because of its durability, high market prices can be obtained.

Glossary

Aeration	The process of exposing something to air or charging a liquid with gas.
Aerobic/Anaerobic	The biological state of living and growing in the presence/absence of oxygen.
Baling	Packing of paper, plastic or clothes in bales after sorting out into type and quality, in order to reduce space and allow easy transport.
Biodegradable	Waste material which is capable of being broken down by bacteria into basic elements. Most organic waste, such as food remains and paper, is biodegradable.
Carbon nitrogen	The ratio of carbon to nitrogen. Abbreviated C/N. Used in describing compost, humus

ratio (C/N)	etc.
Carrier	A person who harbours a specific infectious agent, while not affected by clinical disease, and serves as a potential source of infection for humans.
Compactor	Enclosed vehicle provided with special truck mechanical devices for loading the refuse into the main compartment of the body, for compressing the loaded materials and for distributing the refuse within the body.
Composting	A controlled microbial degradation of organic waste yielding a nuisance-free product of potential value as a soil conditioner
Cross-financing	The rich parts of the city pay a higher price than the real cost per unit, in order to subsidize the poor sections of the city which cannot afford to pay the real cost.
Cullet	Scrap glass, usually broken up into small, uniform pieces.
Decomposition	Reduction of the net energy level and change in chemical composition of organic matter caused by micro-organisms in an anaerobic environment.
De-inking	The chemical removal of ink from printed paper or pulp.
Density	The ratio of the mass of a substance to its volume.
Front-end loader	Detachable container system in which collection vehicle has arms which engage container (usually 1–10 cubic yards capacity), move it up over the cab and empty it into the vehicle body. Container is left with the customer.
Humus	Decayed organic matter. A dark fluffy swamp soil composed chiefly of decayed vegetation; also called peat.
Landfill	A method of disposing of refuse on land without creating nuisance or hazards to public health or safety, by utilizing the principles of engineering to confine the refuse to the smallest practical volume and by covering it with a layer of soil at the conclusion of each day's operation or at such more frequent intervals as might be necessary. A sanitary landfill is a system for final disposal of solid waste on land, in which the waste is spread and compacted on an inclined working face in a series of cells and a daily cover of soil is provided, so that no hazard to the environment results.
Leachate	Liquid emanating from a land-disposal cell that contains dissolved, suspended and/or microbial contaminants from the solid waste.
Manure	The faecal and urinary defecation of livestock and poultry. Manure may often contain some spilled feed, bedding or litter.
Mineralization	Chemical reduction of organic matter to stable mineral compounds.
Newsprint	The kind or type of paper generally used for printing newspapers.
Pathogen	Any infective agent capable of producing disease; may be a virus, bacterium, protozoan etc.
Recycling	Separating a given waste material (e.g. glass) from the waste stream and processing it so that it can be used again as the raw material for products which might or might not be similar to the original.
Scavenging	A form of selective picking. Some people select papers, others plastics, etc.
Screening	Separating pulverized waste material into various sizes by using a sieve-like device. Usually two or more stages of separation are used, each stage having a different hole-size in order to separate material according to size.
Seepage	Movement of water through soil without formation of definite channels.
Thermoplastics	Plastics which can be formed repeatedly by the application of heat and pressure.
Transfer station	A fixed facility used for removing refuse from collection trucks and placing it in long-haul vehicles.
Vector	A living insect or animal (not human) which transmits infectious diseases from one person or animal to another.
Waste	Synonymous with refuse and garbage.
Windrow	A long row of heaped material left on the ground or in a special area. In composting, waste material is sometimes made into windrows so that the materials can be easily turned over.

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Annexes

Annex I. Sample domestic refuse collection and disposal questionnaire

EXERCISE: Adapt this questionnaire for your own environment and spend a morning on obtaining the information. In the afternoon, compile the information and make an analysis of the total volume of waste.

House No.: _____ How many people live in this sector: _____ How many families live in this sector _____

1. How many persons reside in this house? _____ adults, _____ children below the age of 10		
2. Where do you store your garbage?		
<input type="checkbox"/> In a pile on the floor	<input type="checkbox"/> Big oil tin	<input type="checkbox"/> Galvanized iron bucket
<input type="checkbox"/> Plastic bucket	<input type="checkbox"/> Paper or plastic bag	<input type="checkbox"/> Other (specify)
3. Approximate dimensions of container: Height _____ cm. Width _____ cm.		

Volume ____ litres		
4. How much refuse do you collect in a day?		
<input type="checkbox"/> Quarter container	<input type="checkbox"/> Half container	<input type="checkbox"/> Three-quarter container
<input type="checkbox"/> Full container	<input type="checkbox"/> Other (specify) _____	
5. How often is the waste from your house removed for disposal?		
<input type="checkbox"/> Once a day	<input type="checkbox"/> Once in two days	<input type="checkbox"/> Once in three days
<input type="checkbox"/> Once in four days	<input type="checkbox"/> Once a week	Other (specify) _____
6. Who removes the refuse from your house for disposal?		
<input type="checkbox"/> Householder	<input type="checkbox"/> Sweepers	<input type="checkbox"/> Other (specify) _____
7. How much do you pay your sweeper each month for removing refuse? _____		
8. Where do you dump your refuse?		
<input type="checkbox"/> Open plot	<input type="checkbox"/> Compost pile	<input type="checkbox"/> Front of house
<input type="checkbox"/> Roadside	Other (specify) _____	
9. What happens to the dumped refuse?		
<input type="checkbox"/> Stays there	<input type="checkbox"/> Removed by municipality	<input type="checkbox"/> Burnt
<input type="checkbox"/> Searched by scavengers	<input type="checkbox"/> Other (specify) _____	
10. Do you retain any material, either re-using it yourself or selling it; if so which?		
<input type="checkbox"/> No <input type="checkbox"/> Paper <input type="checkbox"/> Coloured glass		
<input type="checkbox"/> Plastic	<input type="checkbox"/> Clear glass bottles	<input type="checkbox"/> Metals
<input type="checkbox"/> Metals	<input type="checkbox"/> Cardboard	<input type="checkbox"/> Cloth
<input type="checkbox"/> Food-wastes	Other (specify) _____	
11. For what price do you sell the above-mentioned articles and in what quantity? _____		
12. How often do you sell the above-mentioned quantities? _____		
13. What articles would you store if they paid you for it? For what minimum value? _____		

Annex II. Data–collection guide: waste composition

WASTE CHARACTER

Percentage of weight ___% wet weight basis and ___% dry basis

WASTE CATEGORY	1	2	3	4	5	7	6	7
Vegetable/putrescible:								
Above 50 mm								
10 mm–50 mm								
Below 10 mm								
Total								
Paper								
Metals:								
Ferrous								
Aluminium								
Total								
Glass:								
Coloured								
Clear								
Total								
Textiles								
Plastics:								
Polyethylene								
Other								
Rubber:								
Tires								
Other								
Bones, wood, straw, shells								
Miscellaneous:								
Combustible								
Non–combustible								
Inerts below 10mm								
Moisture content								

Annex III. Fly breeding, groundwater, pollution, composting

A. FLY BREEDING

Fly breeding in refuse is the most critical factor of waste management. Diseases spread by flies are the main childkillers in developing countries. It is not the waste in itself that is dangerous but the fly–breeding associated with it. The availability of breeding grounds can, in a matter of weeks, cause an explosion in the fly population.

Waste management should, therefore, be based on a sound understanding of how flies breed. They do not like dark places but tend to fly towards light. There is however one exception: female flies, about to lay eggs, will ignore the direction of the light and will seek out the source of the smell of decaying organic matter. This is the reason why flies even breed inside dark latrines. The young flies, on the other hand, will fly towards the

light and so escape from the latrine.

When waste is stored in a container, decomposition of the material soon starts. It takes about one day for decay to set in, and, as a result, smelly gases that attract flies are emitted. Once the eggs have been laid, it takes one day, in a warm climate, for them to hatch. The larvae remain in the waste to feed for the next five days. During the following stage, the larvae might spread, but inside the containers this is prevented. After two days, small flies emerge from the waste container.

The whole process takes eight days, and it is, therefore, essential that the complete waste-handling process be completed within one week from disposal in the household to final treatment. A good covering layer of earth, say 20 cm thick, will prevent the young flies from emerging, whereas the transfer of refuse from different containers to vehicles and *vice versa* offers larvae the possibility of escape. Such operations should, therefore, include the observation and hence destruction of larvae. Chickens eat the larvae.

If the final disposal is done by open-land application or composting, fly-breeding might be difficult to control in large-scale operations. Such sites should, therefore, be located well away from human settlements.

B. GROUNDWATER POLLUTION

Waste deposits can be very harmful to groundwater, because of the dangerous fluids which might drain into it ("leachate"). Leachate occurs when surface water or rain filters through a large deposit of solid waste. Since numerous chemical processes take place in a decaying waste pile, the filtering water will pick up many loose substances, chemicals and harmful matter that seep into the groundwater.

Since a variety of harmful chemicals might reach the groundwater, dumping sites should be carefully planned to collect the leachate and treat it before it is discharged. This means that very permeable sites should be avoided for dumping purposes, and dumping areas should be planned with proper drainage and fluid-treatment facilities. It is also important to know that leachate might result from dumping sites for periods of up to 20 years after the disposal of the waste.

Elements which cause chemical poisonous substances include the following:

- Batteries – torch and car batteries;
- Paints – painted surfaces, solvents, ink;
- Oils from engines and garages;
- Metals, such as lead, zinc, cadmium, mercury;
- Plastics;
- Electronic equipment, wiring;
- Fertilizers, insecticides, sprays;
- Cleansing acids, detergents, bleaches;
- Tannery waste, photography chemicals.

Although some of the materials are specifically from industries, it is known that, in squatter settlements, all sorts of small industries might develop. In the same area, the groundwater is often used for drinking or washing. In certain countries, special collection is obliged for harmful chemicals.

C. COMPOSTING

Composting waste mainly concerns 'aerobic' (see glossary) composting. It takes place in four phases:

- The latent phase of about one day needed for spontaneous distribution of the micro-organisms carried in the air throughout the waste material;
- The growth phase, during which the temperature rises;
- The heat-generating phase which destroys many of the harmful substances in the material (If this phase is not interrupted, complete decay takes place, and few substances suitable for fertilizing remain);
- The stabilization phase which brings the temperature back to normal and yields a material suitable for fertilizer or soil improvement.

Composting requires 40–60 per cent humidity in the material and a good balance between nitrogen (N) and carbon (C) in the material. A C/N ratio of 1:25 is the optimum composition for rapid composting. It is, also, important that air circulate regularly throughout the material to keep the micro-organisms alive. This is usually achieved by turning the material over from time to time or by blowing air through it. Composting can be arranged in open fields, keeping the material ventilated and static for most of the time, or by regularly turning over the material.

A turning of the material once a week might be sufficient. A ridge about 1 metre high will be composted in about one month in a tropical climate.

The compost obtained after the fourth aerobic phase should be used within a month, otherwise the nitrogen value reduces and, hence, the fertilizing value. The ready compost should not remain in the sun. This compost is most effective when mixed with ordinary soil.