MODULE - 1

“Planning a Waste Collection, Storage and Transport”

MODULE STRUCTURE:

1. **LEARNING OBJECTIVES**
2. **WASTE COLLECTION COMPONENTS**
3. **STORAGE: CONTAINERS/COLLECTION VEHICLES**
4. **WASTE COLLECTION SYSTEM PLANNING/ DESIGN**
5. **HUMAN RESOURCES MANAGEMENT**
6. **MAINTENANCE OF VEHICLES AND CONTAINERS**
7. **HEALTH AND ENVIRONMENTAL CONCERNS**

Contents

1. LEARNING OBJECTIVES:

After completing this module, you should be able to:

- Discuss the various components of a waste collection system;
- Explain the characteristics of waste containers, vehicles and assess which better fit locally;
- Evaluate how a collection system is planned and implemented;
- Design and implement an effective waste collection system.
- Gain knowledge on maintenance procedures of waste vehicles and containers
- Learn how to maintain effective response to waste collection emergencies;
- Underline the effects of poor waste management on the environment.

2. WASTE COLLECTION COMPONENTS

Waste collection does not mean merely the gathering of wastes, and the process includes, as well, the transporting of wastes to transfer stations and/or disposal sites. Before starting a new waste collection service or improve the existing one, it is important that the authorities take basic decisions on the main elements of the quality of the service of waste collection, which are the following:

a) Zone of collection:

Define the zone of collection or waste service area where the local authority plans to offer or improve the waste collection service. The definition of waste service area serves to clarify the area where the contractor (private company) or municipal enterprise performs its activity on waste collection or other waste services specified at the contract and at the same time to define the service area under local responsibility.

b) Collection points and distance from the houses:

These affect such collection system components as crew size and storage, which ultimately control the cost of collection. The points must be placed on specific places (residential, markets, commercial zones, restaurant, etc.), on populated zones, infrastructure, urban typology, and characteristics of urban space, and in relation with the defined distance between the inhabitants and the waste collection points. It is important to reduce the number of collection points to reduce the cost of recollection. On another hand, it is also important to place the collection points on places which are easy to reach and to work for the trucks: mainly on the main roads. The position of these points also must be defined in order to reduce the distance from the inhabitants to the point.

c) Roads of streets cleaning:

The cleaning of the street has an influence on the position of the collection points, because the waste collected in cleaning the streets must normally be places on one or more waste collection point.

d) Collection frequency:

The easier for the organization is to collect the waste every day (7 days a week): this needs the minimum number of bins. However, the cheapest solution often is to have a lower frequency, with a higher number of bins.

Climatic conditions and requirements of a locality as well as containers and costs determine the collection frequency. In hot and humid climates, for example, solid wastes must be collected at least twice a week, as the decomposing solid wastes produce bad odour and leachate. And, as residential wastes usually contain food wastes and other putrescible (rotting) material, frequent collection is desirable for health and aesthetic reasons. Besides climates, the quality of solid waste containers on site also determines the collection frequency. For instance, while sealed or closed containers allow collection frequency up to three days, open and unsealed containers may require daily collection. Collection efficiency largely depends on the demography of the area (such as income groups, community, etc.), where collection takes place. While deciding collection frequency, therefore, you must consider the following:

- Cost, e.g., optimal collection frequency reduces the cost as it involves fewer trucks, employees and reduction in total route distance;
- Storage space, e.g., less frequent collection may require more storage space (more containers) in the locality;
- Sanitation, e.g., frequent collection reduces concerns about health, safety and nuisance associated with stored refuse.

e) Hours of collection:

The hours of collection can have a very important effect on the costs of the service. They depend also of the traffic conditions.

f) Storage containers:

The standardization, quality and quantity of the container and the truck are the key elements to reduce the cost of the recollection. If they are good, the cost can be reduced to a minimum. If not, the cost of collection can increase up to 50 % to 70 % for the same quantity of waste and collection zone. Proper container selection save collection energy, increase the speed of collection and reduce crew size. Most importantly, containers should be functional for the amount and type of materials and collection vehicles used. Containers should also be durable, easy to handle, and economical, as well as resistant to corrosion, weather and animals. In residential areas, where refuse is collected manually, standardised metal or plastic containers are typically required for waste storage. When mechanised collection systems are used, containers are specifically designed to fit the truck-mounted loading mechanisms. While evaluating residential waste containers, consider the following:

- Efficiency, i.e., the containers should help maximise the overall collection efficiency.

- Convenience, i.e., the containers must be easily manageable both for residents and collection crew.
- Compatibility, i.e., the containers must be compatible with collection equipment
- Public health and safety, i.e., the containers should be securely covered and stored.

g) Collection crew:

An effective collection crew size and proper workforce management influence very much the productivity of the collection system. The crew size, in essence, can have a great effect on overall collection costs. The optimum crew size for a community depends on labour and equipment, collection methods, and mostly on the number, size and type of bins and collection vehicle used.

In order to reduce the crew, and the costs, to a minimum, it is very important to have enough bins to store all the waste of the collection point, as well as a technological truck with loading system. This aloud to reduce the work and time of stopping the truck to a minimum: 2 workers can be enough to do the job.

At the opposite, if waste is laying on the floor, the same quantity of waste needs much more work and crew, and the immobilisation of the truck and driver in this time of charging the waste is a very important factor of cost.

Note also that the collection vehicle could be a motorised vehicle, a pushcart or a trailer towed by a suitable prime mover (tractor, etc.). It is necessary to adjust the ratio of collectors to collection vehicles such that the crew inactive time is minimised. However, it is not easy to implement this measure, as it may result in an overlap in the crew collection and truck inactive time.

However, in order to reduce the collection costs, the trend is towards:

- Decrease in the frequency of collection; and increase the volume of bins
- Increase in the degree of automation used in collection.
- Increase in the dependence on residents to sort waste materials;

h) Collection route:

The collection programme must consider the route that is efficient for collection. An efficient routing of collection vehicles helps decrease costs by reducing the labour expended for collection. Proper planning of collection route also helps to minimise working hours and vehicle fuel consumption. It is necessary therefore to develop detailed route configurations and collection schedules for the selected collection system. The size of each route, however, depends on the amount of waste collected per stop, distance between stops, loading time and traffic conditions. Barriers, such as railroad, embankments, rivers and roads with heavy traffic, can be considered to divide route territories.

Routing (network) analyses and planning must be done with the following objectives:

- collect all the collecting points (see above)

- reduce the distance and time of collection (minimise working hours and vehicle fuel consumption)
- correspond to a quantity of collected waste so that the truck is full at the end of the tour
- integrate traffic problems (for example it is necessary to organize the route and timing so that the work during in the peak hours is done on quiet periphery streets)

i) Waste transfer:

Waste transferring is an intermediate process between final disposal and collection point in order to increase the efficiency of the system, as collection vehicles and crew remain closer to routes. If the disposal site is far from the collection area, it is justifiable to have a transfer station, where smaller collection vehicles transfer their loads to larger vehicles, which then haul the waste long distances. In some instances, the transfer station serves as a pre-processing point, where wastes are dewatered, scooped or compressed. A centralised sorting and recovery of recyclable materials are also carried out at transfer stations (EPA, 1989).

3. STORAGE: CONTAINERS/COLLECTION VEHICLES

Waste storage is an important component of a waste management system. Waste storage encompasses proper containers to store wastes and efficient transport of wastes without any spillage to transfer stations/disposal sites.

3.1 Containers/storage bins

The design of an efficient waste collection system requires careful consideration of the type, size and location of containers at the point of generation for storage of wastes until they are collected.

As mentioned, the choice of the type of bins is an important element of the planning. It is very important to choose a standardized of bins, and only one, and to have enough bins to be sure that all the waste will be in the bins and not on the floor. The standardization, quality and quantity of the container and the truck are the key elements to reduce the cost of the recollection.

While single-family households generally use small containers, residential units, commercial units, institutions and industries require large containers. Smaller containers are usually handled manually whereas the larger, heavier ones require mechanical handling. In all the case it is much more efficient to define one unique size of container, the biggest possible, and reduce the number of collection points.

The containers may fall under either of the following two categories:

a) Stationary containers: These are used for contents to be transferred to collection vehicles at the site of storage. This is the normal case.

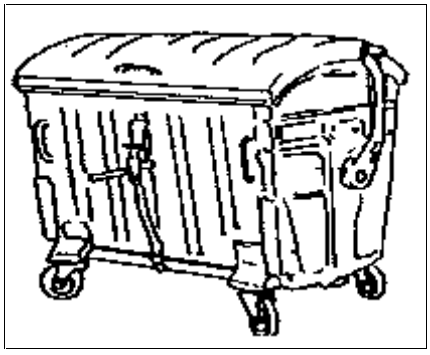
b) Hauled containers: These are used for contents to be directly transferred to a processing plant, transfer station or disposal site for emptying before being returned to the storage site. This is used only for specific waste (like hospital waste)

The desirable characteristics of a well-designed container are low cost, size, weight, shape, resistance to corrosion, water tightness, strength and durability. For example, a container for manual handling by one person should not weigh more than 20 kg. Containers that weigh more than 20 kg, when full, require two or more crew members to manually load and unload the wastes, and which result in low collection efficiency.

Containers should not have rough or sharp edges, and preferably have a handle and a wheel to facilitate mobility. They should be covered to prevent rainwater from entering (which increases the weight and rate of decomposition of organic materials) into the solid wastes. The container body must be strong enough to resist external pressure (atmospheric or other factors) as well as withstand rough handling by the collection crew and mechanical loading equipment. Containers should be provided with a lifting bar, compatible with the hoisting mechanism of the vehicle. The material used should be light, recyclable, easily moulded and the surface must be smooth and resistant to corrosion.

(i) Communal containers

Generally, the containers used for waste storage are communal containers, which a compactor collection vehicle can lift and empty mechanically.



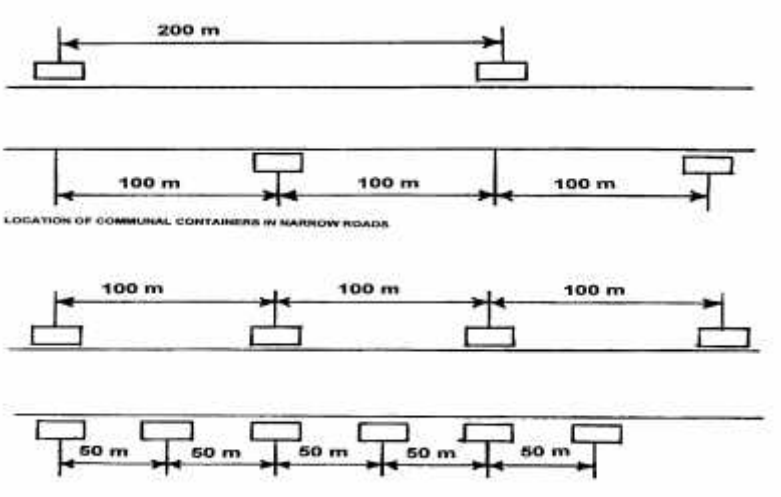
Typical Communal Container

The use of communal containers is largely dependent on local culture, tradition and attitudes towards waste. Communal containers may be fixed on the ground (stationary) or movable (hauled). Movable containers are provided with hoists and tails compatible with lifting mechanism of collection vehicles and such containers have capacities of 1 – 4 m3. The waste management authority must monitor, maintain and upgrade the communal containers.

In areas with very high waste generation rates, i.e., rates exceeding two truckloads daily, such as wet markets, large commercial centres and large business establishments, roll-on-roll or hoisted communal containers with capacities of 12 – 20 m3 and a strong superstructure with wheels are used. Normally, the collection vehicle keeps an empty container as a replacement before it hauls the filled container. When a truck is used as a collection vehicle, the use of communal containers may be appropriate.

It is advisable to place the containers 100 – 200 m apart for economic reasons. The communal containers are usually staggered such that the effective distance of 200 m is maintained as shown

in the below Figure. In a second phase, when the system is economically sustainable, the distance can be reduced to 100 m for example.



This means that the farthest distance the householder will have to walk is 50 meters. However, in narrow streets with low traffic, where the house owner can readily cross the street, a longer distance is advisable. If the collection vehicle has to stop frequently, say, at every 50 m or so, fuel consumption increases, and this must be avoided. In contrast, the placement of high number of containers in the same (four and more) may cause the throw of garbage out of containers which brings long stopping time (waste needs to be collected manually by crew) and consequently inefficient collection service.

(i) Maintenance of the bins.

The major disadvantage of communal containers is the potential lack of maintenance and upgrading. The residuals and scattered solid wastes emit foul odours, which discourage residents from using the containers properly. The maintenance (repair and regularly washing) of the bins is of very big importance for the sustainability and the global cost of the system: each damaged bin will need much more time to do the same work of loading the waste. If repairs (wheels, cover, etc.) are not done with regularity, the time and costs of collection will increase in a few months. So it is very important to insure that each damaged bin must be identified and repaired in a few days.

In addition, if fixed containers are built below the vehicle level, the collection crew may be held responsible for sweeping and loading the solid wastes into transfer containers before being loaded into the collection vehicle. Sweeping and cleaning the communal containers of residuals obviously impinge on the time of the crew members and take a longer time than if the wastes are placed in smaller containers. As fixed communal containers have higher rates of failure, their use is not advisable.

To overcome the problem of maintaining communal containers, individual residents should maintain their own containers and locate them in designated areas. The communal area must have water and drains to facilitate the cleaning of the containers. This practice has the advantage of reducing the number of collection stops and at the same time maintaining the householder's

responsibility for cleaning them. The residents must also be properly educated on the importance of good housekeeping as the containers in the communal area are subject to vandalism. In the main, if communal containers are to be successful, the design of the containers, loading and unloading areas, and collection vehicle accessories should be coordinated.

(ii) Management of the number of the bins

In the same order it is of very high importance to control and correct the efficient number of bins in the collection points. The number of bins must be adapted so that:

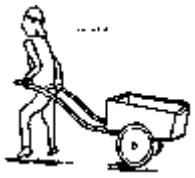
- they are enough bins in each collection point for the quantity of waste: it is necessary to avoid that the waste are put on the floor because of insufficient number of bins, This is important not only for the bad image it can give, but mostly because the work and time used for collecting the waste on the floor is very bigger than to collect the waste in the bins.
- They are not too much bins in total.

For this control it is important to have an organization and also an identification of the bins and a list of bins, repairs and position of each. It is also important to define a budget for buying bins regularly, when necessary. The cost of buying a limited number of bins is much lower than the additional cost for collection of waste lying on the ground.

3.2 Collection vehicles

Almost all collections are based on collector and collection crew, which move through the collection service area with a vehicle for collecting the waste material. The collection vehicle selected must be appropriate to the terrain, type and density of waste generation points, the way it travels and type and kind of material. It also depends upon strength, stature and capability of the crew that will work with it. The collection vehicle may be small and simple (e.g., two-wheeled cart pulled by an individual) or large, complex and energy intensive (e.g., rear loading compactor truck). A description of some vehicle types follows:

a) **Small-scale collection vehicles**: These are common vehicles used for collection of waste in small scale or litter or for the collection of litter from sidewalk bins. This vehicle normally goes to the next public container.

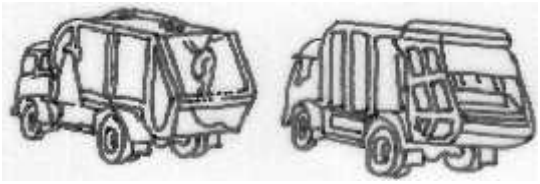


b) **Non-compactor trucks:** Non-compactor trucks are efficient and cost effective only in specific cases, where distances are very small, in small cities.

When these trucks are used for waste collection, they need a dumping system to easily discharge the waste. It is generally required to cover the trucks in order to prevent residue flying off or rain soaking the wastes. Trucks with capacities of 10 – 12 m3 without compaction are effective, if the distance between the disposal site and the collection area is less than 5 km; if the distance is longer, other compactor vehicles or a potential transfer station closer than 5 km from the collection area is required.

Non compactor open trucks are preferable even to transport heavy material like earth materials. They are not so good to collect urban waste (too much consumption,), but are used for collecting special waste like inert or construction waste**.**

c) ***Compactor truck:*** Compaction vehicles are the common system, generally having capacities of 12 – 23 m3 due to limitations imposed by narrow roads. Although the volume capacity of a compaction vehicle, is similar to that of a dump truck, the weight of solid wastes collected per trip is 4 to 5 times larger since the wastes are hydraulically compacted:



A compactor truck allows big (generally 1100 l) waste containers to be mechanical emptied into the vehicle from the rear, front or sides and inhibits vectors (of disease) from reaching the waste during collection and transport. It works poorly when waste stream is very dense, wet, collected materials are gritty or abrasive, or when the roads are dusty. The advantages of the compactor collection vehicle include the following:

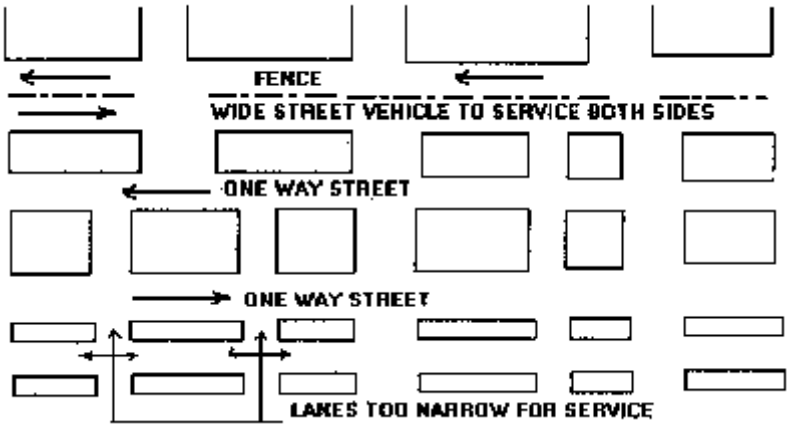
- Containers are uniform, large, covered and relatively visually inoffensive;
- Waste is set out in containers so that the crew can pick them up quickly; the reduced time of charging the waste is an essential key element for cost reduction, as well as for crew number and truck time and consumption.
- Health risk to the collectors and odour on the streets are minimised;
- Waste is relatively inaccessible to the waste pickers.

Maintenance of the trucks: The good and regular maintenance of the trucks is of high importance too. If the truck is damaged, the service can be completely stopped. The waste trucks suffer generally much more than a normal truck, because of the frequent stop and go, the abrasiveness of the waste, the specific needs of the hydraulic system, etc. It is also necessary to have a good and very regular maintenance of the truck to ensure the service every day of the year.

3.3 Movement of collection crew

The movement of collection crew, container location and vehicle stopping point affect collection system costs. The following figure highlights the distance the collection crew will have to walk, if it were to serve the farthest point first or serve the point closest to the vehicle:

Effect of Container Location and Vehicle Stopping



The difference may be one or two minutes per collection stop, but it matters with the number of stops the crew will take in a working shift. Multiplying the minutes by the total number of crew working and labor cost depicts the amount of labor hours lost in terms of monetary value.

Generally, familiarity of the crew with the collection area improves efficiency. For example, the driver becomes familiar with the traffic jams, pothole s and other obstructions that he or she must avoid. The crew is aware of the location of the containers and the vehicle stops. It is, therefore, important to assign each crew specific areas of responsibility. Working together also establishes an understanding of the strong and weak points of the team members and efficient work sequences. The collection operation must also observe a strict time schedule. Testing of new routes, new devices and vehicles is best carried out first in the laboratory and later in a pilot area. Testing of a new sequence using the whole service area could result in disorder and breakdown of the solid waste collection system.

a) Motion Time Measurement (MTM) technique

Motion time measurement (MTM) studies are now an integral part of the standard procedure in the development of solid waste collection systems. MTM is a technique to observe and estimate the movement of the collection crew with the help of stopwatches. The results thus gathered are tabulated as shown in the following table to determine the best sequence of activities that workers must follow in order to complete a repetitive task in the shortest possible time:

MTM Study: Determination of Time, Distance and Number on Containers in Collection Route

	Time		Odometer (Km)	Number of Containers	Collection time (Minute Second)	Trip time to next Station
	Arrival	Departure				
Garage						
1 Station						
2 Station						
.						
.						
.						
20 Station						
Last Station						
Disposal Site Total						
Weight	With Load:.....Tonne					

MTM also helps in deciding the best combination of equipment (collection points, bins) to maintain a desired level of output, reduce health problems related to the repetitive work sequence and predict the effects of changes in materials handled.

Sophisticated MTM studies involve hidden or open video cameras at different collection stops to record, replay and study the operation sequence of the collection crew. If the crew is conscious of being observed, they tend to work faster and reduce time wastage in unauthorised salvaging and other non-scheduled activities.

b) Collection vehicle routing

Efficient routing and re-routing of solid waste collection vehicles can help decrease costs by reducing the labour expended for collection. Routing procedures usually consist of the following two separate components:

- **Macro-routing:** Macro-routing, also referred to as route-balancing, consists of dividing the total collection area into routes, sized in such a way as to represent a day's collection for each crew. The size of each route depends on the amount of waste collected per stop,

distance between stops, loading time and traffic conditions. Barriers, such as railroad embankments, rivers and roads with heavy competing traffic, can be used to divide route territories. As much as possible, the size and shape of route areas should be balanced within the limits imposed by such barriers.

- **Micro-routing:** Using the results of the macro-routing analysis, micro-routing can define the specific path that each crew and collection vehicle will take each collection day. Results of micro-routing analyses can then be used to readjust macro-routing decisions. Micro-routing analyses should also include input and review from experienced collection drivers.

The heuristic (i.e., trial and error) route development process is a relatively simple manual approach that applies specific routing patterns to block configurations. The map should show collection, service garage locations, disposal or transfer sites, one-way streets, natural barriers and areas of heavy traffic flow. Routes should then be traced onto the tracing paper using the following rules:

- Routes should not be fragmented or overlapping. Each route should be compact, consisting of street segments clustered in the same geographical area,
- Total collection plus hauling time should be reasonably constant for each route in the community,
- The collection route should be started as close to the garage as possible, taking into account heavily travelled and one-way streets,
- Heavily travelled streets should not be visited during rush hours,
- In the case of one-way streets, it is best to start the route near the upper end of the street, working down it through the looping process,
- Services on dead-end streets can be considered as services on the street segment that they intersect, since they can only be collected by passing down that street segment. To keep right turns at a minimum, (in countries where driving is left-oriented) collection from the dead-end streets is done when they are to the left of the truck. They must be collected by walking down, reversing the vehicle or taking a U-turn,
- Waste on a steep hill should be collected, when practical, on both sides of the street while vehicle is moving downhill. This facilitates safe, easy and fast collection. It also lessens wear of vehicle and conserves gas and oil,
- Higher elevations should be at the start of the route,
- For collection from both sides of the street at the same time, it is generally best to route with long, straight paths across the grid before looping anti-clockwise.
- For certain block configurations within the route, specific routing patterns should be applied.

3.4 Transfer Station

Transfer station is a centralised facility, where waste is unloaded from smaller collection vehicles and re-loaded into large vehicles for transport to a disposal or processing site. This transfer of waste is frequently accompanied by removal, separation or handling of waste. In areas, where wastes are not already dense, they may be compacted at a transfer station. The technical limitations of smaller collection vehicles and the low hauling cost of solid waste, using larger vehicles, make a transfer station viable. Also, the use of transfer station proves reasonable, when there is a need for vehicles servicing a collection route to travel shorter distances, unload and return quickly to their primary task of collecting the waste.

Limitations in hauling solid wastes are the main factors to be considered, while evaluating the use of transfer stations. These include the additional capital costs of purchasing trailers, building transfer stations and the extra time, labour and energy required for transferring wastes from collection truck to transfer trailer.

The main problem in the establishment of a transfer station, however, is securing a suitable site. Stored solid wastes and recyclable materials, if not properly handled, will attract flies and other insect vectors. Odours from the transferred solid wastes will also be a nuisance, if not properly controlled. In addition, the traffic and noise due to small and large collection vehicles, collectors, drivers, etc., invite the resentment of the communities living in the vicinity of transfer stations (EPA, 1995).

a) Types

Depending on the size, transfer stations can be either of the following two types:

(i) **Small to medium transfer stations:** These are direct-discharge stations that provide no intermediate waste storage area. The capacities are generally small (less than 100 tonnes/day) and medium (100 to 500 tonnes/day). Depending on weather, site aesthetics and environmental concerns, transfer operations of this size may be located either indoor or outdoor. More complex small transfer stations are usually attended during hours of operation and may include some simple waste and materials processing facilities. For example, it includes a recyclable material separation and processing centre. The required overall station capacity (i.e., the number and size of containers) depends on the size and population density of the area served and the frequency of collection.

(ii) **Large transfer stations*:*** These are designed for heavy commercial use by private and municipal collection vehicles. The typical operational procedure for a larger station is as follows:

- When collection vehicles arrive at the site, they are checked in for billing, weighed and directed to the appropriate dumping area;
- Collection vehicles travel to the dumping area and empty the wastes into a waiting trailer, a pit or a platform;

- After unloading, the collection vehicle leaves the site, and there is no need to weigh the departing vehicle, if its weight (empty) is known;

  Transfer vehicles are weighed either during or after loading. If weighed during loading, trailers can be more consistently loaded to just under maximum legal weights and this maximises payloads and minimises weight violations.

b) Designs for larger transfer operations

Several different designs for larger transfer operations are common, depending on the transfer distance and vehicle type. Most designs, however, fall into one of the following three categories:

(i) Direct-discharge non-compaction station: In these stations, waste is dumped directly from collection vehicle into waiting transfer trailers.

(ii) Platform/pit non-compaction station: In this arrangement, the collection vehicles dump their wastes onto a platform or into a pit using waste handling equipment, where wastes can be temporarily stored, and if desired, picked through for recyclables or unacceptable materials. The waste is then pushed into open-top trailers, usually by front-end loaders.

(iii) Compaction station: In this type of station, the mechanical equipment is used to increase the density of wastes before they are transferred. The most common type of compaction station uses a hydraulically powered compactor to compress wastes.

c) Calculate Transfer Capacity

Transfer station capacity can be determined using the following formulae:

(Pit stations: Based on the rate at which wastes can be unloaded from collection vehicles:

$C = P_c \times (L/W) \times (60 \times H_w/T_c) \times F$

Based on rate at which transfer trailers are loaded:

$C = (P_t \times N \times 60 \times H_t)/(T_t + B)$

Direct dump stations: C = (Nn x Pt x F x 60 x Hw)/ [((Pt/Pc) x (W/Ln)) x Tc + B]

Hopper compaction stations: C = (Nn x Pt x F x 60 x Hw)/[(Pt/Pc x Tc) + B]

Push pit compaction station: C = (Np x Pt x F x 60 x Hw)/[(Pt/Pc x W/Lp x Tc) + Bc + B]

Where:

C = Station capacity (tonnes/day); P_c = Collection vehicle payload (tonnes); L = Total length of dumping space (feet); H_w = Hours per day that waste is delivered; T_c = Time (in minutes) to unload each collection vehicle; F = Peaking factor (ratio of the number of collection vehicles received during an average 30-minute period to the number received during a peak 30-minute period); L_p = Length of push pit (feet); N_p = Number of push pits; B_c = Total cycle time for clearing each push pit and compacting waste into trailer; P_t = Transfer trailer payload (tonnes); N = Number of transfer trailers loading simultaneously; H_t = Hours per day used to load trailers

(minutes); B = Time to remove and replace each loaded trailer (minutes); T_t = Time to load each transfer trailer (minutes); N_n = Number of hoppers; L_n = Length of each hopper (feet).

d) Viability of transfer station

Transfer stations offer benefits such as lower collection costs (because crews waste less time travelling to the site), reduced fuel and maintenance costs for collection vehicles, increased flexibility in selection of disposal facilities, opportunity to recover recyclables or compostables at the transfer site and the opportunity to shred or scoop wastes prior to disposal. These benefits must be weighed against the costs to develop and operate the facility. The classical approach to arrive at the economic viability of operating a transfer station is to add the unit cost of the transfer station to the cost of hauling using large vehicles, and to compare this cost with the cost of hauling directly to the disposal site using the smaller vehicles that service the collection area.

The distance between the disposal site and collection area is one of the principal variables in deciding whether to use a transfer station or haul the solid wastes directly from the collection area to the disposal site. The cost-effectiveness of a transfer station depends on the distance of disposal site from the generation area, and a distance of 10 – 15 km is usually the minimum cost-effective distance (Phelps, et al., 1995).

The analysis on the need for a transfer station should be based on “economic travel times” and “distances for direct haul” by collection vehicles. According to World Bank standards: no more than 30 minutes travel time one way for collection vehicles carrying under 5 tones/load, and no more than 45 minutes travel time one way for collection vehicles carrying 5 to 8 tones) and, if appropriate in terms of “economic breakpoints” for optimum utilization of equipments- no less than 120 tons/day per transfer station.

4. WASTE COLLECTION SYSTEM PLANNING/ DESIGN

4.1 Elements to design and evaluate waste collection service

Note that waste collection often proves to be the most costly component of any waste management system. However, with a proper collection system design and management, we can significantly reduce the costs.

Before starting a new waste collection service or improve the existing one, it is important that the authorities take basic decisions on the main elements of the quality of the service of waste collection, which are the following:

a) Zone of collection

First step on designing a waste collection system start by defining the zone of collection or waste service area where the local authority plans to offer or improve the waste collection service.

The local authority has to define how far they plan to give the service of waste collection. Larger will be the area of recollection, more expensive it will be. For example, for a new waste collection service, the service can be limited to the center of the commune and to the market places, or limited to the main streets. In a second step, the service can be developed in other areas of the commune.

b) Distance between the inhabitants and the waste collection points.

Normally, as mentioned earlier, it is expected that people can do 100 m from their home to the next collection point. If the distance is defined as shorter, the number of collection points will be bigger and the service more expensive. For individual houses which are far away from the village, it must be defined if the truck must – and can – reach the place – which could be expensive – off if a collection point can be placed on the main street, not far from the beginning of the road to this place.

c) Streets to be served by the waste collection

The streets where the truck will go for the waste collection must be defined. Longer the route, more expensive the service will be.

Generally it is important, for safety reasons and for limiting the cost, that the truck doesn't have to do complicated handling like go and back, reverse driving, etc.

Normally, the route must follow the main streets, where people are living.

d) Points of waste collection

In addition, the local authority should design the number and positions of public waste collection points (network). This can be done in discussion with head of quarter- if they are - or with representative of the population as well as considering the specifications and important factors mentioned at Section 2 of this module

e) Roads of streets cleaning

The cleaning of the street has an influence on the position of the collection points, because the waste collected in cleaning the streets must normally be places on one or more waste collection point.

f) Frequency of collection

It must be defined the frequency of collecting the waste. The total volume of the bins to be collected is equal to the produce volume per day by the maximum number of days between 2 collections.

But at the end the important for the cost reduction is that the truck will be full once he finishes his collection tour. If the truck is not full, the cost of transportation will be too high. This point, depending on the sizes of the Commune and of the truck, and of the production of waste, can do that it could be preferable to collect the waste every 2 days or less ore to organize the collection integrating various LGU.

g) Hours of collection

The cheaper solution is to use the truck at full time making 3 collections of 7-8 hours in the 24 hours of the day. This allows to reduce the number of required trucks: for one 7-8 hours tour in the day, it requires 3 time more trucks than for 3. For this reason, the possibility to integrate various LGU in the organization can reduce the cost.

The best solution is often to make the waste collection in the most urban areas in the night, and to use the time of the day for collecting more rural or quite areas (for the traffic).

h) Type of bins

The choice of the type of bins is an important element of the planning. It is very important to choose a standardized of bins, and only one, and to have enough bins to be sure that all the waste will be in the bins and not on the floor.
The normal, very commune, standard, size of bin in Albania is the 1100 l bin, plastic or metallic. These types of bin need a technological truck, with an hydraulic loading system, which is also very standard in the country.

We recommend using this kind of 1100 l bin. The metallic ones are a little bit more expensive at the beginning than the plastic ones, but they are less sensible to the fire (frequent), and can be repaired. So we recommend also the metallic ones.

i) Ownership of the bins

They are 3 possible solutions:

1- The bins are owned by the inhabitants : they are forced to buy bins of the standardized type, eventually with an financial help of the commune : each bin has an owner and are marked as well.

2- The bins are owned by the commune: each bins has a number and indication of the commune.

3- The bins are owned by the company collecting the waste.

j) Public/private collection

It must be defined if the waste collection service is done by the own public service of the commune ore if it is done by a private company or by an association of LGUs for example.

4.2 Municipal waste generation

It is necessary to find out the waste generated within local boundaries in total and if possible according to:

- The "sources of waste"(inhabitant, commercial, markets, restaurants, hospital, industry, etc.);

- The “waste streams” : municipal waste, urban waste, inert and C&D waste, non-municipal waste, hazardous waste, etc;

To collect this information the local authorities should have established estimation or a monitoring and auditing structure and keeps a local register for their waste.

In the absence of this information the LGU may refer to national data and rate (average rate which varies from 0.4-0.9 kg/inhabitant/day) in accordance with LGU characteristics (population, commercial and industry activities, etc.)

Type of LGU	**Quantity**
Rural/ Commune	0.3 kg/person/day
Municipality <25,000 inhabitants	0.5 kg/person/day
Municipality >25,000 inhabitants but <50,000 inhabitants	0.6 kg/person/day
Municipality >50,000 inhabitants but <200,000 inhabitants	0.7-0.8 kg/person/day
Municipality >25,000 inhabitants but <750,000 inhabitants	1.2 kg/person/day

Typical values for the different Albanian LGU[1]

Anyway, the LGU should know how to measure its own waste generation, to predict and calculate future waste arising.

4.3 How to measure waste quantity

There are different methods to quantify the volume of waste generated locally.

One used method consists of the weighing of the loaded trucks before disposing to the final destination (recycling facility, transfer station, incinerator or landfill). For this purpose, in the entrance of these facilities should be installed the reception equipments such as weighing scale and should be established registering procedure including the waste register.

Another method consists of only measuring the volume of waste, making an estimation of the rate of filling the bins and trucks.

At the same time measuring waste generation at source is more accurate methods. This method is more appropriate to measure waste generation for big consumers (business, industry and institutions served with individual/ separate waste collection system.

4.4 Waste characteristics

The Waste Audit basically served to characterize the composition of municipal/communal waste and to determine the proportion of recyclable wastes, compostable wastes, hazardous etc and

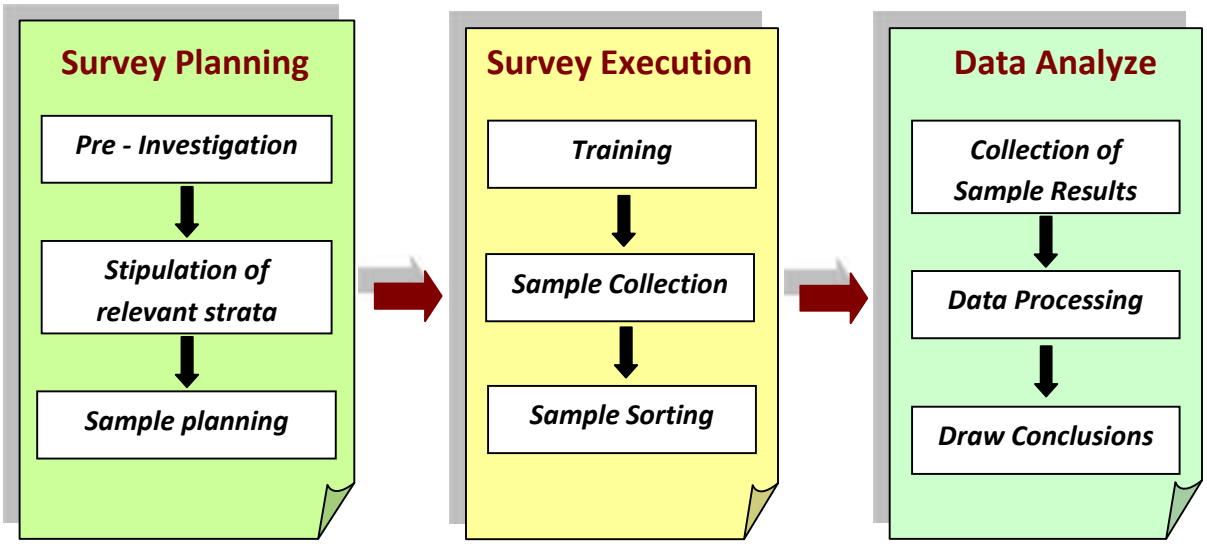
[1] Source: INPAEL Project

consequently the potential for reducing waste quantities or whether materials recovery, composting, or waste-to-energy techniques might be more viable and economic to disposal option.

	Lushnje	Berat	Lezha	Shkoder	Durres	Tirane	Vore	F.Kruje
Organic	48.72	46.16	45.28	44.99	48.78	43.53	50.60	50.82
Wood	1.28	0.19	1.05	2.13	0.53	1.06	0.90	4.34
Paper	4.78	4.96	5.75	4.43	6.69	7.75	3.58	5.08
Cardboard	7.25	6.46	9.73	8.73	8.93	10.56	9.04	4.40
LD-Plastics	10.66	8.54	9.72	10.82	7.98	6.71	6.71	6.55
HD-Plastics	4.08	4.48	5.34	3.15	6.75	6.28	3.92	4.41
Glass	2.79	8.66	6.77	6.36	6.17	5.12	4.30	5.87
Textiles	6.69	6.99	3.07	5.64	2.86	7.50	5.87	3.60
Metals- ferrous	0.20	0.57	0.52	0.59	0.65	0.70	0.74	0.55
Metals- non-ferrous	0.46	0.36	0.74	0.60	0.65	0.54	0.49	0.76
Hospital products	0.10	0.05	0.55	0.13	0.20	0.10	0.06	0.20
Rubber products	0.12	0.10	0.39	0.09	0.46	0.22	0.16	0.06
Inert	8.13	8.40	4.10	6.50	4.74	5.62	9.86	10.31
Sun-Pro products	3.84	2.37	4.53	3.87	2.92	3.27	3.11	2.14
WEEE	0.14	0.09	0.07	0.70	0.97	0.15	0.25	0.18
Battery	0.02	0.01	0.01	0.01	0.02	0.02	0.01	0.04
By-animal products	0.73	1.61	2.39	1.25	0.69	0.88	0.39	0.70

Typical values for the different Albanian LGUs[2]

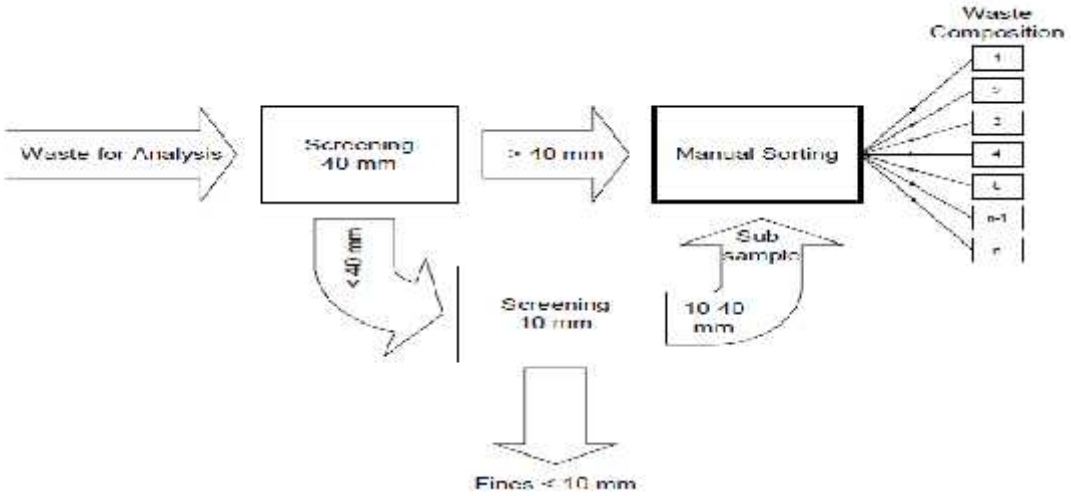
The overall approach to waste composition survey consists of three main elements and a number of steep within each element, see Figure 1 below:



Overview of methodology for generating a waste composition profile

[2] Source: Co-Plan (2009)"Waste characterization survey in Albania"

Sorting procedure:



4.5 Waste under local responsibility

What Policy, legislation, national and local rules on waste management determines and classify types of waste:

a) Definition of waste: Under the Law "On public disposal of waste", No. 8094, dated 21.03.1996, "waste is considered to comprise the materials or the objects created by human activity, household economies or the natural cycles, abandoned or destined for abandonment". According to Law "On the environmental management of solid waste", no. 9010, dated 13.2.2003, "Solid Waste" is considered to comprise any substance, any object or part of object, which are not anymore in use or which otherwise their possessor wants to throw away";

b) The Law on Solid Waste Management which also defines some types of waste, as follows:

(i) Urban waste is considered the household, administrative, social and public buildings waste, including also the waste generated as result of commercial activities, entertainment and rest places the quantity and composition of which does not impede their treatment together with the urban waste; Local authorities are responsible for formulating rules on a case by case basis on the prototype by making reference to the prototype rules approved by central government (art. 11-19 of the Law on Solid Waste Management);

(ii) Industrial waste is waste generated from industrial and handmade activities as well as services;

(iii) Hospital waste is waste generated from hospitals and health services, medical research institutes, including hazardous and non- hazardous materials;

(iv) Construction waste is waste such as stones, soil, concrete, tile that are left from the activities of construction, re-construction, repair and demolition of buildings and other structures;

(v) **Agricultural and animal farming waste** is waste generated from the farmer's activities;

(vi) Bulky waste is waste of big size equipments and machineries, the collection, transportation and disposal of which requires unique technicalities and methods (art. 2 of the Law on Solid Waste);

(vii) Mining waste is waste generated by the exploration and exploitation of mining resources (art. 14 of the Law on Solid Waste Management);

The Albanian Waste Catalogue was drafted in accordance with the European Waste Catalogue and Hazardous Waste List, pursuant to article 1(a) of Directive 75/442/EEC on Waste and article 1(4) of Directive 91/689/EEC on Hazardous Waste. The Albanian Waste Catalogue classifies the waste into non-hazardous waste and hazardous waste.

c) Waste streams under municipal/communal responsibility: Municipal waste which includes the urban streams as specified at urban waste definition (refer to the Law) is the main focus of the local authorities. Meanwhile other waste streams classified as bulky waste, inert waste, WEEE waste, garden waste generated at household level are called "special waste" for which municipality will provide in cooperation or establishing "bring scheme facilities", while will be under producer responsibility its collection and transportation.

In the meantime they will address issues either for other non-municipal waste which are not under local authorities' jurisdiction, but will engage them in cooperate or/ and facilitate its collection and final management. The purpose is not to make the municipality responsible for collection and treatment of the waste but just to strengthen the society's control over the waste.

4.6 Determine number of trucks and bins required

a) In order to choose the best waste collection system that better fits locally or regionally is necessary to give main alternatives (options) how to collect municipal waste and then select which is more adequate by assessing costs and pros and cons per each case. There are three different types of collection methods: simple emptying, exchange, and one-way. In addition, a nonsystematic collection system is used for picking up bulky waste and bulky waste and bulky items (e.g., furniture, appliances). Each collection method has compatible or dedicated container systems and vehicles with appropriate loaders.

(i) Simple Emptying method: is primarily used for the hauling of residential and small scale commercial waste and uses public wheeled containers that are positioned out in public space (along side roads or within neighborhoods) and individual portable bins that are set out by the consumers and then collected by the municipal vehicle. Public collection system is the most largely used by Albanian municipalities and most of the communes.

(ii) The exchange method: (or direct transportation) is suitable for high density waste e.g., construction debris and inert, as well as for low-density (urban) waste from facilities that generate large quantities of waste, e.g., manufacturing or industrial plants, large hotels, institutions, offices, or multi-story buildings. When this method is used, full containers (4 m^3-32 m^3) are exchanged with identical empty containers at their original location. The fill containers are taken and emptied at the disposal site and are used elsewhere. The appropriate

vehicle for picking up these containers is called tilt-frame loaders. This method is considered appropriate for on-call schemes where consumers ask for additional waste collection services.

(iii) One-way method: In the one-way method, waste is picked up "door-to-door" in clear plastic or paper bags. The collection process is rather easy because there are no emptied containers to be returned to the curb. However, the bags are picked up by hand and this may place considerable physical demands on the collection personnel. Most often are used bags in volume of 50-70 liters and limited to a maximum of 110 liters.

(iv) "Drop-off" systems: In the drop-off systems mostly used for recyclables and bulky waste, where waste are taken by the consumers to a municipal central location at appropriate place or appropriate containers.

b) In order to choose best economically waste collection system that local authority or inhabitants can afford. In order to provide a affordable waste collection service, local authorities may analyze local income or perform an demand assessment survey targeting its inhabitants.

- **Low Cost System**: A large communal container - probably of 5 to 8 cubic meters capacity would be placed in a neighborhood at a central location and each household and establishment would be expected to carry its container of refuse to empty it into the container. The container would have an attendant to sweep the area and keep it tidy. A vehicle would pick up the container and take it away to be emptied before it is completely full.

- **Low Cost System:** A vehicle would come to the neighborhood on a scheduled basis and park for a few minutes at each block or road junction to collect solid waste. When the vehicle parks, it would ring a bell, sound its horn to summon residents to bring their containers out to be emptied. All waste in the neighborhood would be kept inside until the vehicle comes.

- **Medium Cost System:** Medium communal containers would be placed in the neighborhood. It is required to carry/throw the waste to the communal container and a compacted truck empty the containers daily or before it is completely full.

- **Higher Cost System:** A vehicle would come to the neighborhood on a scheduled basis and provide a door-to-door service. At each building, containers of waste, which have been left at the curbside, would be emptied into the vehicle. The emptied containers would be placed neatly at the curb for residents to bring back into their household (or establishment). Residents would be required to adhere to the schedule and bring their waste to the curb in proper containers before the vehicle arrives.

c) Waste collection capacity required: consists of calculation of volume and tonnage of municipal waste that should be removed (collected and transported) and then define the temporary storage (bins/ containers) and vehicles/truck capacity to transport to the final treatment facility. For this purpose the authority (managers and technical staffs) should determine and select appropriate vehicles/trucks and bins for the selected waste collection schemes.

d) Frequency of recollection: In line with the selected waste management schemes it is important to decide the most effective and efficient collection frequency considering also urban typology, population density and distances from main roads; A USEPA study[3] found that once-a-week systems collect 25 percent more waste per collection hour, while serving 33 percent fewer homes during that period. Personnel and equipment requirements were 50 percent higher for once-a-week collection (USEPA 1974a). Some communities with hot, humid climates maintain twice-a-week service because of health and odor concerns.

e) Determining the disposition of the collecting points: public-collective/ private-individual; at source/curbside …that better work with selected waste collection system or for different costumer. (inhabitants, business, institutions or industry)

4.7 Calculate needed resources and work schedule aiming the optimization of waste collection[4]

Principles, how to optimize waste collection service: ("*trucks utilization and time efficiency are the keys"!*) This objective is strongly related on improvement of effectiveness and efficiency of operation due to better routing and better containers and waste trucks performance. Reduction of overall collection time and more precisely- uploading time, avoidance of half-loaded trips, or the use of good trucks with better payload capacity will enhance effectiveness and efficiency of waste collection. This will require:

a) Define the collection points and than for each one an approximate number of bins in relation with the professional activities (markets, etc.), the number of concerned inhabitants and the specific waste production. One important hypothesis is the density of waste in the container, or the weight of waste a container can store in average. This is strong related to the composition of waste and of the quantity of cardboard: more cardboards, less waste in the bin. Following the experiences made in Albania, the average density vary from 112 kg/m3(in Shkodra[5]) to 118 kg/m3 (in Fier[6]), which mean that in average a 1100 l bin can carry 125-130 kg of waste.

After some weeks of experience it must be controlled if the number of bins is appropriate to the real quantity of waste collected at each collecting point, and the number of bins must be adapted. The control and adaptation must be followed all along of the years.

b) Determine the possible and effective routes for waste collection in accordance with waste collection network aiming the optimization of services (see above)

c) Another important issue on waste transportation consists of the use of transiting (transfer station). As previous cited, the analysis should be based on "economic travel times" and "distances for direct haul" by collection vehicles and standards. The use of multifunction transit-station for the purpose of transferring residual (mixed) waste to regional plant

[3] Decision Makers' Guide to Solid Waste Management—Vol. II , EPA

[4] The development of this section will be more concrete during exercises

[5] Felix Schmidt feedback

[6] Co-Plan (2010): Study in purpose of EELGP Project;

remains a possibility which should be analyzed when the final treatment plant design has been decided.

Volume of work (time, km): Calculation of time of use of the vehicles for recollection, transportation, maintenance. Calculation of km for each vehicle and overall comprising collection, transportation and transiting if required. A Waste collection Model[7] recommended to calculate the volume of work and to evaluate the efficiency of waste collection by a two-person crew working with a rear-loading compactor as follows:

P= 0.0033D + 0.16N + 0.09T + 0.03S + 0.02,

Where

P= productive collection time required per stop including the driving time from the previous stop (min)

D= distance between stops (m)

N= number of refuse containers at each stop;

T = total number of throw-away items at a stop

S= number of services collected at each stop.

For one operator, using a rear –loading compactor, the equation is modified to:

P= 0.0165D + 0.15N + 0.089T + 0.08.

However, this model does not consider other factors like non-productive time, waste characteristics and so on, but is based on route-related only.

d) Determine the required number of human resources (operative workers and supervisors), job description and time allocation of personnel; the optimum crew size for a community depends on labor and equipment costs, collection methods and route characteristics.

There has been a trend toward (1) decreasing frequency of collection, (2) increasing requirements on residents to sort materials and transport them to the curb, and (3) increasing the degree of automation used in collection; and consequently has resulted in smaller crews in recent years.

Generally, a one-person crew can spend a greater portion of its time in the productive collection of wastes than a two- or three-person crew can. Multiple-person crews tend to have a greater amount of nonproductive time than do single-person crews because non-driving members of the crew may be idle or not fully productive during the haul to the unloading point. Some communities address this problem by requiring that non-drivers perform other duties, such as cleaning alleys, while the driver hauls collected wastes to the disposal or transfer facility. Although the one-person crew has the greatest percentage

[7] Stearns Model (1982)

of productive time, many municipalities use larger crews, mainly for three reasons: some trucks (for example, rear-loading packers) do not readily support use of a single-person crew, the municipality wants to provide a higher level of service than one-person crews can provide, or labor contract provisions require more than one person on each crew. These multi-person crews can be efficient if properly trained and provided with suitable performance incentives.

e) Calculation of annual vehicle and labour costs:

Vehicle costs = Depreciation + Maintenance + Consumables + Overhead + License + Fees + Insurance;
Labour costs = *Drivers* salary + Crew salaries + Fringe benefits + Indirect labour + Supplies + Overhead

f) Assessment of the waste collection options and best scenario, calculation and comparison of time, volume, weight, costs). The best scenario consists of the most effective and most efficient option or group of options.

g) Define waste collection schedule: the volume of work comprising personnel assigned, time schedule and other specifications of waste collection services; the working schedule should be approved by local officials.

h) Control and adapt the system in order to reduce time of work and distances.

5. HUMAN RESOURCES MANAGEMENT

5.1 Efficient management of human resource:

Usually in Albania as in other developing countries, waste collection is assigned to the lowest social group. More often, the collection crew member accepts the job as a temporary position or stopgap arrangement, while looking for other jobs that are considered more respectable.

Apart from this cultural problem, the attitude of some SWM authorities affects collection operation. For example, some authorities still think that the collection of solid waste is mechanical, and therefore, the collection crew does not need any training to acquire special skills. As result, when a new waste collector starts working, he or she is sent to the field without firm instruction concerning his or her duties, responsibilities and required skills. For an effective collection operation, the collection team must properly be trained. The collection crew and the driver of the collection vehicle must, for example, work as a team, and this is important to maintain the team morale and a sense of social responsibility among these workers.

a) Clear jobs description, responsibility and discipline:

The good management of collection crew is essential for the success and cost of waste collection. The management process must be based on clear organisation and hierarchy: who decides who gives the order and control?

Clear rules of work: time for beginning, hours of effective work, quantity of work to be done, routes, required equipment, correct handling of material (bins), correct but limited time of rest, hygiene, no robbery, etc., as well as penalties for inconvenient comportments.

Personnel should have clear responsibilities and job description: This means that at first it should be prepared a job-description (working program) and working schedule documents on each activity and each waste facility. The following table presents an example of "Personnel Types and Descriptions", including training needs and responsibilities for each position.

Position	No. of personnel	Responsibilities
Supervisor	**1**	Control daily work operations, schedules, equipment maintenance and repair, direct supervise of personnel and direct control of safety procedures, etc
Manager	**1**	Overall manage and control of the operations and human resources and direct supervise of the supervisors; plan and design services, investments, estimate costs, safety and health measures, etc.
Driver	**6**	Collecting and transporting waste, supervise worker operations, ensure the fulfillment of schedules, procedures and rules, etc;
Mechanic	**1**	Maintain vehicles and equipments, follow procedures and rules;
Worker	**12**	Operate waste collection process, and collection aggregate of the truck, follow the schedules, procedures and rules, etc.

An example of personnel types and descriptions[8]

Employment is often tenured, for life and based on political patronage rather than qualifications for the job. Low workforce discipline can seriously hamper service performance and the reliability and regularity of services. Supervisors should be firm in the management of staff, and in particular in ensuring attendance and proper work performance. Sanctions for poor performance may become effective measure securing discipline and accountability.

b) Good work environment and encouragement

[8] The table represents only a general example how to assign personnel and responsibilities. A full personnel structure and their job description should consider all the requirements of this module.

Waste collection workers often suffer from very low morale. This is understandable given the difficult and often unpleasant working conditions that they face, and also their poor public image and stature. Management can become an impossible task where workforce morale is low, and therefore all efforts should be made to improve the morale and public image of waste collection workers and improve working conditions.
Measures that can be employed to boost morale include improving overall working conditions, providing uniforms, incentives for good performance, and training and team building. Collection workers perform an extremely important and valuable role in society and should be regarded accordingly.

Labour productivity is strongly related to:

- Working environment: good and enthusiastic working conditions, safety working environment and safety equipments, under required hygiene and sanitation conditions;
- Poor pay scales, fixed working hours;
- System for approving overtime working and;
- Incentives payments for good performance.

c) Field supervision and inspection:

A critical problem in many cities is the combination of a large number of workers for waste collection and street sweeping, combined with very limited resources for supervision. From experience in industrialized countries, one field supervisor per five to eight collection vehicles is recommended,

The supervision of the quality of the service is important:

- Controls to avoid the robbery of material (fuel, tires, etc.);
- Controls to avoid the robbery of time (additional rests, private tours, private sorting of waste);
- Control of the quality of the service (cleanliness of the streets and collection points, inert wastes, etc);
- Control of the condition (damaged bins to be repaired) and number of bins.

A controller must normally be designed for this, equipped with a bicycle or a motorcycle and mobile phone, in direct relation with the responsible of service.

d) Education/ training*:*

Labour productivity is strongly related with the level of training staff. Efficiencies can be achieved by training workers in the proper use of vehicles and equipment, and using crew sizes that maximize the productivity of the vehicles as well as by training managers and supervisors in running the management and control of the services. There is often limited attention placed on training staff to enable them to carry their jobs more effectively. Not only can focused training deliver improved service performance, but it also provides staff with a sense and vision of personal development and improvement.

6. MAINTENANCE OF VEHICLES AND CONTAINERS

6.1 Maintenance of vehicles

a) Importance of maintenance

Waste collection vehicles are suffering much more the other vehicles, because of the “stop and Go” activities and of the abrasion effect of waste. Most semi-automated and fully automated waste collection vehicles have complex hydraulic systems that require more maintenance than manual collection equipment. Specific schedules of preventative maintenance and proper garaging facilities to undertake both routine maintenance and repair work can contribute substantially to increasing long term vehicle productivity.

b) Maintenance Cost

Maintenance usually amounts to between 10% and 20% of the total annual cost of owning and operating collection vehicles. Every effort should be made to standardize components of the fleet for maximum parts interchange without necessarily standardizing the entire fleet.

c) Operations and safe driving

A very simple step in improving day-to-day maintenance is to assign each vehicle to one driver (or two drivers if a shift system is in use). The driver is then personally responsible and should be encouraged to take pride in looking after his vehicle. Another important issue on ensuring good operation of vehicles is guarantee that operator’s certificate and vehicles test certificates are up to date.

In proposing new waste collection systems there is a need to review vehicle standardization. It is often claimed that vehicle standardization will reduce maintenance costs. While this is, in general, true, it should be ensured that standardization is compatible with the local conditions of the waste collection.

d) Maintenance measures

Routine maintenance regimes can improve safety and reduce business losses. Regular, routine, scheduled cleaning, lubrication, examination and maintenance schedules are important. Other measures include:

- Identification of faults before catastrophic failure: e.g., review breakdowns, braking system, lights and tires regularly and take appropriate action;
- Planed changes of oils, lubricants, antifreeze, filters, exhaust systems, batteries, etc

- Identifying incompatibilities or misuse, and permitting remedial action to be taken, especially where there are: problems with the interface between hoists and bins or equipment used in an inappropriate manner, before the equipment becomes unserviceable;
- To ensure continued safe operation of the hoist, servicing and maintenance schedules for refuse collection vehicles should also include planned servicing and maintenance of the hoist, following the instructions provided by the manufacturer or supplier;
- The waste vehicles shall be washed and disinfected each day at the end of the work.

e) Maintenance and consumption record registers

Each vehicle should have an individual maintenance record that includes the following items:

- Preventive maintenance schedule: A description of repairs and a list containing information on the repair date, mechanic, cost, type and manufacturer of repair parts and the length of time the truck was out of service, for each maintenance event.
- Record faults: Ensure that operatives record faults and initiate repairs consistently;
- Each vehicle should also have an individual consumption and time table record that includes the following items: This record allows to control the consumption of the truck and to control that the staff and driver don't steal fuel or time.
- Daily km
- Daily consumption
- Hours of departure, discharge, return, washing

f) Vehicle Workshops and Stores Management

Adequate stores control and stocking of spares (engines, transmissions, axles, etc.) is essential for reducing down time. Keeping adequate spares allows defective parts to be replaced quickly, and is a major way of reducing downtime. Where possible, the defective part should then be reconditioned. The possibility of the municipality undertaking small repairs and contracting large works to a private contractor should also be evaluated. For solid waste management services in populations in excess of 300,000 inhabitants, it might prove economical to develop a specialized workshop facility for the municipality (possibly contracting out the facility to the private sector).

It is also important to ensure that vehicle types are selected for which spare parts may be easily procured. Many municipalities have been mislead by into purchasing vehicles and machinery for which no spares are available locally and have suffered long and costly delays in procuring replacements from overseas. The key issue can be to purchase locally manufactured vehicles as a priority in order to minimize problems and delays in obtaining spare parts and appropriately qualified mechanics.

Garages and service centers carry out a number of operations and processes that have the potential to damage the environment. These include cleaning of vehicles, the storage, use and disposal of polluting liquids such as oils, paints, solvents, antifreeze and other coolant additives, brake fluids and solid waste such as oil filters, exhaust systems, batteries and tires. Care should be taken in handling of waste materials such as antifreeze, batteries and battery acid, solvents and oil to avoid contamination of surface water drains.

6.2 Maintenance of containers

a) Why it is important

Condition of the containers is a very important factor impacting the effectiveness, costs and efficiency of the entire waste collection service. When the emptying cycle does not work properly, because a container or the wheels are warped, the operation is delayed or blocked, and needs more personal than with a good one, as well as it may bring other costly consequences such as e.g., repair of vehicle or repair of container itself. The difference of time for doing the same job of carrying a certain weight of waste can easy take 2,3 or 4 time more and increases proportionally the costs. As in cases of burns, where deformation of containers or the damage of the covers, wheels or pedals, may cause inappropriateness from its full technical operation, hygienic or aesthetic conditions.

b) Common technical and operational problems

Safe lifting of containers relies upon effective engagement of the container with the hoist and the structural integrity of the container throughout the emptying cycle. In the absence of an effective maintenance regime, or frequent problems are identified on containers during their usage or emptying operation, and consist of:

- Fail during the emptying cycle, (e.g. fall from the hoist due to flexing around the rim of the bin);
- ‘Hang-up’ during the emptying cycle (e.g. when damaged lids catch on the hoist/vehicle structure);
- The damage or deformation of the container body as consequence of accidents, bad operation or in case of burning;
- Damage of wheels and/or led, pedals as consequence of accidents, bad operation or in case of burning;
- Steel and ferrous containers are subject to corrosion; the rust peels off exposing sharp edges, which could be hazardous to the collection crew.

c) Maintenance and repair measures

Routine planned examination of container stock in service should use to identify containers which are likely to be repaired or replaced. Repairs and maintenance to containers should use parts and materials specified in the manufacturer's instructions, or exhibit equivalent or superior performance standards, and are in accordance with the original specification.

All the containers used shall be kept clean, in a good technical condition and be painted in the same color.

Arrangements should be made for prompt reporting and replacement of containers that have been identified as unacceptably worn or faulty. Usually, these arrangements are part of the main service contracts but there are cases when specialized service is required.

7. HEALTH AND ENVIRONMENTAL CONCERNS

7.1 Public and employee health and safety

An effective solid waste management system is necessary to avoid public health disasters, spread of disease and adverse effect on soil, water and air (Phelps, et al., 1995).

Specific rules of hygiene must be defined. Normally the worker should take a shower and change clothes at the end of the work before to go back home. Specific installation must be constructed and maintained. Specific work and security clothes, visible in the night, are very important to reduce the accidents. This is also very important to create a corporate identity and a good image of the service.

Solid waste workers are the most exposed to the risks of parasitic infections and accidents, and therefore, a SWM system must include proper mechanisms to avoid these incidences. To the direct and indirect risks through accidents, exposure and spread of disease, we must add the effect of visual pollution caused by litter and nuisance created by smoke and dust at disposal sites.

The term "emergency" includes a fire, spilles or other hazard that threatens public health and safety, public welfare or the environment during waste management related activities. An emergency situation appears even when external factors like natural disasters, large-scale accidents, strike etc, hamper the collection, transportation and waste disposal activities.

Local officials, emergency management professionals and solid waste managers are advised to evaluate and plan for emergency waste cleanup procedures. Planning for emergency waste cleanup will help protect public health and safety, control cost and stress of the situation, and minimize impact on local communities and the environment.

7.2 Maintain effective response to waste collection emergencies

Waste management companies/ operators should demonstrate competence in ensuring protection of health, and environment during waste collection, transportation and disposal operations. You must identify potential threats arising from your own actions or actions of others in relation with your company, which may be encountered during waste operations, and set up procedures to deal with them.

Local authorities/ a municipal enterprise or private company, prior starting a waste collection services, or operating a waste facility or site should:

- Establish a emergency procedures ensuring an effective response to waste collection emergencies;
- Ensure that maintenance procedures provide continuous availability and serviceability of emergency equipment; Ensure effective use of emergency procedures for waste collection and transport;
- Ensure that emergency procedures are communicated effectively to people concerned;
- Review emergency procedures, resources, and equipment at appropriate intervals and ensure that necessary action is taken as a result;
- The emergency procedures and measures shall be regularly inspected by Fire Police, who permit the activity if the operator demonstrates compliance with rules. Local authorities should require Fire Police authorization for each waste management activity which operates within local territory.

7.3 Prevention and Emergency Programs/ Procedures

A waste management facility shall be designed, constructed, maintained and operated to prevent and minimize the potential for fire, explosion or release of solid waste constituents to the air, water or soil that could threaten public health or safety, public welfare or the environment;

In order to prevent accidents and protect human resources, the local authority should approve and monitor a set of emergency procedures to avoid fires and waste spillage. The emergency procedures are formulized based on the national regulation and guidelines for each waste management activities or waste operating site. As far as these national standards and procedures are ready, local authorities and waste management companies should develop their own emergency procedures to prevent potential accidents.

The emergency procedures may include the following measures to mitigate potential adverse impact to the environment as well as public and employee health and safety.

a) Prevention Procedure:

The following steps should be taken regularly by personnel in order to prevent fires:

- Assess actual or potential hazards to public health and safety, public welfare and the environment that are occurring, or may occur;
- Ensure that fires, spills or other hazards do not occur, reoccur or spread to other solid waste;
- Check every load (collection points, containers, trucks) for fire before it is loaded or unloaded. Attendants will be alert for signs of burning waste such as smoke, steam, or heat being released from incoming waste loads;
- Do not discharge the waste in a open flames or nearby fires;
- Do not allow open flames in the unloading areas or near the collection points;
- Do not keep fuel or other combustibles on loading part of the vehicle;
- Smoking will not be permitted near the waste management areas.

b) Emergency tools & equipment

A person or municipality operating a waste facility or operates a compacted waste truck shall have available in proper working condition the following equipment at the immediate operating area of the facility:

- An internal communications or alarm system capable of providing immediate emergency instruction by voice or signal to facility personnel;
- Communications emergency contacts from local police, fire departments, emergency medical;
- Portable fire extinguishers, fire control equipment, spill control equipment and decontamination equipment. For fire control equipment requiring water, the facility shall have a water supply of adequate quantity and pressure to supply the equipment;
- Equipment and material required shall be tested and maintained so that it is operable in time of emergency;
- Adequate space shall be maintained to allow the unobstructed movement of emergency personnel and equipment to operating areas of the facility.

c) Useful procedure in the event of fire:

The facility staff will take the following steps if a fire is discovered:

- Contact the Fire Station by calling emergency numbers and alert other facility personnel;
- Assess the extent of fire, possibilities for the fire to spread, and alternatives for extinguishing the fire;
- If it appears that the fire can be safely fought with available fire extinguisher until the arrival of the Fire Police, attempt to contain or extinguish fire.

- Upon arrive of the Fire Police personnel, direct them to the fire and provide assistance as appropriate;

- Be familiar with the use and limitations of firefighting equipment available on-site.

d) After an emergency, the operator of a facility shall do the following:

- Clean up the area affected by the emergency and treat, store or dispose of recovered solid waste, contaminated soil, contaminated water or other material in a manner approved by the responsible authority (Fire Police and/or Public Health Inspectorate and or Environmental agency);

- Prevent processing or storage of solid waste in the area affected by the emergency until the operator has cleaned up the area, and the responsible authority has approved the resumption of operation after the cleanup.

e) Enforcing safe working practices

Waste/recycling collection operations are particularly vulnerable to "short cuts" and "workarounds" due to the desire to finish the allotted task in the shortest possible time. Practices which are important to good health, safety and welfare but perceived as 'slowing down the job' may be among the first things to be 'short cut' or 'worked around'.

When devising and implementing safety-critical procedures, you need:

- To include a suitable education and training campaign (so that employees understand the importance of complying with procedures) and,

- Make sure that frequent and effective supervision of the safety critical elements is included within the overall operating regime. Supervisors with an appropriate, positive, approach to health, safety and welfare can have a significant influence in disseminating and maintaining a high standard of health and safety in the teams that they have contact with.

7.4 Other technical emergency situations

a) What happens in case of reparation of equipments or road obstruction?

If streets or roads are blocked in the emergency area or if any collection equipment is not available, temporary community drop-off points may be developed for handling municipal waste. Local authorities or waste collection operators should have foreseen adequate measures and an emergency plan to face emergency or blockage situation in order to deal with urban waste collection. Waste collection operator may also consider the support/help by other neighbor operators.

Another option may consider the advertisement of households or commercial units to avoid throwing of waste until the waste collection system is in operation.

b) Illegal points

Illegal dumping usually means waste dumped on roads, in forests or in the sea, any places other than the specified final disposal sites. Illegal dumping of wastes could cause infectious diseases, public health problems as well as environmental pollution. Scattered garbage in the neighborhood may lead to overflow of water by blocking street gutters, or multiplication of mosquitoes that breed in the collected water in the abandoned cans. Or, a pile of waste might be unlawfully left in the places not easily exposed to the public eye. In that case the pollution problem often remains unseen, resulting in serious environmental pollution.
Illegal dumping may be attributed to the problems including incomplete collection service by local governments, lack of resident's sense of public duty, unsuitable disposal site that leads to dumping of the collected garbage on the way to disposal sites, and inappropriate consignment of the service to private sectors.

If the problems are of incomplete collection service by local governments including total lack of collection services, low collection frequency, or remote collection station, collection service extension or service improvement is inevitable. As for approaches to stop illegal dumping by the residents, social campaigns and school trainings are needed along with establishment and enforcement of regulatory controls.

To prevent illegal dumping by private sectors, it is important to establish and strengthening permission/ licensing procedure, control and monitoring system to punish contractors and commercial units who dump wastes illegally, which needs and use a legal system. Setting of special license is also important for handling of hazardous waste.

7.5 Environmental effect

Besides causing health disorders, inadequate and improper waste management causes adverse environmental effects such as the following:

a) Air pollution: Burning of solid wastes in open dumps or in improperly designed incinerators emit pollutants (gaseous and particulate matters) to the atmosphere. Studies show that the environmental consequences of open burning are greater than incinerators, especially with respect to aldehydes and particulates. Emissions from an uncontrolled incinerator system include particulate matter, sulphur oxides, nitrogen oxides, hydrogen chloride, carbon monoxide, lead and mercury. Discharge of arsenic, cadmium and selenium is to be controlled, since they are toxic at relatively low exposure levels. Polychlorinated dibenzofurans (PCDFs), commonly called dioxins and furans, are of concern because of their toxicity, carcinogenicity and possible mutagenicity.

b) Water and land pollution: Water pollution results from dumping in open areas and storm water drains, and improper design, construction and/or operation of a sanitary landfill. Control of infiltration from rainfall and surface runoff is essential in order to minimize the production of leachate. Pollution of groundwater can occur as a result of:

- The flow of groundwater through deposits of solid waste at landfill sites;
- Percolation of rainfall or irrigation waters from solid wastes to the water table;

- Diffusion and collection of gases generated by the decomposition of solid wastes.

c) Visual pollution*:* The aesthetic sensibility is offended by the unsightliness of piles of wastes on the roadside. The situation is made worse by the presence of scavengers rummaging in the waste. Waste carelessly and irresponsibly discarded in public thoroughfares, along roads and highways and around communal bins (i.e., makeshift containers, without lids, used for the storage of residential, commercial and institutional wastes) gives easy access to animals scavenging for food. The solution to this social problem undoubtedly lies in the implementation of public education at all levels – primary, secondary, tertiary and adult, both short- and long-term, and in raising the status of public health workers and managers in solid waste management.

d) Noise pollution: Undesirable noise is a nuisance associated with operations at landfills, incinerators, transfer stations and sites used for recycling. This is due to the movement of vehicles, the operation of large machines and the diverse operations at an incinerator site. The impacts of noise pollution may be reduced by careful sitting of SWM operations and by the use of noise barriers.

e) Odour pollution: Obnoxious odours due to the presence of decaying organic matter are characteristic of open dumps. They arise from anaerobic decomposition processes and their major constituents are particularly offensive. Proper landfill covering eliminates this nuisance.

f) Explosion hazards: Landfill gas, which is released during anaerobic decomposition processes, contains a high proportion of methane (35 – 73%). It can migrate through the soil over a considerable distance, leaving the buildings in the vicinity of sanitary landfill sites at risk, even after the closure of landfills. Several methods are available for control of landfill gas, such as venting, flaring and the use of impermeable barriers.