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JICA

Project For Institutional Capacity Development On Nation-Wide Solid Waste Management In Dominican Republic

Manual for the Characterization and Projection of Municipal Solid Waste

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INTRODUCTION

The elaboration of a Plan for the Integrated Management of Solid Waste -ISWM-, includes a series of steps of equal importance. After knowing the legal framework and the policies on which will be worked, the first step is the elaboration of a Study of Characterization and Projection of Solid Waste, objective of this Manual. This manual is structured in two parts: the first part contains general information on the solid waste situation, and the second contains the planning and methodology for conducting the study. In the same, the units of generation, characteristics, composition and projection of the solid waste will be analyzed, with the purpose of generating the basic instruments for the elaboration of the ISWM Plan of a municipality.

All solid waste does not have the same characteristics. The volume and type of waste generated in small towns and rural villages may vary from community to community and are different from those produced in large cities. The characteristics depend on the activity that generates them and it is convenient to know the type and volume of waste produced by each activity to develop appropriate management methods (OPS, 1997). There are different parameters that are taken into account to measure the amount of solid waste generated in the different strata of society.

The Ministry of Environment and Natural Resources has prepared this manual for the characterization of municipal solid waste, as an important management tool for decision making in terms of design of management systems and final disposal of Municipal solid waste.

Objective

The objective of this manual is to generate the basic instruments for the development of a study of municipal solid waste characterization through a series of methodological guidelines that describe, in a clear and simple way, the steps to follow to obtain the information about the characteristics and projection (qualitative and quantitative) of solid waste, such as: per capita generation, weight, volume, density, humidity and physical composition of solid waste, municipal solid waste.

PART I

1 Generalities on Solid Waste in the Dominican Republic.

1.1 Current situation of Solid Waste in the Dominican Republic

At the moment of taking decisions about the management of solid waste, it is extremely important to have a characterization to know what we have, what we can count on and what we need. E.g., knowing how much is generated per capita and each of the activities that take place within the territory the rate of arbitrary collection can be calculated. The characterization is the principal base for the elaboration of municipal plans, these are a tool to obtain results.

In 2008, the National Coordination Committee for ISWM -CCN-GIRESOL-, in the framework of the triangular Cooperation between Mexico, Germany and the Dominican Republic, with the objective of creating the Network and training the human resources with the needed knowledge to offer training and advise to the municipalities of the countries; The first covenant of cooperation was signed on March the 27th, 2008 with the participation of the Dominican institutions with orders, responsibilities and competencies on the topic: MARENA, The Vice Minister of international cooperation of MEPyD, CONARE and FEDOMU. And the institutions Secretary of Foreign Relations (SRE) and the Mexican Secretary of Environment and Natural Resources (SEMARNAT); Ministry of Economic Cooperation and Development of Germany (BMZ) and the German Cooperation Agency (GIZ). Being necessary, the participation of other institutions, relevant to the topic, the following Dominican institutions were included: MSP, MINERD, LMD and The National Network of Support to Companies on the Protection of the Environment (EcoRed).

Since then, together with the institutions that conform said Committee, they decided to train environmental promoters at a national level with the objective of transferring knowledge and capacity nationwide to strengthen the elaboration of the diagnosis, creation of the ISWM plans, exchange of experiences, turning them into agents of change and referent to other communities.

As a result of the training of environmental promoters, a nationwide gathering of

information was carried out, geo-referenced 235 FDSs out of the, approximately, 350 that currently exist.

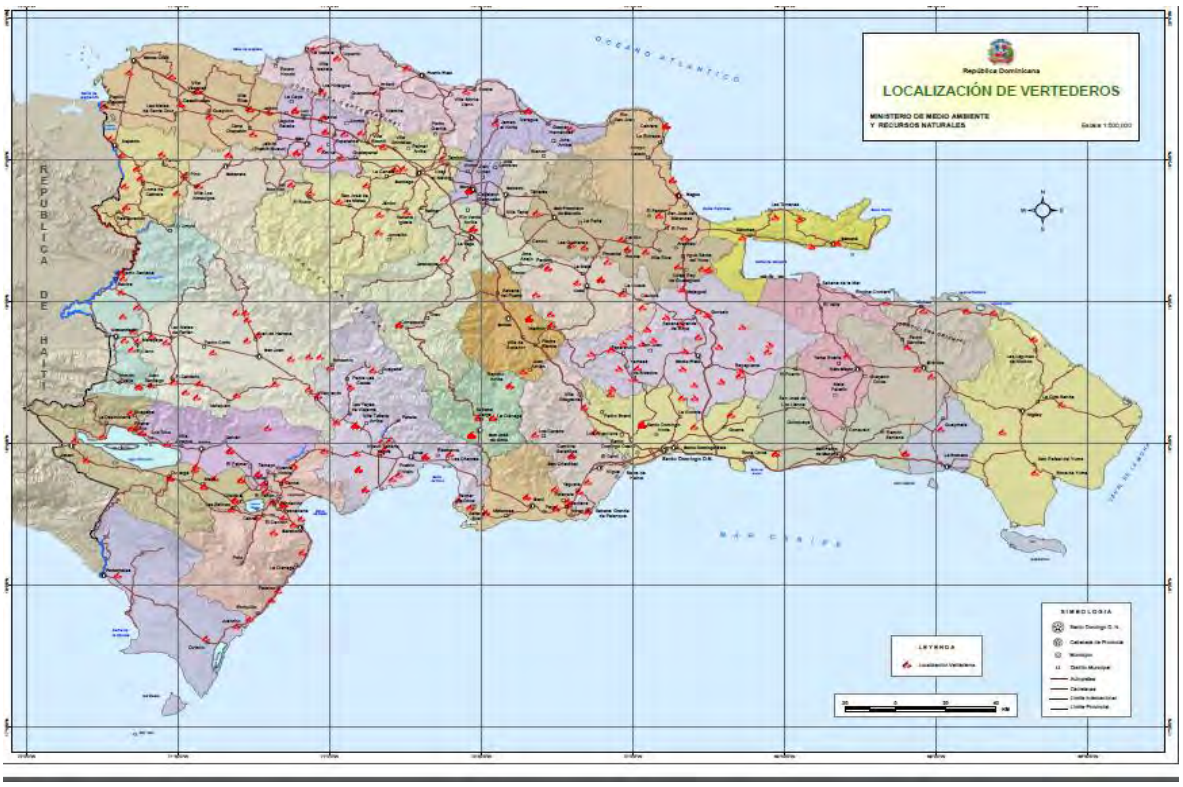
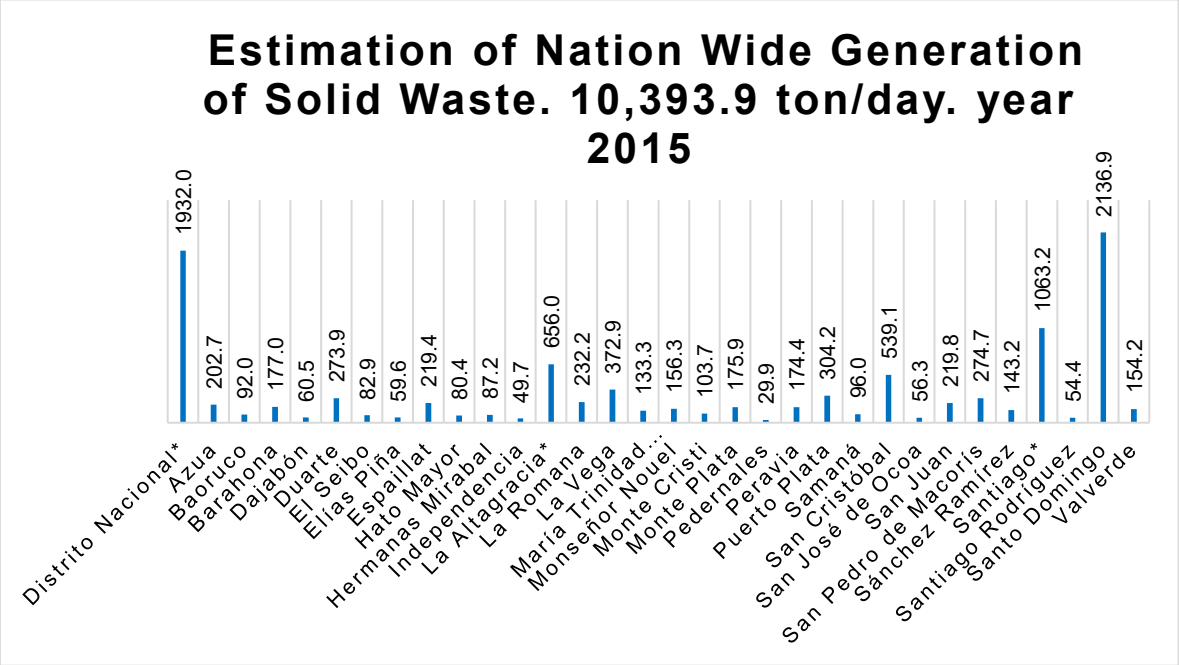


Figure 1 Dumping sites location map

In the following chart we can see an estimation of the amount of solid waste generated by each province, taking into account as the reference for its estimation the 2010 population census and the projection until 2015, an analysis of the territorial reality based on the experiences and field visits done by the technicians of MARENA, an average of the per-capita generation determined by the different local studies (0.9). In the province la Altagracia (Bávaro, Verón Punta Cana), it is estimated based on the municipal and hotel sector collection. In the province of Santo Domingo, Santiago and the D.N., the data is collected based in the weighing of waste that gets to the main dumping sites (Duquesa and Rafey).It is estimated that, nation-wide, the generation of waste until 2015 was 10,393.9 tons per day (ton/day).



Source: MARENA

Figure 2 Estimated generation at a national level in Dominican Republic

According to the norm in force, the city halls are responsible of municipal SWM (law 176-07), however, most of them do not have the necessary resources required to fulfill the important function assigned to them, because most of the weaknesses of institutional, legal, financial, managerial, technical-operational, among others.

The Solid Waste Management Bill in the Dominican Republic is in the process of being approved, which contemplates that all city councils must elaborate their plan of integrated management of solid waste.

Institutions, such as MARENA, in coordination with CCN-GIRESOL, GIZ, JICA, the OPS, the PNUMA, Ecored, the BID, have done a characterization and composition study of solid waste, both at a national level as well as locally (municipalities), in the following municipalities: National District, Santo Domingo Oeste, North Santo Domingo, East Santo Domingo, San Pedro de Macorís, Romana, Seibo, La Altagracia, Monte Plata, Bavaro, Samaná, Boca Chica, Cotui, San Juan de la Maguana, San Francisco de Macorís, San José de las Matas, Navarrete, Sabana Iglesia, Las Placetas, Las Terrenas, Barahona, Miches, Bajo de Haina, San Cristóbal, los Alcarrizos, Guerra, San Gregorio de Nigua, Pedro Brand, Moca, Azua, Sánchez, etc.

1.2 Basic Concepts

According to the Standard for Environmental Management of Non-Hazardous Solid Waste, Waste is any solid, liquid or gaseous material, whether isolated or mixed with others, resulting from a process of extraction from nature, transformation, manufacture or consumption, which its holder decides to abandon.

1.2.1 Municipal solid waste

Depending on their composition, the waste can be organic and inorganic.

Organic refers to materials that decompose naturally and do not take long to degrade. These residues, including food waste, can be processed by removing the moisture by heating them, then crushing them and turning them into fertilizer for the plants.

Inorganic waste refers to those materials that, because of their chemical characteristics, do not decompose naturally or take a long time to degrade, such as plastic, glass, paper and metals.

Depending on their origin or source of generation, there are many types of waste. These should be classified according to their characteristics. In relation to the generation source, the Standard for Environmental Management of Non-Hazardous Solid Waste establishes the following types:

Commercial: waste generated in commercial establishments, such as warehouses, hotels, restaurants, cafes and market places.

Domestic: waste that by its nature, composition, quantity and volume is generated in activities carried out in homes or any similar establishment.

Agricultural: those generated by the raising of animals and the production, harvesting and mowing of crops and trees, which are not used to fertilize the soil.

Biomedical: those generated during the diagnosis, treatment, provision of medical services or immunization of humans or animals, in research related to the production of these or in the trials with biomedical products.

Construction or Demolition: those resulting from the construction, remodeling and repair of buildings or the demolition of pavements, houses, commercial buildings and other structures.

Industrial: waste generated in industrial activities, as a result of production processes, maintenance of equipment and facilities and treatment and control of pollution.

According to their potential risks, waste can be hazardous and not hazardous. The municipal waste, object of this manual, fall within the category of Non-hazardous.

1.2.2 Physical composition of solid waste.

The composition refers to the individual components/materials present in the waste mass and its distribution in percentage, normally in weight. The composition depends on the factors pointed out for the generation. In our country, the organic waste constitutes the biggest fraction of domestic waste.

Basically, solid waste are composed by the following types:

Table 1 Physical composition of solid waste

N	Components
1	Paper
2	Cardboard
3	Food Waste (organic)
4	Plastics
5	Glass
6	Metals
7	Tetra pack
8	Foam
9	Tires, rubber and leather.
10	Electronic material.
11	Textile material
12	Wood
13	Batteries
14	Pruning and Garden
15	Diapers
16	Others

Elaborated by MARENA

1.2.3 Characterization study of solid waste

It is a field study, its objective is to determine the amount of waste that is currently generated by the different types of source: domestic, commercial, institutional, markets, and street sweeping. It is a tool that allows us to obtain primary information related to the characteristics of solid waste: like the amount of waste generated, its density, composition, and humidity in a given

geographical area.

By knowledge of the composition, the data related to the chemical and physical composition of the waste generated in the study area will be determined.

The methodological guide for the elaboration of the characterization study for municipal solid waste of Peru indicates that a characterization study, as such, represents a fundamental input for the elaboration of a series of environmental solid waste management instruments, as well as related public investment projects and others that allow decisions on the integral management of solid waste in the short, medium and long term.

This information allows the technical and operational planning of solid waste management as well as administrative and financial planning since knowing how much each of the activities that took place in the locality generates can help determine the type of system to be implemented and calculate the rate of collection of taxes.

There are several general methods to determine the amounts of solid waste, among the main ones, are:

Total weighing analysis. Weigh all the waste that arrives at the treatment or disposal facilities. It is also called analysis of the number of loads involved in weighing scales on a number of loads that arrive at the treatment or final disposal sites in a given period. Generation rates per unit are determined using field data. (Comparative analysis of the different methods of characterization of urban waste for its selective collection in urban communities).

Weight-volume analysis. This method determines the weight and volume of the loads that arrive at the treatment or pouring facilities, whereby loose and compacted densities can be achieved. Based on the volume of the load of the trucks can determine the weight and based on the density can give an idea of the type of material contained in cargo trucks, this aspect is widely used in the reception of waste in treatment plants of construction and demolition waste. It is also widely used for the design of Eco-parks. (Comparative analysis of the different methods of characterization of urban waste for its selective collection in urban communities).

Mass balance analysis. It is the best way to determine the generation and

movement of waste with some degree of reliability. It consists of identifying inputs and outputs of materials from a limited system. The method becomes very complex because a lot of data is needed, many of which are not available. For the application of a mass balance, it is necessary to know the boundaries of the system, the activities that cross or occur within it and the generation of solid waste associated with the activities of the system. (Comparative analysis of the different methods of characterization of urban waste for its selective collection in urban communities).

Analysis by statistical sampling. This method involves taking a representative number of solid waste samples from one of the sources, for a time, determining the total weights and their components, from a statistical analysis determine the rate of generation and composition. The number of samples will depend on the accuracy to be achieved, using statistical methods. (Comparative analysis of the different methods of characterization of urban waste for its selective collection in urban communities).

Once the field study has been carried out, the following stages of the Characterization Study will be carried out, corresponding to the calculation of the generation and the projection.

1.2.4 Per capita generation of waste

The per capita generation of waste must be organized for each generation source. When municipalities cannot identify the commercial area where residential and commercial buildings exist, per capita data are stored as residential areas. This data is obtained through the field study.

Current population

The municipalities organize the current data of the population in the area of the municipality. For the understanding of the fluctuation of the population number the municipalities must have data of the population of at least the last 5 years.

Generation can be calculated analytically if there are generation and population data, on the amount of waste, using the following formula:

$$Grs = Current\ P \times GPC$$

Where:

Grs = Current amount of waste (ton/day)

Current P = Current population (person)

GPC = Generation per capita (Kg/inhab/day)

Note: As the Grs data are in ton / day and the GPC is kg / inhab / day, the final result is multiplied by 10-3 so that the values are expressed in ton / day or per 1000 for it to be expressed in Kg / day.

For the determination of the per capita generation and the analysis of the production of domestic solid waste in each area of the municipality, the following steps:

Once the bag collection routing for the characterization study has been completed, the samples are taken to the designated municipal area to perform the weighing.

Bags collected with waste will be weighed daily (Wi) during the eight days of the sampling. This process represents the amount of daily garbage generated in each household (Kg./household/day). To do this, a balance of 0 to 5 kg will be used.

During the weighing previous identification of the code or number of each sample is carried out, registering the weight in the corresponding format. (See attached format).

Once the average weights of the waste of each house are obtained, the results obtained to obtain the average per capita generation (GPC) of each zone are processed in the office.

To obtain the per capita generation (Kg./hab./day), the weight of the bags is divided between the numbers of inhabitants (for each sampled household).

The per capita generation of waste will be determined using the following formula:

For the households:

$$GPC = \frac{Kg\ \ collected\ \ weight}{\#\ \ of\ \ sampled\ \ inhabitants}$$

For businesses:

$$\boldsymbol{GPC = \frac{Kg\ \ collected\ \ weight}{\#\ \ of\ \ sampled\ \ businesses}}$$

For schools:

$$\boldsymbol{GPC = \frac{Kg\ \ collected\ \ weight}{\#\ \ of\ \ students\ \ of\ \ the\ \ sampled\ \ school}}$$

For hotels:

$$\boldsymbol{GPC = \frac{kg\ \ peso\ \ recolectado}{Number\ \ of\ \ sampled\ \ hotels}}$$

Note: For another type of per capita waste production, the same methodology is used.

Calculation of average per capita generation

$$GPCprom\ \ v1 = \frac{(\mathrm{P1d2}\ +\ \mathrm{P1d3}\ +\ \ldots\ +\ \mathrm{P1d8})}{7x}$$

$$GPCprom\ \ v2 = \frac{(\mathrm{P1d2}\ +\ \mathrm{P1d3}\ +\ \ldots\ +\ \mathrm{P1d8})}{7y}$$

$$GPCprom\ \ vn = \frac{(\mathrm{Pnd2}\ +\ \mathrm{Pnd3}\ +\ \ldots\ +\ \mathrm{Pnd8})}{7z}$$

Where:

GPC v1: Generation per-capita of a household 1

P1d2: Weight of bags collected from household 1 on day 2

P1d3: Weight of bags collected from household 1 on day 3

P1d8: Weight of bags collected from household 1 on day 8

X: Number of inhabitants of the household 1

GPC v2: per-capita generation of household 2

P2d2: Weight of bags collected from household 2 on day 2

P2d3: Weight of bags collected from household 2 on day 3

P2d8: Weight of bags collected from household 2 on day 8

Y: Number of inhabitants of the household 2

GPC vn: Per capita generation of household n

Pnd2: Weight of bags collected from the household n on day 2

Pnd3: Weight of bags collected from household n on day 3

Pnd8: Weight of bags collected from household n on day 8

Z: Number of inhabitants of the household n

1.2.5 Projection of the amount of waste

Future population

In the Dominican Republic, the future population of each region is published by the -ONE-. If this data covers the target year and the municipal area, the municipality can use this data.

In the case that the existing public data were not available, the municipalities will estimate the future population independently by one of the following methods:

1) Estimation using the growth index

The projection of the population for the year of study is made taking as reference the last Census of Population and Housing with the following formula:

$$Pn = Po \times (1 + r)^n$$

Where:

Pn = Estimated Final Population

Po = Initial Population

R = Growth Rate

n = years

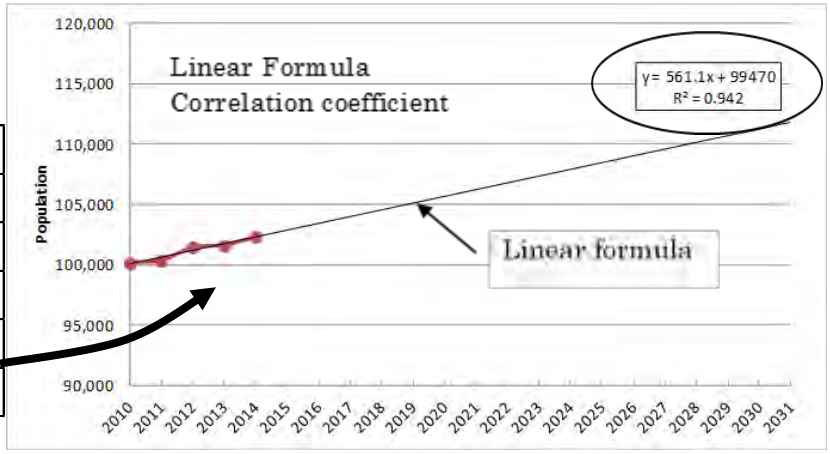
Taking into account the results of this study and the projection of population growth, the quantities generated in the period in question will be estimated.

It is important to have recent population data.

From the result of the projection, the total number of houses in the municipality is calculated and an average of 5 inhabitants per household.

2) Estimation with linear formula

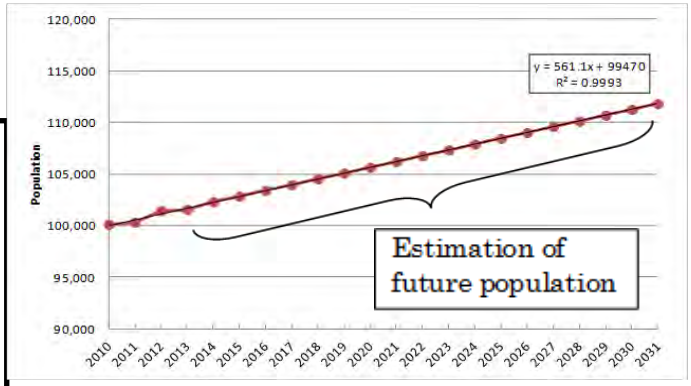
Año	Población
2010	100,123
2011	100,324
2012	101,450
2013	101,559
2014	102,311



Past data from the population (over 5 years)
Estimating future population using Excel.

Figure 3 Past data from the population

Año	X	Población
2010	1	100,123
2011	2	100,324
2012	3	101,450
2013	4	101,559
2014	5	102,311
2015	6	102,837
2016	7	103,398
2017	8	103,959
2018	9	104,520
2019	10	105,081
2020	11	105,642
2021	12	106,203
2022	13	106,764
2023	14	107,325
2024	15	107,887
2025	16	108,448
2026	17	109,009
2027	18	109,570
2028	19	110,131
2029	20	110,692
2030	21	111,253
2031	22	111,814



$y = 561.1\,\mathrm{X}x + 99{,}470$

Figure 4 Estimating future population using Excel

1.2.6 Per capita generation in the future

If the municipality has current information or obtained it through the characterization study, they can project the generation per capita in the future as well as the population, using the estimation method.

However, if no data is collected, current data on per capita generation are used as per capita in the future.

1.2.7 Amount of waste in the future

The amount of waste should be calculated using the following formula:

Amount of waste (tons/year)

= Population (people) × Per capita production (kg/person/day) × 365(days/year)×10^{-3}

Table 2 Amount of waste in the future

Año	Población	Per capita (g/persona/día)	Cantidad de residuos (ton/año)
2015	102,837	0.81	30,404
2016	103,398	0.81	30,570
2017	103,959	0.81	30,735
2018	104,520	0.81	30,901
2019	105,081	0.81	31,067
2020	105,642	0.81	31,233
2021	106,203	0.81	31,399
2022	106,764	0.81	31,565
2023	107,325	0.81	31,731
2024	107,887	0.81	31,897
2025	108,448	0.81	32,063
2026	109,009	0.81	32,228
2027	109,570	0.81	32,394
2028	110,131	0.81	32,560
2029	110,692	0.81	32,726
2030	111,253	0.81	32,892
2031	111,814	0.81	33,058

1.2.8 Data entry to the future waste stream

The objective of the previous data will be to elaborate the current flow and the future of waste, on the basis of which it will be possible to elaborate the ISWM Plan later and any improvement to the operation of the components of the management in the municipality.

For example, the annual amount of waste should be indicated on the main stream line. With this indication, the municipality can determine the required equipment capacity and the dimensions of the necessary facilities.

For example, Capacity of the Segregation / Separation Plant:

Mixed waste: Annual generation; 10,000 tons / year

Daily amount generated; 27.4 ton/day = 10,000 ton/year ÷ 365 days

$$\text{Percentage of operation}(\%) = \frac{\text{Daily annual operation (day)}}{\text{Annual number of date (day)}} = \frac{300(\text{day})}{365(\text{day})}$$

$$= 82.2\%$$

$$\text{Capacity}\left(^{\text{ton}}/_{\text{day}}\right)$$

$$= \text{Daily amount generated (ton/day)}$$

$$\div \text{Percentage of operation}(\%) = 27.4\left(^{\text{ton}}/_{\text{day}}\right) \div 82.2\%$$

$$= 33.3(^{\text{ton}}/_{\text{day}})$$

1.2.9 Total flow of waste

The waste stream will be prepared for both the current and future stages. It reflects, in addition to the amount of waste, the components and stages to be included in the Comprehensive Solid Waste Management Plan (ISWMP). We must make the future ISWMP waste stream for the target year.

Once all the data have been collected and organized, a flow chart of the components of the solid waste management is carried out, so as to have a baseline to project the same in the long term to predict the behavior of solid waste generation and viability of any project.

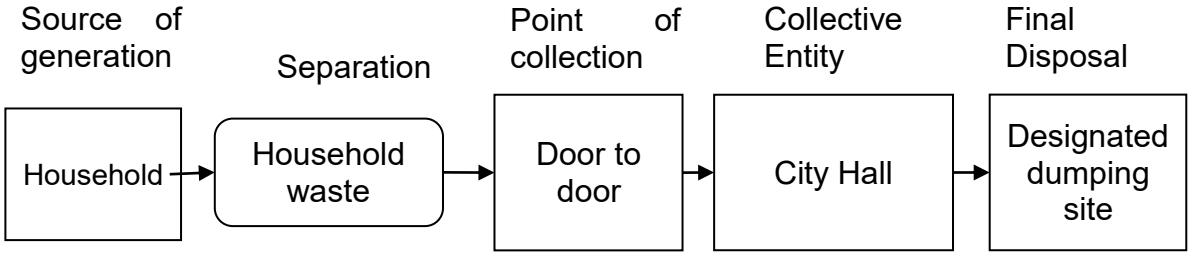


Figure 5 Sequence for the flow of waste

Here is an example of the current waste stream in the municipality of Moca for the year 2016:

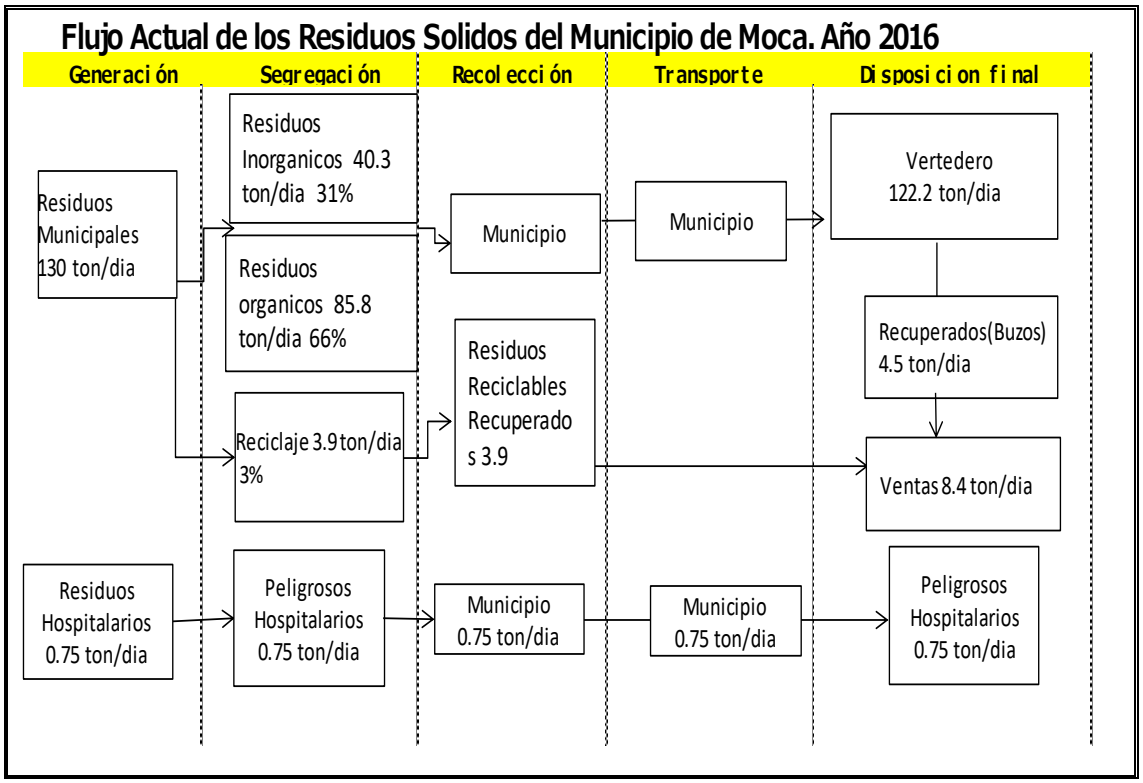


Figure 6 Current flow of Solid Waste of Moca's Municipality, 2016

Below you will see the future flow of SW:

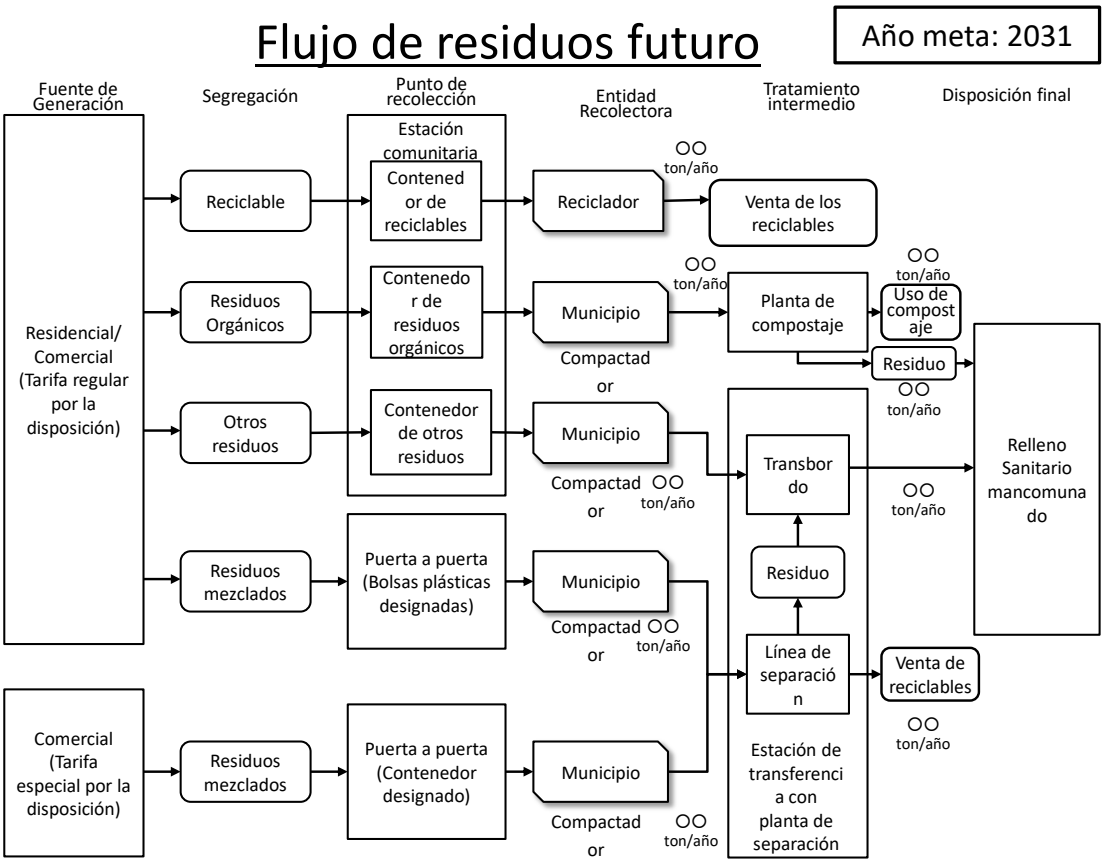


Figure 7 Total waste flowchart

PART II

2 PLANNING

2.1 Stages for the elaboration of a characterization study of municipal solid waste.

The characterization study of municipal solid waste is composed of three fundamental stages, which are:

- Planning stage.
- Design stage.
- Execution stage.

2.1.1 Planning stage: Organize and plan the study

This stage corresponds to the planning of the different Activities of the characterization study during the field development; when it comes to the organization at a municipal level and the planning of the study; where the will, active participation and support of the City Hall is to involve the authorities and municipal officials.

General coordination

The different levels of management of the Municipality must coordinate (Mayor, Technical Assistant of the Mayor, General Secretary, Planning department, Administrative and Financial areas, Cleaning and Beautification, Environmental Management Unit, among others) in order to approve and monitor the implementation of the study.

Determine the participation and responsibilities of the different municipal areas. Furthermore, establish partnership with public and private institutions such as the sectors of health, education, local organizations, among others.

Elaboration of the Work plan

The work plan and schedule of activities, are documents focused in the understanding, ordering and systematization of the activities of the study. See work schedule format below:

Municipality:																
Area of responsibility:																
Name of the person in charge of the study:																
General objective																
	Schedule															
ACTIVITY	**ANSWER**	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15
Coordinate with the authorities and the officials of the municipality.																
Identify the sampling areas (socioeconomic stratum)																
Determine sample size																
Determine resources (human and material)																
Determine resources (human and material resources)																
Manage resources for the study																
Organize and train the team																
Distribute and select the sample according to Socioeconomic stratum areas.																
Inform and raise awareness of the participants.																
To enroll participants, encode Sample and apply survey.																
Collect and deliver bags.																
Determine parameters.																
Process and analyze the results.																
Write the report of the study.																
Present the previous report of the study.																
Correct observations from the study report.																
Submit the final study report																

Figure 8 Format of a Work Schedule

To carry out a waste characterization plan that is efficient, the fundamental criteria to define the number of parameters to be analyzed must be know or fulfilled, such as the size of the sample and the duration of the study or:

a) The objective of the characterization of the municipal waste.
b) The preexistence of municipal solid waste characterization studies.
c) The seasonal variation of the Solid Waste production.
d) The availability of human and financial resources.

Some of the factors above may alter the type and volume of waste characterized in a given time

For the exercise of a characterization, different aspects must be considered:

- Municipality's location.
- Environmental aspects.
- Weather.
- Hydrograph.
- Geography and geomorphology.
- Socio - demographic aspects.
- Health.
- Education.
- Predominant activities. (Important economic activities such as tourism, agriculture, etc.)
- Special events (natural disasters, celebrations).
- Significant environmental aspects:

  ✓ Impacts on the air
  ✓ Impacts on water
  ✓ Soil impacts
  ✓ Solid waste management
  ✓ Noise
  ✓ Risk management
  ✓ Habitability and citizen coexistence
  ✓ Seasons of the year
  ✓ Population habits
  ✓ Socio Socioeconomic conditions.

These steps can help to make the study faster and more efficient in surveying the information required in the field.

Operative works include three types of activities:

1. Elaboration of formats for the gathering of information, which must be used during the practice and elaboration of one or various programs of the study.
2. Field work and recognition; confirmation of sources and planning of the optimal sample collection route; and adjusting of the collection program.
3. Preparation of materials to be used in the study.

2.1.2 Design Stage

This stage covers the study of characterization, for this determining the sample is the, resources and the assembling of the technical equipment goes first.

- Determine the size of the sample.
- Determine the distribution of the sample by socioeconomic stratum.
- Identify the main economic activities of the district according to the index of uses.
- Create and design technical equipment.
- Determine the human and logistic resources.
- Elaborate the budget.

1) Determination of Samples Quantity

Results are in function of the sample quantity taken from the solid waste generation source, samples quantities taken and unit of measure.

According to the OPS, the following formula must be applied to determine the number of samples:

Formula to determine the number of samples

$$n = \frac{Z^2_{1-\alpha/2}\, N\, \sigma^2}{(N-1)\, E^2 + Z^2_{1-\alpha/2}\, \sigma^2}$$

Where:

n = number of household to sample

N = Total households of the area of study

Z = trust level 95%=1.96

σ= standard detour

E= allowable error

To apply the formula, the estimation of all variants previously mentioned are required. In this sense, it's considered that the *E= allowable error*, is a 10% from the national GPC *σ = standard detour is from 0.20 to 0.25 Kg. / person. / Day.*

Considerations to take into account to use the formula:

It is necessary to fix a minimum number of samples so that the results to be obtained reflect a certain degree of reliability and a reduced margin of error when it comes to the prevalent conditions population universe.

There are different formulas to determine the amount of samples to analyze in a characterization study.

Among the different sampling methods for the selection of the sample, the most common is the proportional stratified sampling method. In this method it is ensured that each household of a social stratum has the same probability of being selected.

The simplified method for the calculation of the number of samples requires to have a map of the city and doing a field visit to pre-select the households that will be part of the study.

Source: OPS/CEPIS/04/IT-634.Original: Spanish – Page 61

Implementation example

For a population of 97,601 inhabitants, it is assumed that there are 5 people per household, calculate the number of samples needed to carry out the characterization study; a permissible error of 10% of national GPC is assumed and a standard deviation of 0.25 kg/person/day. Consider a GPC of 0.85 kg/person/day:

Solution:

Assuming that there are 5 inhabitants per household this is the result:

$$N = \frac{97{,}601\ \ people}{5\,\frac{hab}{vi}.} = 19{,}520\ \ vi.$$

Afterwards:

N= 19,520 households

Z= 1.96

Ɣ= 0.25 kg/person/day

E= 0.085 kg/person/day

$$n = \frac{Z^2_{1-\alpha/2}\, N\, \sigma^2}{(N-1)\, E^2 + Z^2_{1-\alpha/2}\, \sigma^2}$$

$$n = \frac{(1.96)^2 \quad (19{,}520)(0.25)^2}{(19{,}520-1)(0.085)^2 \quad + (1.96)^2 \qquad (0.085)^2}$$

n= 374.37 e.g., 375 viviendas

a. Distribution of the sample by socioeconomic stratum for domiciliary waste

According to the OPS, for the distribution of the sample the sample is divided by stratum, this is done establishing at least the following 4 zones or stratum:

I. Commercial Zone (Commercial Stratum).

ii. Residential Zone (Stratum 1), high income households.

iii. Residential Zone (Stratum 2), medium income households.

iv. Residential Zone (Stratum 3), low income households.

Location of the socioeconomic strata in the city where they are registered and each sample unit, so they can be selected within the sample.

Utilization of the generation per capita, as it is considered that the population is conformed N households, which have Ri inhabitants and produce Wi kg of waste per day. Because of this each of them produce Xi = Wi /Ri kg/person/d.

The zoning of the municipality will allow to determine homogeneous areas or with similar characteristics and graphically delimit them for planning, in the Dominican Republic, for statistical purposes, the population is classified by level of income in quintiles. See more at: www.one.gob.do and http://www.bancentral.gov.do. The box shows the income of the population in quintiles registered in 2011.

Table 3 Socioeconomic Stratum

Quintile	Income
Quintile **I**	$5,501
Quintile **II**	$9,061
Quintile **III**	$12,495
Quintile **IV**	$19,409
Quintile **V**	$51,312

Source: Banco Central De La Rep. Dom. 2011

For the definition of the stratum we must start based on the socioeconomic data gathered by ONE, according to the characteristics of the municipality being studied they can be presented by income.

Example

For the case of the municipality that presents three socioeconomic strata, such as what is shown by the table and by the following figure, for a population of 97,601 inhabitants, the strata grouped in the quintiles I, II, III, IV and V were determined.

A municipal profile study determined the following socioeconomic data:

Table 4 Number of households per socioeconomic Strata

Quintile	Households
Quintile **I**	7,300
Quintile **II**	5,520
Quintile **III**	4,400
Quintile **IV**	1,500
Quintile **V**	800
Total	**19,520**

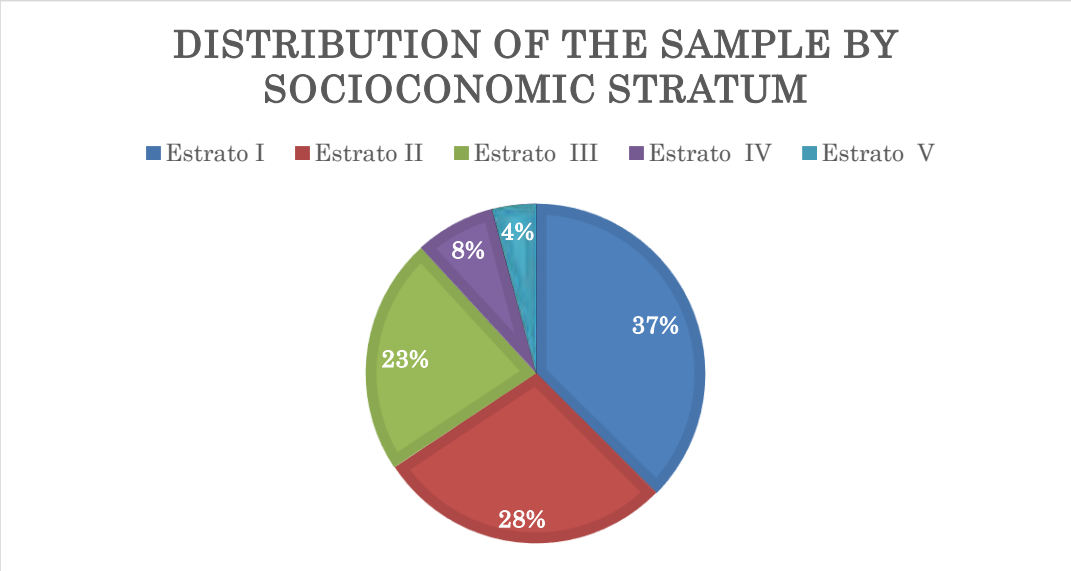


Figure 9 Distribution Of The Sample By Socioeconomic Stratum

The size of the household sample n = 375, now it has to be assigned or distributed proportionally in the strata, which means:

Table 5 Percentage of households per Socioeconomic Stratum

Quintile	Household	%
Total	375	100.00%
Quintile I	139	37%
Quintile II	105	28%
Quintile III	86	23%
Quintile IV	30	8%
Quintile V	15	4%

b. Identify the main economic activities of the municipality according to its index of uses

We must take into account the relation of the municipal businesses according to their index of use enabling us to know how many properties do the commercial establishments represent in the municipal aspect, different types of businesses: restaurants, markets, hotels, public and private institutions, schools, among others.

Taking into account the type of commercial activities, the sample must be distributed by percentage and then for the sampling the most representative by commerce must be taken as sample.

Table 6 Relation box of the principal sources of generation of the municipality

Source	Amount	Percentage	Distribution of the sample
Store			
Pharmacy			
Home			
Bakeries			
Administrative office			
Hairdressing and cosmetics			
Doctor's office, dentistry, veterinary			
Advertising agencies			
Minimarkets			
Food Markets			
Accommodation - Hotels			
Restaurants - Cafeterias			

Source	Amount	Percentage	Distribution of the sample
Health Establishments			
Temples, monasteries, churches			
Libraries			
Educational institutions			
Farms			
Industry			
Cultural centers - Museums			
Shopping malls - Galleries			
Sports Complexes - Clubs			
Public institutions			
Business Consulting			
Store			
Pharmacy			
Home			
Bakeries			
Administrative office			
Hairdressing and cosmetics			
Doctor's office, dentistry, veterinary			
Advertising agencies			
Minimarkets			
Food Markets			
Accommodation - Hotels			
Restaurants - Cafeterias			
Health Establishments			
Total			

Once the number of the sample and the distribution sectors are known, what follows up is the spatial distribution of the samples, these will be done randomly in each stratum and must be spread as much as possible. This is a preliminary distribution, which will be adjusted when the field visits are done.

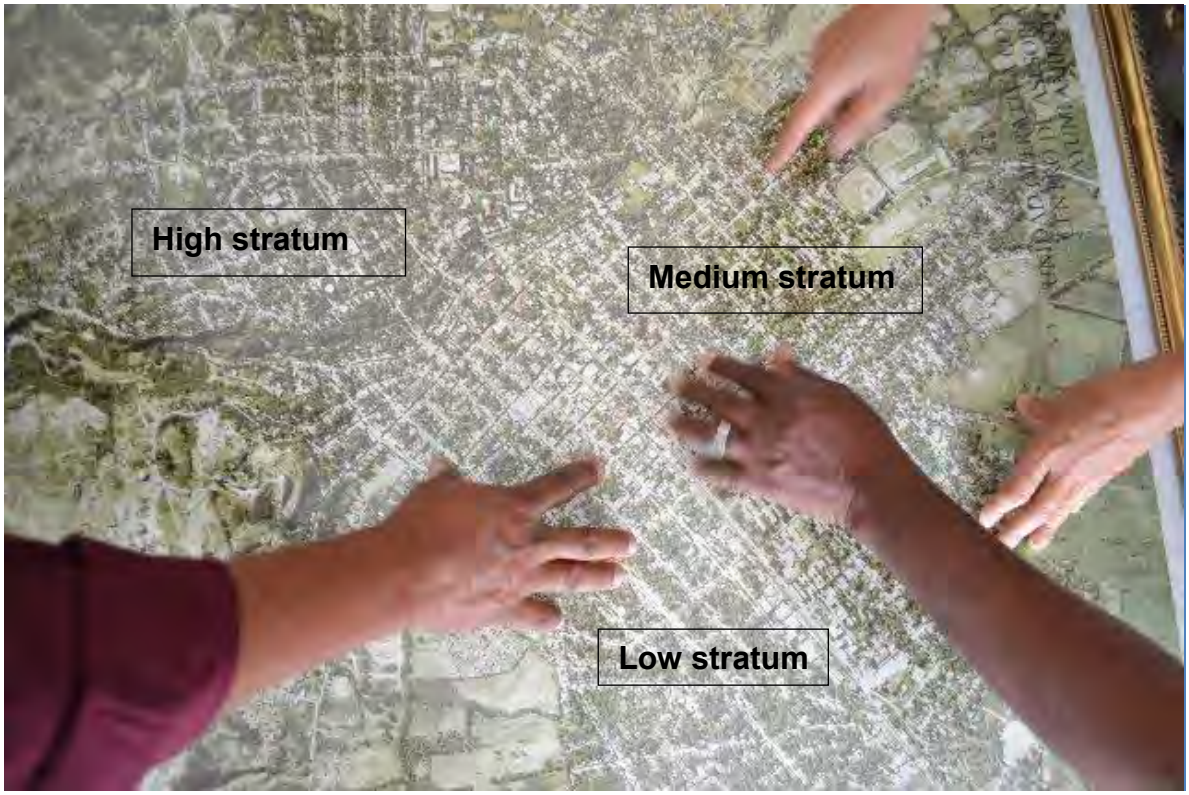


Figure 10 Sample Distribution Sectors

This picture shows a planning to gather information from different areas of the municipality, where the strata and the households to be interviewed are defined during the study.

2) Assemble and design of the technical team.

The person responsible for the project must count with a technical team (technical operative) that supports the execution of a study, for this the municipality must provide the facilities of the case, so that the personnel assigned fulfills the duties that they are responsible for.

The technical team will carry out the following functions and will be composed by:

Table 7 Technical Team

Members	No.	Profile	Functions
Responsible for the study	1	General experience in solid waste management and specific experience in solid waste characterization studies.	Direct and plan the Activities. Forecast the logistics. Coordinate meetings. Systematize the necessary information Train staff. Elaborate the formats.
Field coordinator	1	Specific experience in solid waste characterization studies.	Supervise field activities and the proper use of equipment and materials used and development of procedures. Coordinate preparation of materials. Record study data.
Sponsors / Sensitizers / pollsters	4	Good level of communication and good treatment.	Visit the sampled homes to be registered in the study. Apply the perception survey of the Public Cleaning service. Process Results
Operator of harvest	3	Knowledge of the study area	Collect bags.
Driver	1	Driver's license.	Transport the waste to the conditioned area.
Operators of classification and weighing		Knowledge in classification of waste, recycler or cleaning personnel.	Separate the waste and weigh the bags at the point of collection. Support in the determination of density, samples for moisture, among others.
Registry		Experience in handling formats.	

The technical team listed above will require a logistics for the study in addition to the inputs and / or materials, as listed in the table below:

Table 8 Necessary Human Resources and Necessary Logistics

<table>
<tr>
<td>Human Resources
• Responsible for the study
• Field coordinator
• Employers
• Surveyors
• Responsible for weighing and separation.
• Responsible for recording data.
• Sensitizers
• Harvester
• Carrier</td>
<td>Uniforms and personal protection equipment
• Leather gloves
• Rubber boots
• Dust masks
• Plastic apron
• Double sheet of 6 x 3 m polyethylene.</td>
<td>Cleaning Supplies
• Bleach / alcohol
• Soap
• Detergent
• Water</td>
</tr>
<tr>
<td colspan="3">Vehicle
• For the collection of plastic field bags and the collection of waste at the end of each day of characterization.
• For field supervision.</td>
</tr>
<tr>
<td colspan="2">Sample Collection and Study Area
• Characterization Area
• Free area, ventilated, with roof, toilet,
• Access to water, tool storage and Watchman.</td>
<td>First Aid Supplies
• First aid kit</td>
</tr>
<tr>
<td colspan="2">Tools and Supplies
• Balance (weight), electronic platform with a minimum reading of 0.005 kg and a maximum reading of 50 kg, or analytical of 500 g.
• Metal cylinders of 200 liters capacity.
• Cylinders with capacities less than 200 liters.
• Tape measure of 5 meters
• brooms
• Rakes
• Picker
• lamps
• Polyethylene bags (use one color for solid household waste and another for commercial).
• Toothed or zippered bags for moisture samples.
• Knives or machetes.
• Digital photo camera.</td>
<td>Office Supplies
• Copies of letters for neighbors.
• Copies of letters for representatives of establishments, institutions, etc.
• Copies of enumeration formats
• Copies of characterization data record formats.
• Plans of the study area and collection routes.
• Wood panels.
• Carnets for team members.
• chalks
• Stickers for homes and establishments.
• Pencils
• Permanent Ink Crayons
• Adhesive tape or maskintape tape
• Scissors
• Materials of diffusion: leaflets, posters, others.
• Computer equipment.</td>
</tr>
</table>

3) Budget.

Once the logistic requirements are established, it is necessary to coordinate with the administrative area in order to carry out the corresponding purchase. Partial or unit costs may vary according to the area where the study is to be carried out. **See annex Format No. 2 of the budget of the characterization study**.

2.1.3 Execution stage

The stage of execution for its better understanding and application is divided in two moments: Cabinet phase and field phase.

Once identified, the field activities and the cabinet, we proceed to:

A. Organizing and training the technical team.
B. Develop materials for the study
C. Develop the health and safety plan.
D. Design the preliminary collection route
E. Invite, register and deliver material
F. Survey household heads and representatives of establishments and deliver bags.
G. Collect samples of dwellings and establishments.
H. Study the sample and determine the per capita generation of waste.
I. Determine the density of solid household and commercial waste.
J. Determine the physical composition of household solid waste.

Details:

A. Organize and train the technical team.

Organize and train the members of the technical team to carry out the tasks necessary for the execution of the study, with emphasis on awareness raising, enumeration, survey, sample collection, data recording and analysis of results. As part of the preparation, the staff must be trained through the different stages of the study and depending on the functions to be performed.

The topics to be taught to the personnel can be: Solid waste management, solid waste characterization study methodology, detail of the tasks to be performed: survey application and / or environmental awareness. Comprehension and use of elaborated formats. Safety and hygiene measures in waste management. Use of protective equipment.

B. Elaborate materials for the study.

It consists of bag coding, letter writing, surveys, registration formats and awareness material (posters for talks and workshops, house-to-house awareness campaigns and awareness campaigns through local media).

As part of the organization of the work to go out in the field, we should take into account: Label the bags according to the codes of houses and establishments, you can write on the bag with a permanent marker or stick a label. It is recommended to use one bag color per socioeconomic stratum for household waste and another bag color for waste from establishments.

Table 9 Labeling Format

Coding model of
Home bags
DAY 1

EB/V-01

CODE	DETAIL
E	Stratum
B	Low
M	Medium
A	High
V	Household

Bag coding model
For commercial generators
DAY 1

RS-01

CÓDE	DETAIL
RS	Restaurant
EC	Commercial Establishment
MR	Market
HO	Hotel
BO	Grocery Store

Bag coding model

C. Develop the health and safety plan.

It is necessary to take the safety measures during the field work, it is recommended to carry out the following measures in each of the following activities.

Table 10 Security measures for requierd task

Selective collection	Use of all the persona protection equipment (Gloves, Masks, Boots, Uniform)
Bag unloading	Unload the bags carefully without dropping them.
Bag weighing	If the bags are very heavy, handling them, manipulate the between two members of the team.
Transference of bags for segregation and/or separation.	Take the bags to the work table, if the bags are very heavy, handling them, manipulate the between two members of the team.
Segregation and or separation	Open the bags and empty them carefully on the work table, use the individual protection equipment.
Determination of the density	Lift the cylinder carefully to avoid bumps.
Final disposal	Carry out the transference of bags to the final disposal area with the security measures necessary to avoid any accident.

D. Identify and select households and commercial establishments

For that, cadastral blueprints of the municipality or municipal district must be used and draw the solid waste collection route per stratum. This process will be validated during the field visit where the route will be modified according to the approval of the neighbors and the representatives of the establishments. See Moca's Municipality's blueprints.

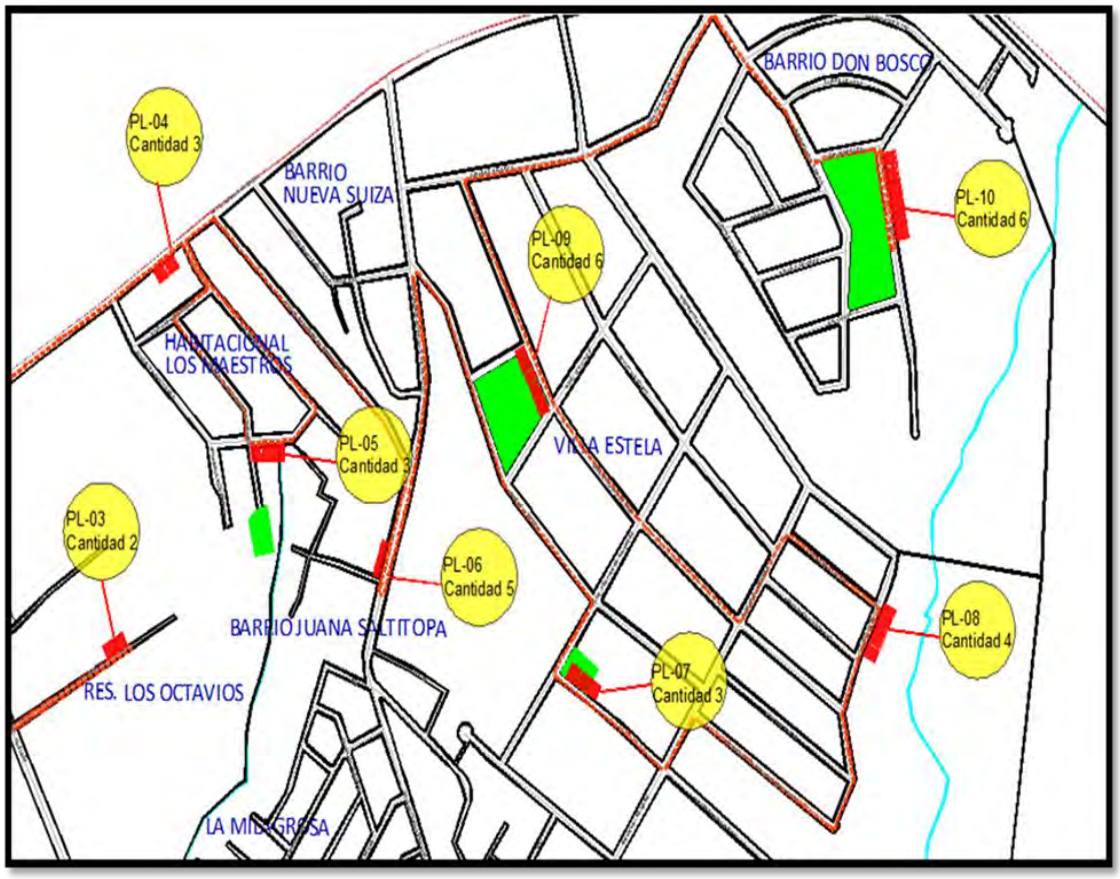


Figure 11: Design of the preliminary bag collection route

E. Invite, enroll and deliver material

Following the collection route, the personnel of the study must be properly identified, then, after introducing themselves they will explain their objective to the head of the household and represent ants of selected establishments, importance and the methodology of the characterization study and then an invitation letter is provided to participate in the study.

Once the representatives of the different establishments accept participating in the study, they are enrolled with the correspondent format, coding the household or establishment and request permission to paste a label or write with chalk the code in front of the house, in a visible fashion.

F. Survey the heads of the households and representatives of the establishments, then provide them with the bags.

After having enrolled the households and establishments, they proceed to interview a representative of the family (Preferably, the head of the family or someone of age) and a representative of each establishment, with the objective

of gathering qualitative data on their perception of the SWM and quantitative on the number of people that live in each household, socioeconomic data and the estimated generation of waste.

Elaboration of surveys for solid waste generators

When developing and conducting a survey to determine the generation of solid waste, a few minimum points should be followed to review the information obtained from them that is valid and reliable, and for each question, a response that can be analyzed, So that the results meet the objectives of the survey.

The perception of the population and the management conditions manifested by the community is important to determine many aspects that condition the reality of the municipality in question.

Although this does not reflect an accuracy of the generation or composition of solid waste, it provides important information for the study, such as the number of inhabitants in each dwelling, the approximate constructed area, the conditions of solid waste storage by The population, the desired and actual frequency of the public cleaning service, etc. (See attached survey format No. 1).

Steps for the preparation of the survey

In the formulation of the characterization survey of solid waste, for the research, certain steps are followed that help ensure that the information collected is significant:

1. Language election, e.g., that the vocabulary, the construction of the expressions and the concepts offer the best opportunity to transmit the complete and exact ideas, between the interviewer and the person interviewed. The language of the survey, must be like the language of the person interviewed. Because of this it is important to clearly understand the group that will be interviewed.
2. It is necessary to avoid asking questions to the interviewee that make them face the need to give a socially inadmissible answer.
3. Questions should be limited to a single idea or to a single concept.
4. The consecutive order of the questions allows us to make them more logical for the person questioned.

5. It is preferable that the time to respond to the surveys should not take more than 30 minutes.

Results of the survey

The surveys will focus the interest on family conditions, conditions of solid waste management, perception of solid waste services and the intention of payment of taxes by the interviewees.

It is important to know:

- ✓ Economic occupation of the interviewee
- ✓ Level of education of the head of the family
- ✓ How much is the family income per month
- ✓ Services that you have in your home
- ✓ Wastes that are discarded the most
- ✓ Type of container in which it stores its solid waste
- ✓ Optimum storage time
- ✓ Location of the trash receptacle in the dwelling
- ✓ If he keeps the pot, bag or container of solid waste covered
- ✓ The person responsible for removing solid waste from the dwelling
- ✓ Frequency of waste collection
- ✓ Disposal of solid waste in the absence of collection service
- ✓ Re-use of organic solid waste
- ✓ Harnessing of plastic bottles
- ✓ Harnessing of glass bottles
- ✓ Harnessing of plastic bags
- ✓ Harnessing of cans
- ✓ Re-use of waste in handicrafts
- ✓ Availability for recycling
- ✓ Desired frequency of solid waste collection
- ✓ Payment for solid waste services
- ✓ Satisfaction with the quality of solid waste services.
- ✓ Payment availability for an improved service
- ✓ Desired payment frequency
- ✓ Payment method desired

G. Collect the samples of the households and establishments.

Guided with the validated collection route in the field, the bags are collected in the houses for 8 consecutive days. Each day it is verified that the code of the bag that is received coincides with that registered in the register and the label of the house, then a new bag with the code of identification is given to each representative of the house.

H. Study the sample and determine the generation per capita of the waste.

To determine the amount of household solid waste generated in each study area, it is necessary to:

- Weigh bags with household solid waste, Identify the code or number of the bags.
- Weigh the bags and record the result in the format set, perform this procedure during the 8 days for all samples and record the results.

This process represents the amount of daily garbage generated in each dwelling (kg./household./hab.). For this it uses a balance of 0 to 50 kg.

I. Determine the density of domiciliary and commercial scattered solid waste

To determine the density of solid waste, the following must be performed:

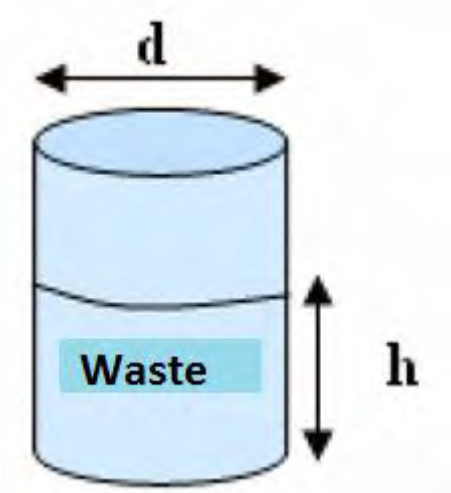
- Condition the 55 gallon capacity tank.
- Measure the height and diameter of the cylindrical vessel.

A sample of material from each stratum is selected, registering on the weight and height clearance form to determine the density. See density format in annex 4

The material is introduced into the vessel, its volume and weight have been previously obtained.

Once filled, lift the container 10 cm over the surface and let it fall three times, in order to fill the empty spaces in it, and measure the upper clearance, registering in the corresponding format.

Finally the container is weighed with the material contained, by calculating the difference, the weight of the garbage will be obtained. With this data we will calculate the volume of waste.



$$Density = \frac{\text{weight (w)}}{volume\ (v)} = \frac{\text{weight } (w)}{\pi\left(\frac{d}{2}\right)^2 * h}$$

Figure 12

J. Determine the physical composition of household solid waste

For the determination of the physical composition of the solid waste the cylindrical vessel method is used, a recommended 55 gallon tank, which consists of:

Empty the contents of the container used to determine the density, then separate the components according to the type of waste.

The bags are broken and the waste is poured into a pile. In order to homogenize the sample, the most voluminous solid waste are chopped up to a size that is manipulable. See figure of separation and classification of waste.

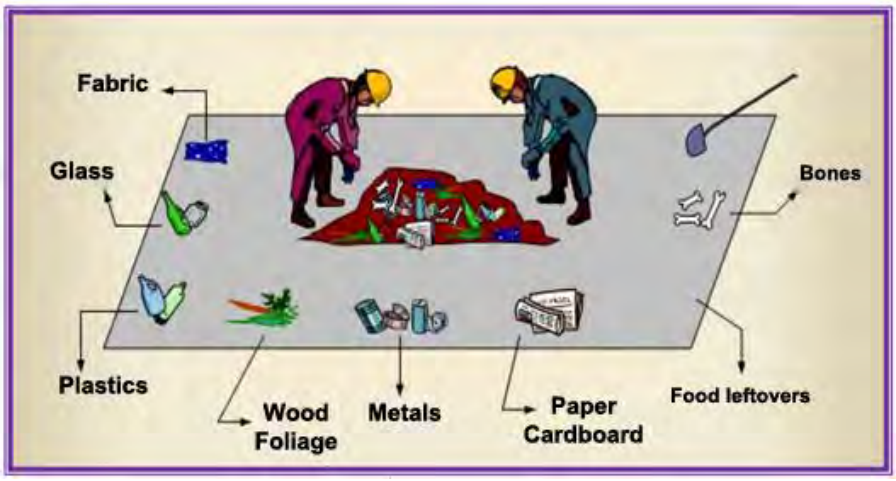
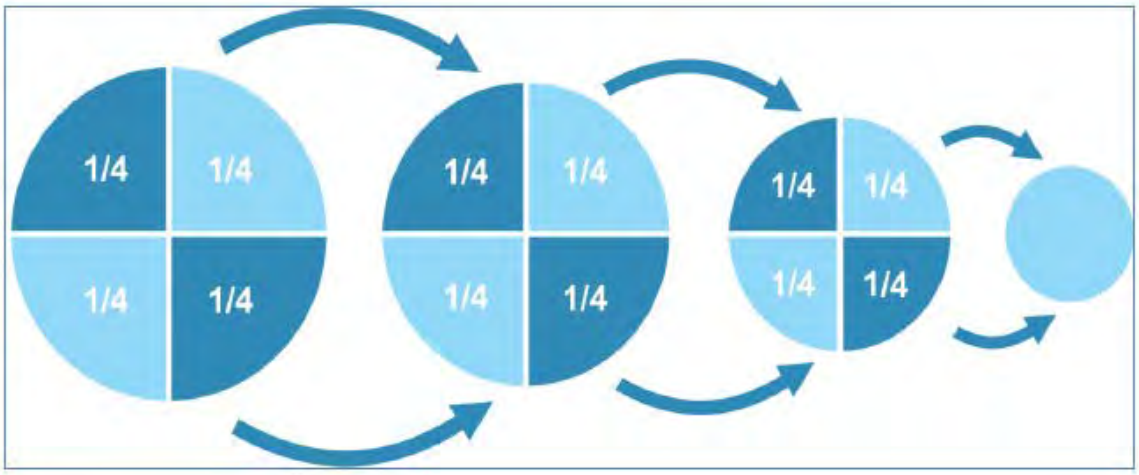


Figure 13 Segregation of the material to know the composition

To perform this work the sample of one day is used. The waste should be placed

in a paved area or on a large plastic, in order not to combine the waste with soil.

If you have a very large volume of waste, divide it into four parts (quartet method) and choose the two opposite sides (shaded sides of the chart below) to form a new smaller heap. The smaller sample is re-mixed and divided into four parts again, then two opposing ones are chosen and another smaller sample is formed. This operation is repeated until a sample that is manageable is obtained.



Source: Guía Metodológica para el Desarrollo del Estudio de Caracterización de los Residuos Sólidos Municipales (EC-MRS).

Figure 14 Sample quartet

Once the classification of the components has been completed, the weighing and recording of the data are done in the solid waste composition form, see physical composition format in Annex 3.

The percentage of each component is calculated taking into account the data of the total weight of the collected solid waste in a day (Wt) and the weight of each component (Pi):

$$\text{Percentage (\%)} = (Pi/Wt) \times 100$$

Repeat the procedure during the seven days of waste sampling. It is necessary to remember that out of the initial eight days that the sampling lasts, the sample of the first day is eliminated for not being considered it useful.

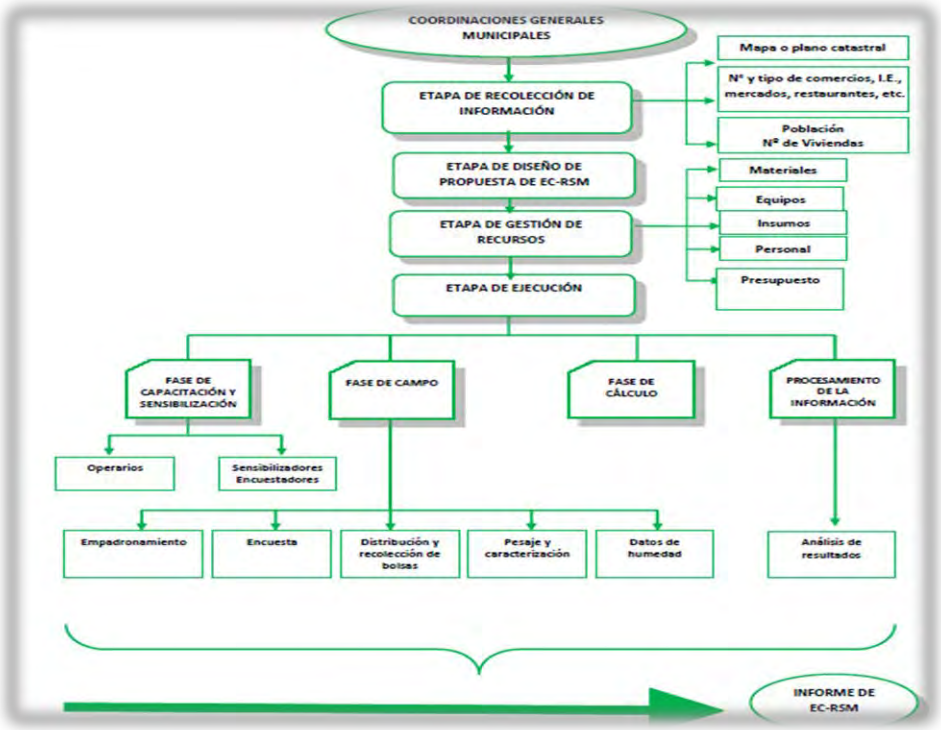
2.2 Logical sequence of intervention for the execution of the Characterization Study of Solid Waste.

The following diagram shows the logical sequence of intervention for the Solid Waste Characterization Study (household solid waste and non-household solid waste), both components require the same steps in planning and analysis of information.

The sequence used to determine household waste:

- The sequence used to determine household waste:
- The purpose of the study is disseminated and explained.
- The bags for sorting the waste are delivered.
- The bags are collected from homes and establishments.
- The bags are moved to the workplace (space identified for the study).
- We proceed to carry out the weighing.
- The volume, density is calculated.
- The generation and physical composition of the waste is determined.

A random sample of commercial establishments is taken.



Source: Guía Metodológica para el Desarrollo del Estudio de Caracterización de los Residuos Sólidos Municipales (EC-MRS).

Figure 15 Logical sequence of intervention for SW characterization

Non-household waste are all those that are not generated in households, these are generated in industries, industrial businesses, construction activities, agricultural, cleaning public spaces, health centers, electronics, etc.

Its management responsibility is the generator's own responsibility.

The methodology used to determine these waste is the same used in household waste.

2.3 Analysis and processing of the results.

2.3.1 Data validation

In the validation process a new sample number "N" is calculated, assuming the initial sample number is "M", then:

If N > M, the sample is validated

If N < M, A study should be carried out for the remaining households (M-N)

2.3.2 Process the surveys

After having applied the surveys to the owners of the houses and shops, process the surveys of perception of the solid waste management through different questions and to interpret them through graphs, as detailed in point 2.4, for household waste.

The results are presented in the report through tables, graphs and their interpretations.

2.3.3 Systematize the data.

To systematize the data, it is recommended to use the following formats and adapt according to the different activities (housing, shops, street sweeps, markets, hotels, institutions, etc.). See example of household and commercial waste format.

Table 11 Format for weight of residencial solid waste

MUNICIPALITY:_____											
STUDY IN THE HOUSEHOLDS											
Household	**Inhab**	**PESO**								**Average weight**	**PPC**
		0	**1**	**2**	**3**	**4**	**5**	**6**	**7**		**(Kg/person/ day)**
1)											
2)											
3)											
4)											
5)											
…											
N households											

Table 12 Format for weight of commercial solid waste

MUNICIPALITY:_____											
STUDY IN THE COMMERCES											
COMMERCES	**Activity**	**WEIGHT**								**Average Weight**	**PPC**
		0	**1**	**2**	**3**	**4**	**5**	**6**	**7**		**(Kg/Co/ day)**
1)											
2)											
3)											
4)											
5)											
…											
N COMMERCES											

2.3.4 Elaboration of conclusions of the study:

A report of results to be presented to the municipality should be prepared. It must contain at least information on the methodology used and a record of the data obtained.

The Per Capita Generation results will be recorded in the study areas in kg./inhab./day.

The results of the total generation of solid waste for the field of work expressed in Ton / day will be recorded.

The results of the solid waste density expressed in kg / m3 shall be recorded.

In the case of physical composition of solid household waste, we obtain the usable waste and non-usable waste expressed in percentages (%).

The results of moisture in percent (%) will be recorded.

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Manual for Plan of Collection and Transportation of Solid Waste

May 2017

NIPPON KOEI LAC

NIPPON KOEI

ABBREVIATIONS

ADN	Ayuntamiento del Distrito Nacional / Nacional Districto municipalityl
D.R.	Dominican Republic
GIS	Geographic Information System.
ISWM	Integrated Solid Waste Management.
MSW	Municipal Solid Waste
PO	Plan of Operation
PPC	Production per capita
PPE	Personal protection equipment
PPP	Public -Private- Partnership.
SW	Solid waste
SWM	Solid Waste Management
T/S	Transfer Station

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INTRODUCTION

The collection of solid waste and its transportation to the treatment or final disposal areas is one of the activities of integrated solid waste management under the responsibility of the mayors. Of the quality and proper execution of this, it depends that the solid waste generated by the population does not become vectors transmitting diseases, and that its execution does not trigger the budgets of the cities hall, since, its costs are the highest of all the management system.

A solid waste collection system should take into account the characteristics of each municipality, these are: geographical characteristics, demographic characteristics, economic characteristics, vial structures, among others.

Establishing a solid waste collection and transportation system requires an exhaustive and detailed study that ensures that the service will be done efficiently and that it won't obstruct the development of other daily activities carried out by either the town hall or the general population that receives the services provided. This should be done in a sufficient and timely manner with a budget that the town hall will use to avoid unexpected collapses.

Objectives

Provide a document that covers the basic criteria for establishing an adequate solid waste collection and transportation system that allows the municipalities to complete the following tasks:

- Evaluate the current situation of the solid waste collection and transportation at the communities that they are being collected from and analyze the problems that need solving.
- Formulate a plan for improving the practices of solid waste collection and transportation.

PART I

1 GENERAL

1.1 Current situation and issues of collection and transportation of solid waste

The issue of solid waste in the majority of countries, but particularly in determined regions, has been worsening as a consequence of the accelerated population growth and its concentration around urban areas, the industrial development, the changes in consumption and increased quality of life, as well as because of a series of other factors that lead to the contamination of the environment and the deterioration of the natural resources.

Some of the indirect impact is due to the fact that the waste in itself and the blockage that it causes when it accumulates in ditches and drains, transforms into insect and rodent reservoirs. The insects and rodents are the cause of diverse types of diseases such as dengue, leptospirosis, parasites and skin infections. The open burning on the ground and also at the dumps increases the risk factor of the incidence of diseases related to the respiratory tract.

In the case of the Dominican Republic, even though both the big and the small municipalities have turned solid waste collection and transportation into the main activity of the municipal service, an efficient system has not been achieved yet, because such service does not follow any study or detailed plan that involves all the elements that influence the system. Excluding some exceptions, it is still understood that hiding the generated solid waste from the citizen is the objective, disregarding when or how it is removed from their sidewalks or what their final destination will be.

Even though when it comes to economic figures, not a single city in the D.R. can be considered a big city, in regards of their generation of solid waste, many cities can be compared to any foreign city with a superior economic development and with more advanced infrastructure.

1.2 Legal framework

Law 176-07 of the District National and the Municipalities establishes in article 19, on *Competences of the City Hall* and Article 20 on *Minimal Municipal Services*, that the City Hall, on its own or while associated with others, must offer, as a part of its minimal services, the solid waste collection service.

Law 64-00 of the Ministry of Environment and Natural Resources, in its chapter 6 on Domestic and municipal garbage and waste, Article 106, mentions that the municipal City Halls will operate collection, treatment, transportation and final disposal systems for non-hazardous solid waste within the municipality, observing the official norms issued by MARENA, jointly with the Ministry of Public Health and Social Assistance for the protection of the environment and health.

1.3 Solid waste collection and transportation system: Basic Concepts

The collection and transportation stage covers two processes, clearly differentiated as:

1. Solid Waste Collection.
2. Transportation/Transference.

The formulation of a solid waste collection and transportation plan, must cover the following aspects:

- Adequate storage.
- Equipment for transportation of solid waste.
- Solid waste collection routes, frequency and schedule.
- Applicability of a transfer station (TS).
- Applicability of solid waste segregation at their sources of generation.

1.3.1 Quality of the solid waste transportation and collection service

In order for the solid waste collection and transportation service to work optimally a permanent flow of information that supports managing and planning of such service is necessary.

Before proceeding to design the system, it is necessary to have a clear

understanding of the community's expectations and of the resources available to satisfy their needs, this will allow to establish the technical conditions that the service is supposed to have.

There are many aspects that influence the quality of the system directly, for this reason they must be considered before elaborating the collection plan, establishing a level of quality for each of them. The aforementioned aspects of quality are the following:

- Coverage of the solid waste collection services.
- Frequency.
- Type of storage.
- Type of vehicle, etc.

1.3.2 Classification of solid waste collection

Collection is the activity that involves collecting the solid waste disposed at the indicated sites and their loading into the solid waste collection vehicles.

In general terms, the collection could be classified into different types, depending on the nature of what needs to be classified:

1. Manual, and as a part of this one we have:

1) **Formal solid waste collection:** done as a part of municipal service.
2) **Informal solid waste collection:** done by individual collectors (*Buzos* in Spanish).

2. Mechanical, and as a part of this one we have:

1) **Pneumatic collection:** Uses an underground pneumatic conduction system for transporting solid waste to the transfer stations from where said waste is moved to a treatment plant.
2) **Collection through vehicles:** It is done using vehicles specially prepared for the collection task, such as compactor trucks or flatbed trucks.

Taking into account other criteria, such as the place of collection and/or way it is collected, solid waste collection can be:

1) Door to door.
2) Point to point (Containers).

Taking into account the type of waste to be collected, the collection can be:

1. General: The solid waste is picked up, mixed, from containers where there is not any kind of segregation of such waste.

2. Selective or Differentiated: The solid waste is collected separately, according to its type, characteristics and properties; based on subsequent treatment and assessment.

1) It is based on having the solid waste generators do the selection of recoverable materials, at the source, by placing such waste in independent containers.
2) It requires a high degree of civic cooperation and training.
3) It works more successfully in developed countries.

3. MSW Collection (Or conventional): This method is based on collecting solid waste from households, businesses, and institutions that produce a volume of MSW not higher to the one described in the correspondent municipal legislation.

- **Specific Collection:** at markets, beaches, streets and other public sites.

The next three (3) types of collection ***must not*** be included as a part of the municipal service, but it mentioned for educational purposes.

- **Special collection:** contemplates waste that is not picked up by the regular collection service, such as debris, dead animals and pruning of gardens and trees.

1. **Collection of biomedical Solid Waste**, which include solid waste from hospitals and other health centers, such as labs, clinics, vets, drug stores, etc. These places require special treatment due to the biomedical nature of their MSW.

2. **Hazardous Waste Collection,** which include waste material that, even though it is not of biological nature**,** requires special treatment due to its special impact to the environment.

The municipality must establish the types of solid waste collection that it wants to apply.

Since the conventional collection is the main objective of the municipal service

and of this manual, we will focus on the elements that impact its planning and operation.

1) Collection of Municipal Solid Waste

The collection of urban/municipal solid waste refers to the action of managing solid waste, which allows its elimination from the environment. Solid waste should be transported from its source of generation to the Final Disposal Site for its treatment. The collection and transportation to the final disposal site is known as a service of public operation by the general population, which must prevent the development of vectors and disease transmission.

The municipal service is characterized by the intervention of the municipality, which is in charge of organizing the mechanized transportation, generally, from the point of generation towards the final destination of the solid waste, and by the adequate preparation and allocation of solid waste according to the places and schedules pre-established by the municipality, this allocation and preparation task is the responsibility of the general population.

To plan the collection system, the municipal service must know, previously, a considerable amount of data, which must be researched or found out by carrying out the studies needed.

1.3.3 Types of collection equipment

The main means to transport solid waste are motor vehicles, pneumatic and hydraulic systems have also been used. The most used collection equipment in the country is the compactor truck, which takes waste from the source of generation to the final disposal site or transference station in some municipalities, being this equipment the most conformable due to its operation time, but also the most expensive.

Below you will find some types of solid waste collection equipment:

- Animal Traction Carts.
- Flatbed Trucks.
- Dump Trucks (Big and small).
- Compactor trucks with a mechanical arm of frontal or rear load.
- Special trucks (E.g., a tractor with its own cart).
- Special Dump Truck.

The equipment must be chosen depending on what they will be used for when it comes to the collection system, specifying if their role is compaction, transportation, etc.

Special Dump Truck (Transfer station)

Special Dump Truck (Transfer station)

Compactor Truck

Compactor Truck

Dump Truck

Dump Truck

Photo 1　Examples of collection vehicles (1)

Flatbed truck

Flatbed truck

Tractor con su Carreta

Cart

Photo 2 Examples of collection vehicles (2)

The collection equipment must be adequate for the geographical characteristics and the population of the selected location. Generally, they have a compaction mechanism or a waste pusher plate in order to increase the apparent density (On average it can reach 450 Kg/m^3) or the vehicles have a dumping mechanism. The capacity can oscillate between 6 and 30 m^3.

There are different ways of gathering and accumulating urban solid waste, each of them with specific characteristics, such as automatic collection with a side loading truck, manual collection with rear loading trucks, pneumatic collection through vacuuming, and other equipment, such as collection of furniture or anything that is not being used. Other activity to be considered is the collection of waste from the selective collection such as paper, glass and plastic containers and organic matter, already segregated.

The **Compactor Trucks** are specially prepared and possess a hopper where waste is compacted. The waste is dumped into the bed of the truck, and after it is full it is pushed into the hopper by a movable plate, which is activated by an electric or manual system while another one prevents the solid waste from going

back to where it came from. An employee is in charge of this system. These plates are not only there for pushing the solid waste into the box, they also compact it. The collected solid waste, through various processes, is transported to the facilities or treatment plants for their selection, incineration or dumping.

There are trucks with only one storage or with double storage for selective collection.

Flatbed trucks are used at sites where the conditions of the soil, the topography and the narrowness of the streets don't allow for big trucks to enter. The main disadvantage is the low possibility of compaction and that they are not very comfortable. Their capacity is lower (1 to 3 m^3).

Manual rear load:

Manual rear load:

Rear load with container elevator:

Rear load with container elevator

Photo 3 Solid waste loading system (1)

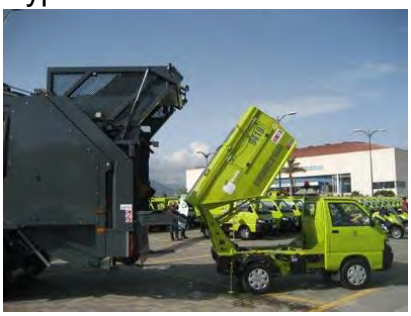
Side load of containers:

Side loading lift

Front load with container elevator:

Front loading lift

Other types of load:



Other types of load

Photo 4 Solid waste loading system (2)

1) Specialized collection equipment and its characteristics

Multiple Solid Waste Collection Equipment exist, from traditional compactor trucks to small manual carts. Solid Waste Collection in small cities and rural

towns can be done in different ways. The decision depends on the volume of solid waste that has to be collected and the distance to be traveled in order to transport said solid waste. It is important that the collection vehicles, or at least their spare parts are available in the place where they will be operated. Taking that into account, it is better to use or adapt a vehicle that is already in the zone where it will carry out the solid waste collection before introducing a new type of vehicle.

SOURCE: GUIDE FOR THE MANAGEMENT OF SOLID WASTE IN SMALL CITIES AND RURAL AREAS

Photo 5 Solid Waste Collection Equipment

1.3.4 Transportation System

The transportation covers the transference of solid waste between different sites that are part of ISWM (collection points, Transfer Station (TS), Material recovery plant, treatment plant, Final Disposal Site (FDS)).

'Transport'' means taking solid waste from the collection area to the established destinations, whether it is intermediate treatment facilities or final disposal sites. Generally, there are two systems of solid waste transportation:

- Direct Transportation: The collection trucks are used for transporting solid waste to the definite destinations that exist close to the collection areas.
- Indirect Transportation or Transference Points: The collected waste are transferred from a collection vehicle at transference points and then to their destination.

The waste collected is transferred to treatment facilities and or to FDS through collection vehicles. If the distance between the generation point and the FDS is big (More than 50 km, approximately), the inclusion of Transfer stations will have to be analyzed.

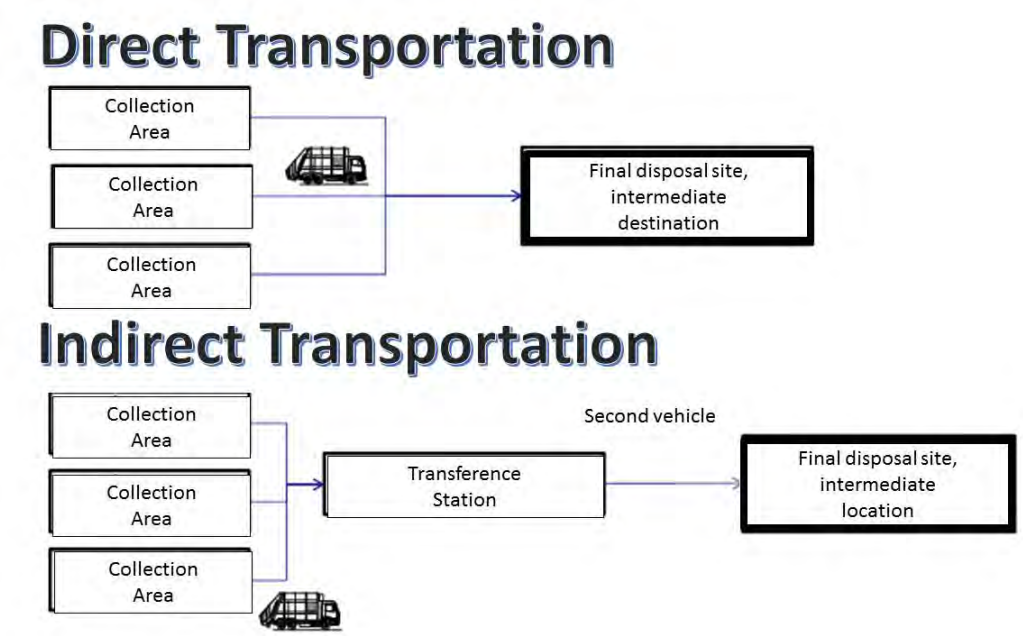


Figure 1 Transportation Methods

For the planning of the collection and transportation, it is necessary to consider the general conditions and the sanitary requirements for the collection and transportation of solid waste, established in the norm for Environmental Management of Non Hazardous Solid Waste of paragraph 5.4.

1.3.5 Transfer station

TS is a group of equipment and installations that make possible the transference of solid waste from lower capacity solid waste collection vehicles to higher capacity vehicles, designed to transfer big loads of waste throughout great distances until they get to their destination. TS, generally, is built with two levels. The collection vehicles that go in dump the waste from the upper level to the lower level.

Ships and trains can also be used for this task.

Even though their reasons of being are mainly economical, the basic objectives of TS are:

1. Increase the global efficiency of the solid waste collection service.
2. Decrease the cost and transportation time, as well as the decreasing the idle time of employees and equipment.

Photo 6 Transfer Station in Villas Agricolas, AND

The transportation of solid waste is very pricy if it needs to be transported throughout great distances. TS is an economic alternative when the distance to the solid waste treatment center is long, said stations will also help with:

1. Rationalizing and optimizing solid waste collection for its transportation.
2. Minimizing transportation cost.

The operations of transfer can be justified when:

1. When in residential solid waste collection, small vehicles, loaded manually, are used to transfer solid waste throughout long distances.
2. Extremely big amounts of solid waste need to be transported throughout long distances.
3. A considerable number of collection vehicles can use a transfer station.

Photo 7 Dumping at the transference station in Villas Agrícolas, ADN

1) Components of a transfer station:

- Access and exit ramps.
- Entrance with buffer zone.
- Weighing machine.
- Reception platform.
- Dumping yard.
- Loading zone/tunnel.
- Storage hopper/well.
- Water collection and treatment system.
- Equipment to move the solid waste to the transfer points.
- Compaction equipment, generally stationary.
- General services area.

Photo 8 Weighing machine at TS de Villas Agrícolas, ADN

2) Environmental impacts generated by Transfer Stations:

- Bad smells.
- Noise.
- Vectors.
- Dust.
- Leachate.
- Risk of fire.

3) Types of transfer station

Transfer stations have been popping up worldwide due to the solid waste collection issue and based on the cost-benefit analysis. This analysis demonstrates that the costs of collection are higher and the amount of time it takes to get to the final disposal site is too big, on top of that, they do not cover the collection needs of the population. There are different types of TS, mainly:

- Direct dumping stations.
- Indirect dumping stations.
- Combined Stations. (Direct and indirect dumping)
- Other types, described in the following table:

Table 1 Types of Transfer Station

Type	Characteristics
Direct transfer station	The waste is dumped directly from the collection vehicles to the transfer trailer on hold.
Indirect transfer station	The waste is dumped into a pit or platform, then it is loaded into a trailer using equipment.
Station with compaction hopper	The waste is dumped into the collection truck, through a Hopper and then loaded into a closed truck through a compactor.
Station with compaction box	The waste are taken from a collection vehicle to a compaction box and then loaded into a closed truck through a compactor.

Direct Transfer Stations are characterized by low capacity vehicles transferring waste directly to higher capacity vehicles, sometimes done through a hopper. This is the most used type of TS in Latin America. They are easy to operate.

Photo 9 Dumping at TS of Villas Agricolas, ADN

The indirect load or storage TS has zones where waste is stored for 1-2 days, generally. Usually, they have a pit where waste is handled, so it can be loaded into higher capacity vehicles. This makes possible to do a separation of some of the waste, so later they can be transported to the harnessing site or sold to recyclers.

Combined Stations possess areas where solid waste is stored temporally and others where they are loaded directly into higher capacity trucks. These stations can be located in solid waste harnessing centers in order to decrease the

transport to the 'potentially recyclable materials' selection, classification and packaging sites.

Solid Waste Load

Trucks' check-in.

Solid Waste loaded into another truck.

Photo 10 Different Type of Operations in a Transfer Station

Trucks leaving the transfer station

Solid Waste being dumped at a Final Disposal Site

Transfer Station

Transfer Station

Katmandú, Nepal

Querétaro, México

Jakarta, Indonesia

Jakarta, Indonesia

Photo 11 Different Type of Operations in a Transfer Station

1.3.6 Temporary Storage and Solid Waste Delivery

Temporary storage systems determine the collection and load system of waste and vice versa, so both are closely related.

1) Types of storage

An effective system must be considered for the storage of waste, taking into account local conditions, such as: existing systems and/or proposed system for the collection, types of waste, population density, housing conditions, culture, etc.

In general, the way of storing solid waste must be determined according to the following aspects:

- Amount of solid waste generated.
- Composition of the waste to be collected.
- Collection Equipment to be used.
- Behavior of the citizen who will receive the service.

In regards of the storage volume, the types of storage are shown in the following table:

Table 2 Type of Storage of Waste

Solid Waste Volume	Types of Storage
Small Volume	Garbage cans on the sidewalks. Plastic, metal and other types of Containers. Movable containers. Plastic Bags.
Great Volume	Container.

It is important to consider the use of ‘‘plastic bags’’ for the domiciliary handling of waste (partially at a commercial level), so it is advisable to encourage its use. Whereas its use contributes significantly to decrease contaminating agents –this must be a *line of action* within the ‘‘Environmental Management Plan’’ to be implemented- the use of cardboard boxes comes from businesses, specially, grocery stores and ‘‘colmadones’’ (bigger grocery stores that specialize in the distribution of high amounts of alcohol to the general population while blasting loud music), as well as small and medium companies located in neighborhoods and commercial centers.

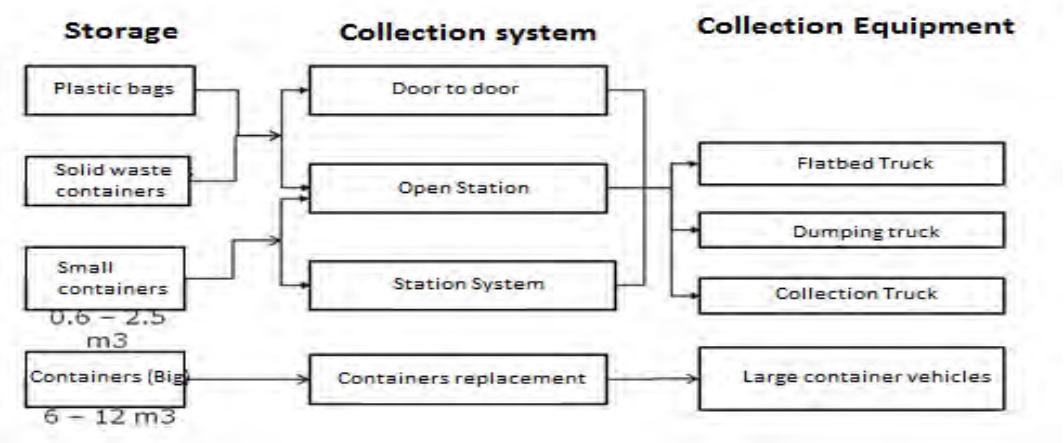


Figure 2 Temporary storage options, load and collection

In the Dominican Republic, the norm for Environmental Management of Non-Hazardous Solid Waste, paragraph 5.3, establishes the "General Conditions and Sanitary Requirements for Storage".

2) Necessary capacity for the use of containers

The temporary storage system should be easy to clean and access.

For designing the collection system it is necessary to previously define the capacity of the containers to be used. The types and capacities of the containers to be installed depend on the characteristics and types of solid waste that have to be collected, the type of collection system used, the collection frequency and the available space for placing the containers. The commercial capacities are usually the following: 90, 120, 140, 240, 360, 700, 800, 1000, 1100, 2400 and 3200 lts. Equally, the average density of the solid waste, inside the container, must be predefined. Typical values are between 120-300 Kg/m$^{3.}$ The number of containers required for the collection is calculated with the following expression:

$$Containers = \frac{PRD}{PV}$$

Where PRD represents the production of the collection system design in kg/day;
P, the apparent density of solid waste within the container in kg/m^3;
and V, the capacity of the selected container in m^3.

Only 33% of the time of the day is dedicated to the collection. The time that the helpers must wait for the discharge of the truck represents 54% of the time of the day, of which 40% is associated Waiting for the unloading shift or the compactor

truck arrives and the remaining 14% is the time spent on the transfer.

3) Storage with Separation of Solid Waste at the source

To define storage when it comes to the separation at the source, there are 3 basic aspects to consider. The first is who will collect the solid waste with commercial value at the source; second, who will carry this material to the gathering facilities and/or to the recycling companies; finally, analyze the viability of economical retribution to the generators for the sale of such material.

The local actors that are involved in the process are:

- City Hall (Municipality).
- Informal Waste Pickers (‘*Buzos* in Spanish’’).
- Intermediaries that buy and sell recyclable material with commercial value.
- Clean points/ Gathering centers.
- Recycling companies.

4) Use of mobile containers

With this method, the vehicle transports the full container to the TS or to the FDS. The equipment requires a mechanized system; this is generally used for containers larger than 10 m^3.

5) Use of fixed containers

The collector truck unloads the solid waste from the containers then places such containers where it found them. Generally, the equipment has a mechanized system. The capacity of the containers vary, between 1 to 7 m^3.

PART II

2 PLANNING

Before proceeding with a plan, it is necessary to know the current conditions that the service in force is applied to.

2.1 Evaluation of the current system: Conditions to be verified in the collection area

The current collection system must be revised before carrying out the plan. The following points must be verified within the collection area.

2.1.1 Estimation of the amount of waste to be collected

The municipality must specify, previously, which types has been collected, but in general, municipal solid waste are the waste generated in:

- Homes (Domestic solid waste).
- Businesses.
- Institutions.
- Sweeping of public spaces and streets.

Even though the generation data must be obtained previously through a waste characterization study, it is important to remember that the total generation of solid waste in the municipality will depend in the following factors:

- Number of inhabitants (P, population)
- Production per capita (PPC)

For example, with a population of 125,000 we would have:

- ✓ P = 125,000 inhab.
- ✓ P.P.C. = 0.90 kg/inhab/day

- **Production day** **= PPC*P**
  = 0.90 * 125,000 = 112,500 kg/day = 112.5 ton/day
- **Production year** **= (PPC * P * 365) / 1000**
  = (0.90 * 125,500 *365) / 1000 = 41,063 ton/year

From where,

- **Monthly production** = Production year / 12 = 82,125 / 12 = 3,422 ton/month
- **Weekly production** = Production day * 7 = 787.5 ton/week

It is necessary to clarify the amount of waste to be collected before planning the collection system. The amount of waste can be calculated using the following formula:

$$V_c = \sum_i \left(r_i \times V_{gi} \right)$$

Equation 1: Amount of Waste Collected

Where:

- ✓ V_c = Amount of waste to be collected (Ton/day)
- ✓ ri = Coverage if the collection (%)
- ✓ V_{gi} = Generation of waste (Ton/day)
- ✓ I = Type of waste generator (general population, businesses, institutions)

2.1.2 Number of inhabitants and households

Within an area of study, its blueprints must be taken into account in order to be able visualize it and its vial infrastructure with clarity:

- The sectors or neighborhoods and its limits, commercial zones, industrial zones and great generators (e.g., isolated businesses or institutions that can be served by authorized companies).
- Number of inhabitants and of households per sector. For the determination of these values, use the data of the latest National Census and compare said values with the year of study, based on the yearly growth rate.

2.1.3 Vial conditions

- The streets where it is not possible to move the collection vehicles (width of the road, height of electric wiring).
- The streets or avenues that are only go one way.
- The high traffic streets or avenues during the busiest hours of the day.
- The streets or avenues that during the day modify their direction of traffic circulation, indicating at the same time when is it that this happens.
- Streets or avenues with steep slopes.

- It will be necessary to identify:
  - ✓ Big generators.
  - ✓ Green areas.
  - ✓ Location of the operation center of SWM.
  - ✓ Location of the Final Disposal Site.

2.1.4 Time and motion study

The study of time and motion directly monitors, in the field, the duration of the routes to be optimized. This information will allow the implementation of a diagnosis of the current collection routes and the generation of the necessary information for its later optimization.

The monitoring period must take place at least once a month and must be done by personnel that has been specially trained for said task, therefore avoiding errors in the gathering of information and, at the same time, train the truck driver when it comes to the collection of data.

On the other hand, if the routes being studied include the collection of industrial waste and / or commercial waste -and it has been decided that as soon as the optimized routes are implemented, data will be collected-, the amount of waste produced by each generator must be quantified, in order to do this, said waste must be collected separately for at least 15 days and the collected tons must be registered.

It is diagnosed that if the collection frequency is adequate, through a comparison between the value obtained for the collected tons / collection time indicator (ton / hour) for the routes being studied with the optimal value indicated in the following table:

Table 3 Acceptable range for Tons/Time indicator, collection total

Type of collection (Urban Zone)	Acceptable Range	Optimal Value
Door to door or mixed method: 3 assistants	2.3 to 2.6 ton/hour	2.45 ton/hour
Point to point method (Containers), 3 assistants,	2.8 to 3.2 ton/hour	3.0 ton/hour

Source: Collection Service Improvement Manual of ADN, 2011.-

It must be diagnosed if the collection routes have been established adequately

and that the vehicles do not operate while overloaded, comparing the values obtained for the indicator tons/trip with the maximum payload that the truck that carries out the route can transport.

It will be established that the route is well designed if the relation between ton/trip and the payload transported by the truck is within the optimal range from 0.9 to 1.05; any value outside of this range will indicate that the route must be optimized.

The maximum useful capacity of transportation of the truck will be established considering the gross weight of the vehicle, weight of the chassis and weight of the compaction box, according to the following formula:

Maximum payload =
Gross Weight of the Vehicle – Weight of the Chassis - Weight of the Compress Box

2.1.5 Storage capacity study

The way of storing the solid waste is determined by:

- ✓ The amount;
- ✓ The composition;
- ✓ The transport (type of collection, frequency).

It is necessary to examine the storage capacity in the following way:

- Verify the condition of the solid waste containers located on the streets for 15 days in a row at the same time of the day.
- Condition of the containers: Filled, overflowed, not filled (→ x% busy), empty, broken.

To carry out the study, it is necessary to know the types of storage.

2.1.6 Analysis of the solid waste collection records

It is necessary to verify any history available on the current collection system. The main points to be registered are:

- Number of trips per collection vehicle,
- Person in charge,
- Working hours and,
- Number and location of the containers, if there is any.

2.2 Collection and transportation system

For the planning of collection and transportation, it is necessary to consider many technical requirements. The solid waste collection system must be prepared efficiently and with sanitary criteria, including the collection frequency, days / hours of collection, routes of collection, collection methods, equipment, possible transfer point, etc. The seasonal and weekly fluctuation must also be considered when it comes to the generation of solid waste.

The collection routes must be decided through tests and simulations in the map with previous knowledge of the traffic and condition of the roads in each zone and the experience acquired with previous collection works (Record of collection).

2.2.1 Objectives of the plan and service characteristics

The design of the collection system will depend on:

- The characteristics of the solid waste and storage (generation, industry or businesses).
- Characteristics of the city (slopes, width of the road, vehicular congestion, etc.).
- Characteristics of the FDS.
- Type of truck.
- Collection Frequency.
- Resources and infrastructure.

Below are some technical considerations that must be discussed before designing the collection routes:

- Number and type of selected equipment.
- Number of people per equipment.
- Collection frequency.
- Distance between stops and stations.
- Distance to the final disposal site or transfer station.
- Handling of Containers.
- Terrain topography.
- Route’s traffic.
- Condition of the routes.

2.2.2 Diagnosis of the current routes

Using the information obtained through the actual evaluation system, a diagnosis of the routes must be carried out in order to establish the need of optimizing them or creating new routes. The diagnosis is done based on Optimal Indicators, defined below:

1) Collected tons vs. Hours of collection

A diagnosis is done to verify if the collection frequency is adequate, this is done through comparison between the value obtained for the indicator collected tons / collection time (Ton / hour) for the routes being studied with the optimal value indicated in the following table:

Table 4 Acceptable range for the Tons indicator.

Acceptable range for the Ton / Total time of collection		
Type of collection (Urban zone)	Acceptable Range	Optimal Value
Door to door method or mixed, 3 assistants.	2.3 to 2.6 ton/hour	2.45 ton/hour
Point to point method, (containers), 3 assistants,	2.8 to 3.2 ton/hour	3.0 ton/hour

If the relation between value of the achieved indicator and the Optimal Indicator is below 0.9, it can be said that the frequency of service is not adequate, and extending the period between the days of collection is required, in other words, the frequency must be reduced, therefore, the route must be optimized.

2) Tons per trip and performance of the personnel

A diagnosis is done to verify if the collection routes have been established adequately and that the vehicles do not operate overloaded, comparing the values obtained for the indicator Tons / trip with the maximum payload that the truck, which follows the route, can transport.

It will be established that the route is well designed if the relation between ton per trip with the truck's maximum payload for transport is within the optimal range between 0.9 and 1.05, any value outside that range will indicate that the route must be optimized.

In the same way, the daily performance of a collection assistant is diagnosed, comparing the amount of waste collected monthly with the number of helpers

who were active in that month. If the value is substantially lower to the optimal value previously established, it can be said that the performance achieved by the helpers is not adequate, which presumably is the result of a low accumulation of waste and a long trip, therefore, another frequency must be studied and the route optimized.

It will be established that the route is poorly designed if the performance of the collection assistant is below 4.3 tons / assistant / day, established as optimal value.

2.2.3 Optimization of routes

The route will be optimized when the diagnosis demonstrates that some of the indicators present values outside the ranges defined as acceptable or optimal.

2.2.4 Design of the Collection Routes

The route corresponds to the trips that the solid waste collection trucks go on in a work day. A truck can go on more than one trip, to the final disposal site, to complete the route.

The number of routes is equal to the number of trucks that carry out the service.

1) Divide area into sectors

The first activity to be carried out is division by sector, i.e., dividing the area covered by the current routes, so that each sector assigns an appropriate work load to each team, therefore, using all of their capacity efficiently. The sectors can be divided into sub sectors, where each of them corresponds to a solid waste collection trip.

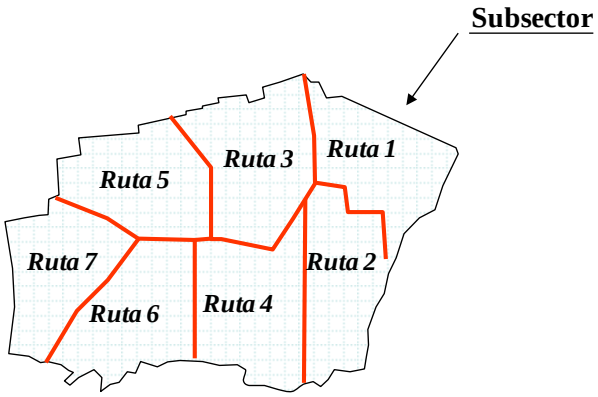


Figure 3 Subsectors for the collection routes.

Before proceeding with the design, the following characteristics of the collection

system must be defined:

Table 5 Characteristics of the collection service

Collection frequency	This can be daily (6 days a week), three times a week or twice a week. The frequency defines the number of days of attention in the subsector.
Payload of the collector truck:	The type of truck(s) to be used and the maximum payload shall be defined.
Number of trips per working day:	The number of trips within the day shall be defined.
Number of working shift per day:	It shall be defined how many working shift is applied to the sector
Number of working days per week:	It shall be define how many days a week the solid waste collection truck in the sector work.

2) Collection frequency

Refers to the number of times the waste is collected in a period of one week.

The frequency depends on:

- ✓ The type of waste (its decomposition level)
- ✓ The combination of the waste generator point and storage facility.

The total tons to be collected daily depend on the frequency of collection, because it establishes the number of days of accumulation in the houses.

The amount of waste that deposited in waste storage is calculated as below.

3) Daily collection except Sunday

In this case, waste collection takes place every day of the week, therefore daily production is collected every day except Sundays, when what has been generated in the last two days is collected, as shown in the following graph:

Figure 4 Area assignation (Daily collection except Sunday)

- **Ton calculation: Daily collection except Sunday: Monday to Saturday**
  - ✓ Normal accumulation days: 1 day
  - ✓ Maximum accumulation days: 2 days

$$\text{ton/normal day} = \frac{(\text{ton/week})}{7} \times \text{Normal accumulation day}$$

  - ✓ Ton/ee
  - ✓ Ton/normal day = 112.5 ton/day

$$\frac{\text{ton}}{\text{day}}\text{peak} = \frac{\left(\frac{\text{ton}}{\text{week}}\right)}{7} \times \text{Days of maximum accumulation}$$

  - ✓ Ton/peak day = 225 ton/day

4) Three times a week collection

The collection of waste is carried out three times a week, so the remains are stored for more than a day in the houses.

The collection is carried out considering two sectors of attention.

- ✓ **Sector 1 of attention:** Monday - Wednesday - Friday
- ✓ **Sector 2 of Attention:** Tuesday - Thursday – Saturdays

Then, the city is divided in two sectors.

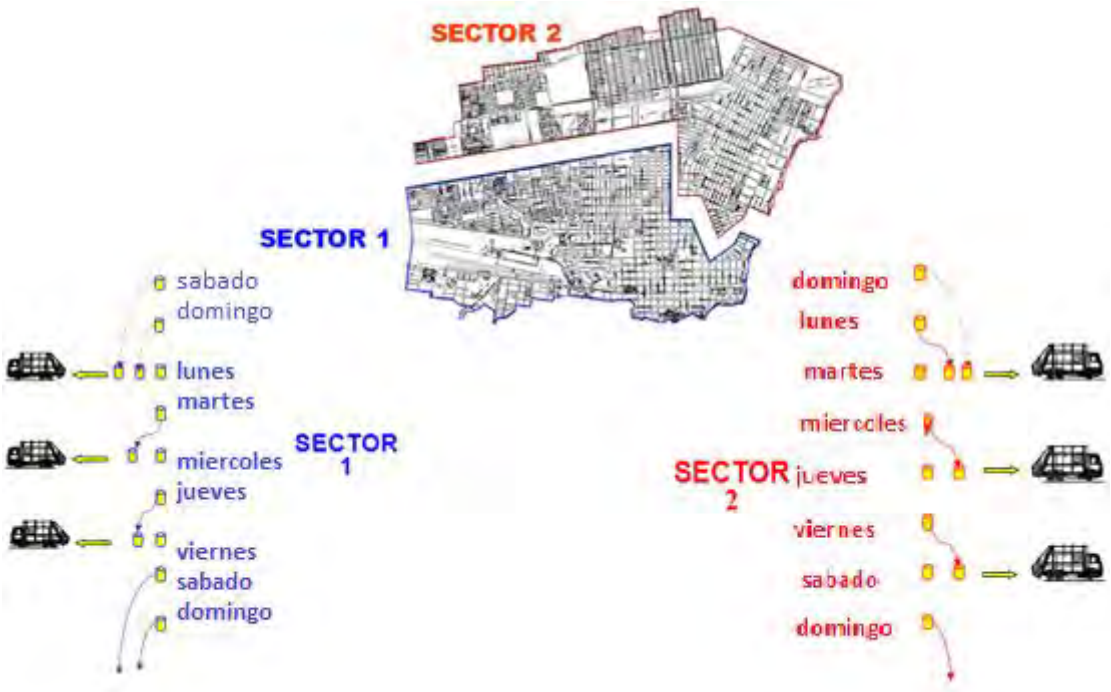


Figure 5 Area assignation (three times a week)

- **Ton calculation: three times a week frequency**
  - ✓ Normal accumulation days: 2 days
  - ✓ Maximum accumulation days: 3 days
  - ✓ Number of sectors: 2
  - ✓ Weekly tons per sector: Weekly tons/# of sectors

Tons per sector =	787.5/2 =	393.8 ton/week
Ton/normal day =	393.8 x 2/7 =	112.5 ton/day
Ton / peak day =	393.8 x 3/7 =	168.8 ton/day

5) Twice a week collection

Waste collection is carried out twice a week. This is why we divide the city into three sectors according to the day of attention.

Sector of attention 1:
Monday - Thursday
Sector of attention 2:
Tuesday - Friday
Sector of attention 3:
Wednesday – Saturday

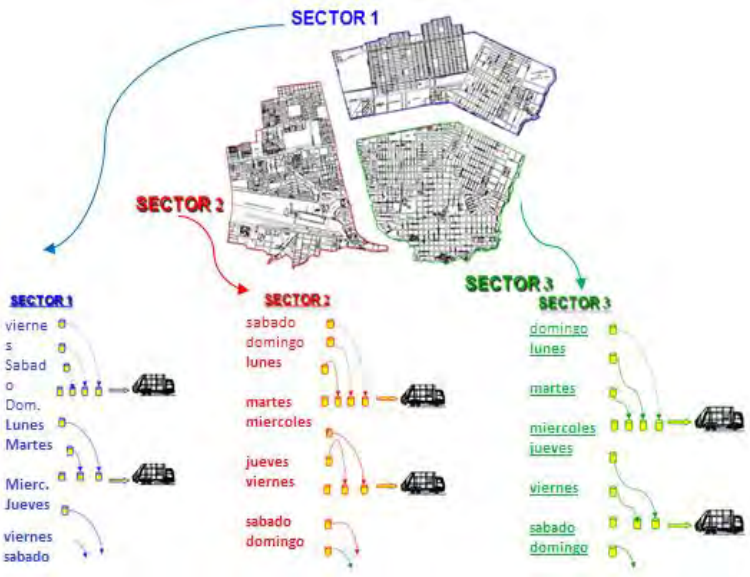


Figure 6 Area assignation (twice per week)

- Ton per week calculation: twice a week frequency
  - ✓ Normal accumulation days: 3 days.
  - ✓ Days of maximum accumulation: 4 days.
  - ✓ Number of sectors: 3.
  - ✓ Weekly ton per sector: Weekly ton/# sectors
    - ✓ Ton per sector = 797.5/3= 262.5 ton/week

✓ Ton/normal day = 262.5 x 3/7 = 112.5 ton/day

✓ Ton/day peak = 262.5 x 4/7 = 150.0 ton/day

Table 6 Tons of waste to be collected by collection frequency

Frequency	Sector	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Total sector	Total
Daily		225,00	112.50	112.50	112.50	112.50	112.50	787.50	788
3 times x week	1	168.75		112.50		112.50		393.75	788
	2		168.75		112.50		112.50	393.75	
2 times x week	1	150.00			112.50			262.50	788
	2		150.00			112.50		262.50	
	3			150.00			112.50	262.50	

Table 7 Daily number of trucks in Operation [assuming 10-ton trucks]

Frequency	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Diaria	23	12	12	12	12	12
3 veces por semana	17	17	12	12	12	12
2 veces por semana	15	15	12	12	12	12

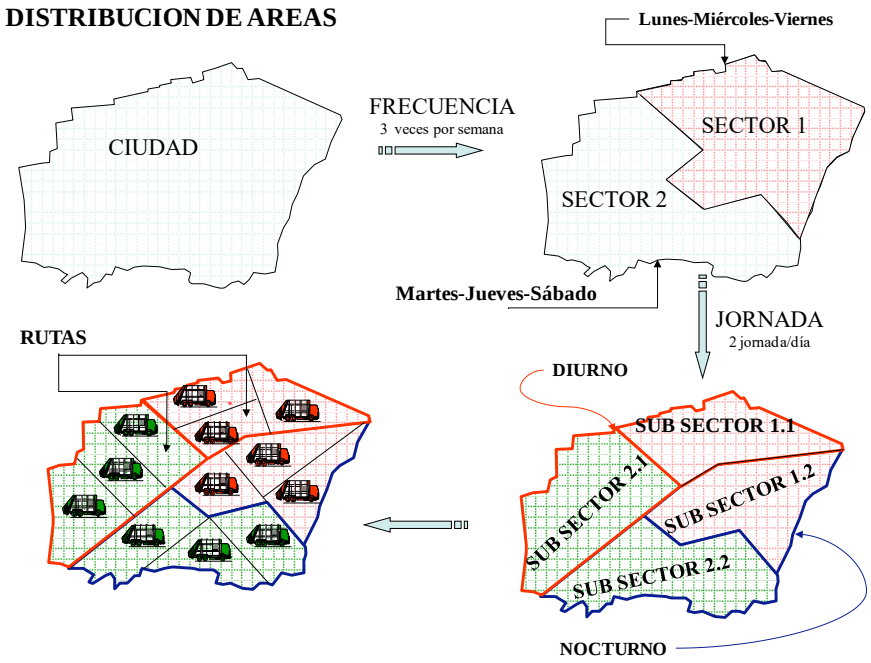


Figure 7 Area distribution

6) Calculation of subsectors and number of collection vehicles

Calculate the total number of subsectors and the number of subsectors served by a truck as follows:

$$\textbf{Total \# of subsectors} = \frac{\text{Maximum accumulation day (Tons)}}{\text{Collection truck's payload} \times \text{Number of trips (working day)}}$$

$$\textbf{\# of subsectors served by a truck} = \frac{\text{Maximum accumulation day (Tons)}}{\text{Collection truck's payload} \times \text{Number of trips/working day}}$$

Once the total number of subsectors and the number of sub-sectors serviced by a truck are calculated, proceed to calculate the number of trucks needed to develop the service according to the following formula:

$$\#\ of\ trucks = \frac{Total\ \#\ of\ subsectors}{\#\ of\ subsectors\ served\ by\ a\ truck}$$

Verification of the number of trips per day made by truck

Knowing the number of subsectors and trucks necessary to perform the collection service in the study area, proceed to verify the time required to make the number of trips established per day and the total tons transported.

Calculate the tonnage that each truck must transport in the day on the day of peak accumulation, according to:

$$\text{Peak day tons to be transported/truck} = \frac{\text{Peak day tons} \times \#\ of\ attention\ days\ weekly\ per\ subsector}{\#of\ Days\ worked\ per\ week \times \#\ of\ Trucks}$$

If more than one trip is considered for the journey, always consider that the first trip is carried out at maximum payload.

The downtime and the productive (collection) time for the first trip can be calculated as follows:

$$Downtime\ 1st\ trip = Base\ Time\ to\ route + Time\ at\ FDS + Time\ at\ FDS\ to\ route$$

$$Productive\ time, 1st\ trip\ = \frac{Tons\ of\ Maximum\ Payload}{Tons\ per\ hour\ of\ collection}$$

The value of the indicator tons/hour of collection equals to the optimal value previously indicated can be adopted, taking into account the type of collection.

The downtime to the productive time shall be added to time of 1st trip to obtain the time of cycle 1 of the 1st trip.

$$Time\ of\ cycle\ 1st\ trip = Downtime\ 1st\ trip + productive\ time\ 1st\ trip$$

Equation 2: Time of cycle 1st trip

If only one trip is considered per working day, compare the cycle time with the working day time, if the cycle time is less than the time of the working day and the relation between tons per trip vs. maximum payload is more or equal to 0.9, the subsectors are well designed, if the opposite occurs, consider the design of the routes with lower capacity trucks and calculate again the number of subsectors.

If more than a trip per working day is considered, calculate the available time for the second cycle according to:

$$Available\ time\ 2nd\ cycle = Working\ day\ hours - 1st\ cycle\ hours$$

Calculate the total downtime for the second trip and the available time for collection as:

$$Downtime\ 2nd\ trip = Time\ route\ to\ FDS + Time\ at\ FDS + Time\ FDS\ to\ base$$

$$Available\ time\ for\ collection\ 2nd\ trip = Available\ time\ 2ns\ trip - Downtime\ 2nd\ trip$$

The tons to be transported in the second trip is calculated as follows:

$$Tons\ 2nd\ trip = Tons\ per\ truck\ peak\ day - Tons\ 1st\ trip$$

The time necessary to carry out the collection of the tons of the second trip is calculated as follows:

$$Real\ time\ of\ collection\ 2nd\ trip = \frac{Tons\ 2nd\ trip}{\frac{Tons}{Hours\ of\ collection}}$$

The value of the indicator tons/ hour of collection is equals to the value used in the 1st trip.

If the time available for collection 2nd trip is more than the time of collection 2nd trip, it is verified that the truck can collect the total tons assigned within the working day, calculate then the total time worked in the working day:

$$Total\ time\ worked\ in\ the\ working\ day = Time\ (Down + Productive)\ 1st\ trip + Time\ (Down + Productive)\ 2nd\ trip$$

If the available time for collection of the second trip is less than the real time of collection 2nd trip, calculate the tons collected corresponding the available time:

$$Real\ Tons\ collected\ 2nd\ trip = Time\ of\ collection\ available\ 2nd\ trip\ \times (down + productive) 2nd\ trip$$

The same value used previously for Tons/hour of collection can be used.

The total collected tons in the working day as the sum of the tons of the 1st and 2nd trips and calculate the number Working day trips:

$$\#\ of\ working\ day\ trips \frac{Total\ ton\ collected\ in\ the\ working\ day}{Payload\ per\ collector\ truck\ per\ trip}$$

With the new value of the number of working day trips, the process of calculation of subsectors and number of trucks is repeated.

7) Calculation of the number of containers

In the case that in the process of optimization of the routes, a variation of the frequency (decrease and increase) is considered and containers exist, the new number of containers must be calculated based on the following procedure.

According to the location of the containers, the information in the blueprints and the characteristics of the current routes the number of inhabitants that use containers to store their waste is determined.

With the number of inhabitants, the calculated Production Per Capita (PPC) and

the number of days of maximum accumulation, the tons to be stored in the containers are calculated:

$$Tons\ to\ be\ stored\ in\ the\ container = \#of\ inhabitants \times PPC \times \#\ of\ days\ of\ maximum\ accumulation$$

The total volume of waste to be stored in the containers is calculated as below:

$$Volume\ of\ waste\ to\ be\ stored\ in\ the\ container = \frac{Tons\ stored\ in\ container}{Density\ of\ solid\ waste\ in\ container}$$

The density of the waste in the container between 0.15 to 0.2 Ton/m^3 is assumed .

The capacity of the containers that will be installed and determine the number of containers is defined as follows:

$$\#\ of\ containers = \frac{Volume\ of\ waste\ to\ be\ stored\ in\ container}{Capacity\ of\ the\ container \times 0.9}$$

It should be considered a safety factor in the calculation, so it was assumed that the containers will only fill up to 90% of their maximum capacity (0.9).

Knowing the number of containers, proceed to distribute in the area, based on the number of inhabitants.

8) Layout of the collection routes

The layout consists in the development of the collection route so that each vehicle can complete the service in the shortest time and distance.

9) Previous information required for the layout:

- Base Location or Operation Platform's location.
- Final disposal site.
- Sense of circulation.
- Hours of increased traffic flow and congestion situation.
- Topography.
- Useful and non-useful routes.
- Route elaboration type.

Within the collection system, several steps must be identified to achieve optimum and efficient system development. For example, for an optimal route you must decide between the following conditions:

Comb: Collecting both sides of the tracks at the same time, it is only run once per way. Recommended for areas with low population density and small area.

Double Comb: Collection of one side of the tracks; it is run at least twice each way. It is recommended for areas of high population density and mainly in commercial areas.

To proceed with the diagramming, prepare a work plan for each sub-sector, from a copy of the Subsectors Boundaries blueprints or using transparent papers.

In both cases, simplify the road network according to the information contained in the target area blueprints and the criterion of the following figure:

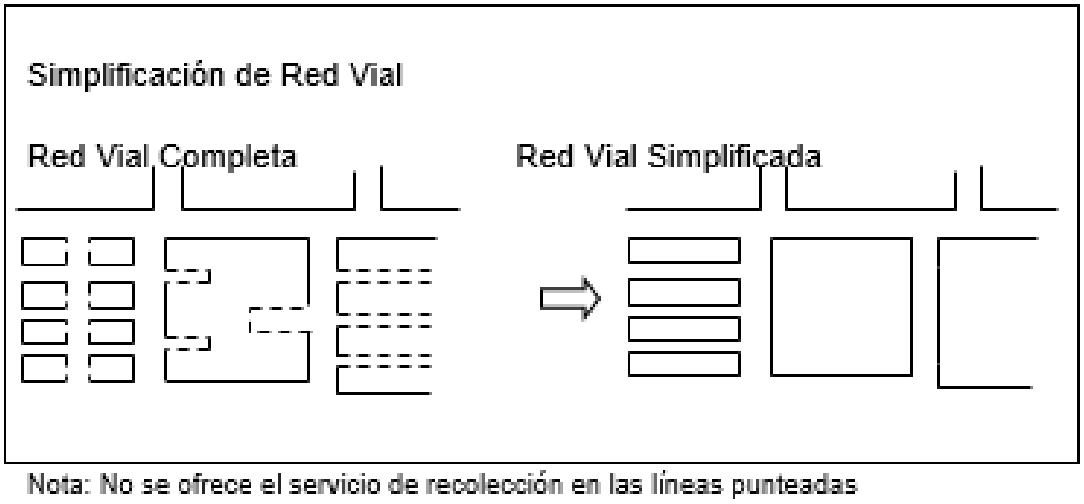


Figure 8 Route layout

Layout of the route shall be developed taking into account the following criteria:

a) Avoid duplicates, repetitions and unnecessary movements.
b) Respect regular vehicles traffic.
c) Minimize the number of turns to the left and rounds, with the objective of avoiding wasting time when loading, reduce danger to the crew and minimize traffic jams.
d) The routes with heavy traffic cannot be used during peak hours.
e) Try to start the routes in the points closest to the base and as the day progresses, go closer to the FDS with the porpoise of reducing the time

of haulage.

f) The highest parts must be traveled at the beginning of the route.

g) Within what is possible, steep ways must be travelled downhill, carrying out the collection of both ways of the road, with the objective of making the collection task safer, speed up the collection, minimize the equipment wear and reduce oil and fuel consumption.

h) When the Comb method is used, it is better to develop the routes with long, straight travels rather than turning right.

i) When the Double Comb method is used, it is preferable to develop the routes with many clockwise turns, around the blocks.

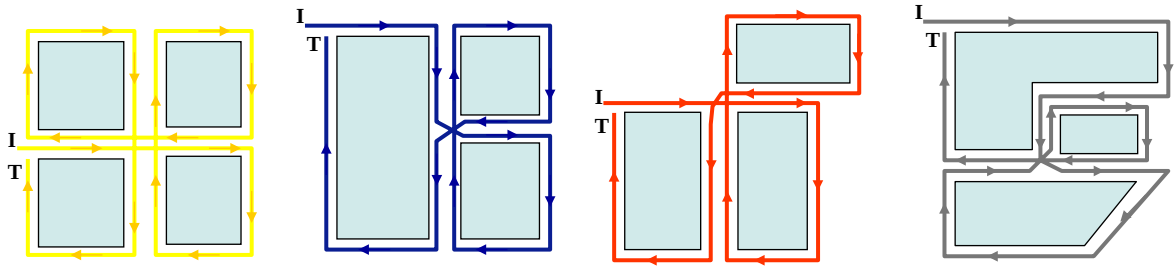
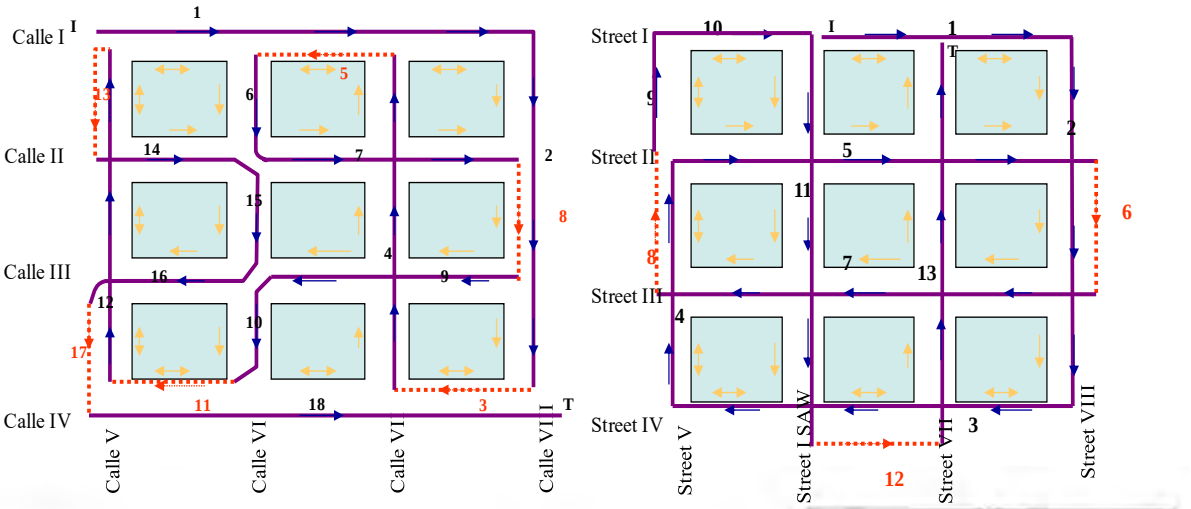


Figure 9 Layout for various blocks



Legenda:

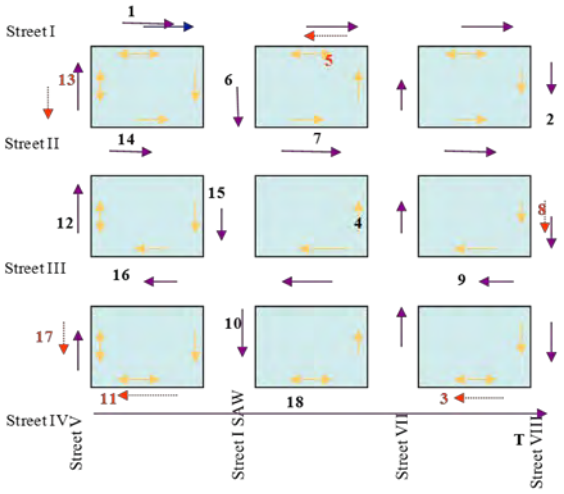
Ruta en Buena condición

Ruta en transito

Dirección del transito

	Esquema Original	Esquema Mejorado
Recorrido estimado	3 km	2.7 km
Recorrido en transporte	0.6	0.3
# vueltas derecha	9	9
# vueltas izquierda	7	2
#vueltas redondas	1	0

Figure 10 Layout for various blocks



Descripción de la ruta

SOBRE	DESDE	A	VUELTA	RECORRIDO	HORA
I	V	VIII	Derecha	Servicio	7:00
VIII	I	IV	Derecha	Servicio	
IV	VIII	VII	Derecha	Transporte	
VII	IV	I	Izquierda	Servicio	
I	VII	VI	Izquierda	Transporte	
VI	I	II	Izquierda	Servicio	
II	VI	VIII	Derecha	Servicio	
VIII	II	III	Derecha	Transporte	
III	VIII	VI	Izquierda	Servicio	
VI	III	IV	Derecha	Servicio	
IV	VI	V	Derecha	Transporte	
V	IV	I	Redondo	Servicio	
V	I	II	Izquierda	Transporte	
II	V	VI	Derecha	Servicio	
VI	II	III	Derecha	Servicio	
III	VI	V	Izquierda	Servicio	
V	III	IV	Izquierda	Transporte	
IV	V	VIII	Fin Ruta	Servicio	9:00

Figure 11 Example layout for the collection route plan

The procedure above shall be repeated to optimize the route, quantifying, for each layout, the number of turns left and right, and non-productive distances.

The layout of the route that has the least number of turns to the left and the shortest non-productive route shall be selected.

10) Verification, Implantation and Evaluation of routes

- You must check each of the route diagrams, then you proceed to:
- Quantify the length of the trip (km) on each route.
- Check the tracks (direction of traffic).
- Check the traffic level of the streets at any time of the year.
- Report whether there are uninhabited blocks within the proposed routes that would not require cleaning.
- Note traffic problems caused by narrow streets, obstruction due to parked vehicles, steep streets, etc.
- Describe the collection path already verified for the zone.

Before starting the new routes, staff, including supervisors, waste pickers and collectors, shall be trained in the following areas:

- Responsibilities established by job and functional relationship between them
- Interpretation of the symbology used in the layout of routes, such as start and end of route, direction of travel, route in service and in exclusive transport, points of control

- Way to execute the service, door-to-door collection, lift of containers, waste that is not part of the service, how to operate the compactor system, loading and unloading procedures, and detection of over generators
- Use of safety implements, aspects related to risks and accidents at work.
- Train the driver and supervisor on how to fill out and operate the Daily Work Order form and prepare it on the ground in relation to the new routes.
- Carry out activities aimed at informing the community about the new collection service, within these developments:
  - ✓ Meetings with the residents of the different neighborhoods where they clearly report the frequency, days and hours of service of the collection service.
- Installation of posters at highly crowded points, such as sports fields, supermarkets, schools, etc.
- Distribution of leaflets indicating the days and hours of service, frequency of service and the telephone number where people can consult about the new service and / or raise complaints.

After starting of the new routes operation, a 30-day trial period shall be considered in which you will constantly monitor them and make the necessary adjustments.

During the first week a supervisor shall be assigned to check daily the compliance of the routes and detect any anomaly. If anomaly is detected, how it impacts the design and / or layout shall be analyzed and the corresponding adjustment shall be made.

The supervisor shall be assigned specific points where you must control the truck's passing time. These points will later be used as route control points.

In the test period, each of the routes during and immediately after the collection shall be randomly reviewed and the quality of the service shall be verified, controlling:

- The correct lifting of all waste.
- The proper handling of the compactor equipment.
- Correct lifting and unloading of containers.
- The existence of scattered waste.

- The cleaning of the entire area surrounding the containers.
- The generation of excessive noises, identify their origin (compaction equipment, horn, personnel, etc.)
- Discharge of leachate from the truck to the streets.
- Proper use of uniforms and safety implements by workers.
- The behavior of collection staff towards users.
- The presence of non-household waste that cannot be loaded on the compactor truck.

If necessary, you should re-train staff and reinforce their training in relation to the way they carry out their work.

You should daily retrieve the data contained in the Roadmap in order to guarantee the correct evaluation of the route.

2.2.5 Indicators for optimal operation

The indicators constitute an excellent tool for the evaluation of the service, through a constant management of these we can:

- Improve service management.
- Monitor and control activities
- Compare between similar activities (routes, sectors, etc.)

The indicators result from relating preset quantities (base information) that is obtained from the constant monitoring of an activity.

Table 8 Indicators for the evaluation of the routes

Possible indicators	Unity
Number of effective helpers	Assistant / month
Amount of waste collected per month	Ton / month
Number of trips per month	Trip / month
Number of hours worked per work month	Hours / month
Number of collection hours per month	Collection / month
Number of hours paid for driver	Hours / month
Number of hours paid for assistant	Hours / month
Total number of hours paid per month	Hours paid / month
Effective working days	Days month / month
Total driving length for collection	Km / month
Monthly fuel consumption	Gallon / month
Population covered by the service	Number of inhabitants served
Total urban population	No. of people
Number of vehicles scheduled	No. of people

For optimal operation, the use of indicators is recommended:

- Tons collected vs. Pick up hours
- Tons vs. Paid hours
- Tons / trip
- Tons / assistant / day

Taking into account the reality in most municipalities, start collecting base information for your future indicators based on:

- Collection work record [trips, hours, collection area]
- Container capacity study.

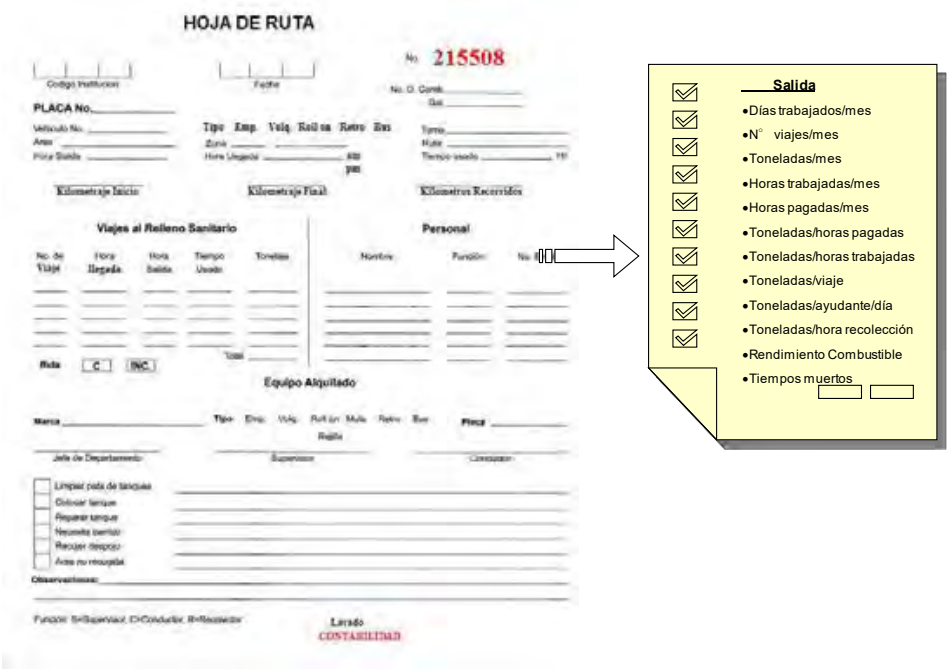


Figure 12 Work order / Trip ticket

2.2.6 Applicability of a transfer station

Since the planning of the collection system includes that of the transportation system, the feasibility of using transfer stations should be verified by:

- Cost analysis
  - ✓ Initial cost: transfer station, transport vehicles, others.
  - ✓ Cost of operation and maintenance: fuel and consumption of the collection vehicle, as well as the transfer vehicle, transfer station operation costs (TS) including the necessary labor, etc.
- Consider the implementation of a Municipal Community, where the main town

in the province can afford a long-distance transport.

2.2.7 Collection with separation of waste at the source

Collection of recyclable waste or other segregated materials at the source may require increased travel and waste collection equipment. It also requires separation of the material at the generation source.

The introduction of segregation at source should be discussed and decided upon considering:

- Material recovery policy
- The solid waste reduction policy at the FDS
- Collaboration of the private sector as well as informal waste pickers (*Buzos* in Spanish).

Due to the operating time of this method, it is the most expensive, but at the same time the most comfortable for citizenship. The way workers perform work on garbage trucks is as follows: collectors move the containers with waste from homes and bring empty containers to the place of origin. Another possible way is to establish specific points to deposit the materials according to the type of segregated waste; citizens must take the waste up to that point.

The collection is done alternately (e.g., three organic days, two inorganic days) or with adapted trucks. It is recommended to make the selection in two groups (organic and inorganic) or up to three groups according to the following table:

The method to be used to segregate solid waste according to its composition can be verified in the Manual of Intermediate Treatment and Recycling of this Project, but in general will be:

- Organic waste - Recyclable waste - Non-recyclable waste (waste)
- Garden waste - Leftovers from food (especially from fruits and vegetables)
- White napkins, paper and cardboard (mixed with organic waste)
- Plastics, Glass, Cans (aluminum and brass), Metals, Deciduous drugs (dangerous) used batteries (dangerous) Remnants of cleaning supplies, Sanitary towels and diapers.

Photo 12 Mobile Containers

Photo 13 Collection Method

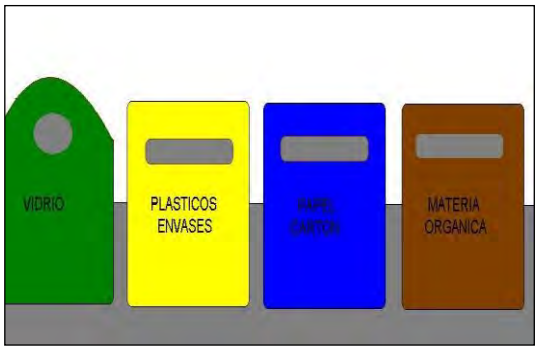


Photo 14 Different containers for different types of waste and types of collection with waste segregation.

Photo 15 Different containers for different types of waste and types of collection with waste segregation.

2.2.8 Collection of bulky waste and pruning waste

For collection of bulky waste and large pruning, it is recommended to establish special routes with very low frequency, such as once a month. Another option will be to provide the service at the request of the interested parties or when it is reported by a municipal inspector.

For this type of waste, it is recommended to use a vehicle without compaction, as this type of waste can damage the internal plates of the compactor truck.

PART III

3 OPERATION

Once the collection and transportation system has been implemented, it begins its operation phase, in which a series of activities must be carried out on a constant basis.

3.1 Monitoring and control

The term ‘‘monitoring’’ is used when the service is carried out by the municipality. If the activity has been contracted to third parties, the municipality will execute a Supervision of the contracted service.

It should be understood that a quality service is one that assures the population that the attention will always be received the same days and within the same schedule, so the first thing that we must verify in the routes to which it has been followed, is if these have been executed according to the programming designed, for which the percentage of compliance of each of them during the operation phase will be calculated.

It is important to keep in mind that the percentage of compliance is not only determined in terms of the number of days of care, but that these strictly coincide with the programmed.

Before establishing a monitoring or control system, the following tasks should be performed:

- Elaborate a list of objectives for each aspect.
- Develop a monitoring procedure.
- List basic compliance indicators
- Develop a schedule and implement the improvement plan.

Supervision of collection and transportation contemplates verifying:

- **Follow up of route:**
  - ✓ That all vehicles are operating.
  - ✓ Faithful completion of the route according to route layout.

- ✓ Compliance with time and place of beginning and end of the route.
- ✓ Compliance with the waste disposal site (final disposal site or TS).

- **Verify the quality of the service:**
  - ✓ Cleaning the collection area.
  - ✓ No leakage of liquids (Leachate).
  - ✓ That the collecting vehicles meet the proper conditions for this activity and are in correct operating and presentation conditions and that at the end of the day the vehicles are washed.

Number of waste collected per zone vs. amount generated = Percentage coverage.

The Supervision of the Transfer Station, if any, should contemplate verifying:

- Scales certified / calibrated.
- Bi-weekly reports sent.
- No recyclers or recycled material exist.
- Cleaning.

The assessment of compliance shall be determined from the available statistical records on the service, so it is necessary that a **registry or database** is kept.

We recommend keeping records in formats prepared for such purposes, of the points that follow:

- Work order: Truck, driver and assistant sheet, Route / sector, tons / hour of collection, among others.
- Verification of basic parameters of collection vehicles, prior to departure for the provision of the service.
- Route monitoring results
- Complaints from users
- Failure and penalties applied, both for faults committed by the collection brigade and for users.

Table 9 Log sheet template

FIRST NAME	FORM	RESPONSIBLE FOR THE FILE	FILE TIME
Work order	Roadmap	Urban Cleaning Manager	1 month
Route control	Route Inspection	Manager of the service of collection and transportation.	1 month
User Satisfaction	Complaint Record	Manager of the collection and transportation service and of solid waste collection fee collection.	3 months
Control of the truck prior to departure	Verification of basic parameters of the collection vehicle	Manager of transportation or workshop.	1 month
Report of sanctions	Registration of non-compliance and sanctions	Manager of the collection and transportation service and the designated municipal official.	3 months

3.1.1 Environmental Aspects

When using open collection equipment, whether in urban or rural areas, remember to instruct that the debris is covered with tarpaulin to prevent spillage during transport.

Take the necessary measures to avoid the spillage of liquids from the collected solid waste, in case the vehicle does not have devices intended for this purpose.

3.1.2 Occupational Health and Security Aspects

Most of the collection and transport of waste in the public highway is currently carried out on compactor trucks. The whole process involves several stages carried out by teams of three or more workers and each of them runs between 7 and 8 kilometers a day, depositing in the truck the tons of weight collected.

In this operation the trucks and the workers travel through cities exposed to inclement weather, vehicular traffic, excessive efforts and exposing their physical integrity, because of the accidents and risks associated with these tasks.

Prevention plays a very important role in the toilet system of cities, including the workers and the citizens receiving the service. The causes of accidents are mostly of human origin.

The most common risks of accidents in the work crew are due to:

- Workers without protective clothing or suitable work clothes.
- Manual lifting of the load incorrectly.
- Personnel moving in the pickup truck improperly and dangerously.
- Collection of containers with the worker's body in the middle of the road, in many cases very busy.
- Loading waste to the collecting vehicle in containers or containers of different types, sizes and weights.

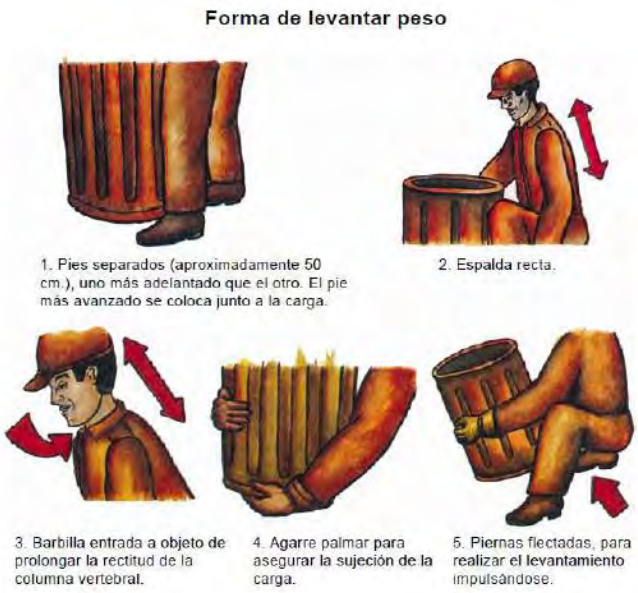


Figure 13 Correct way of lifting containers.

Employees responsible for the collection and transportation of solid waste must use uniforms and minimum personal protective equipment (PPE) appropriate for the performance of their duties, including at least: boots, masks and gloves.

In addition, regular medical or health check-ups should be performed on employees of the urban sanitation service, at least once a year (preferably every 6 months).

CONCLUSION

In the Dominican Republic, the fees for the cleaning service do not represent the real costs, so the municipalities are forced to allocate most of their budget to the subsidy of the service to collect all the waste produced by citizens. There is no defined cost structure that includes direct and indirect costs (depreciation and replacement of equipment and machinery, insurance, financial costs, basic services, facilities, administrative costs, among others), although by simple mathematics it is known that this Service currently accounts for between 60-80% of total waste management costs.

Although the current coverage is relatively acceptable, because the population pressured the municipalities to remove the waste from their houses, the service is not done efficiently, and the costs need to be optimized, due to the need to allocate part of the budget to the fulfillment of other components of what would be an Integrated Solid Waste Management System - ISWM.

The existence of a poor cleaning service motivates the rejection of the population and reinforces the culture of not paying for the service rendered. It is necessary to establish a collection system that covers all the costs of the ISWM and allows substantial improvements in the current collection practices.

REFERRENCE

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Informe final Plan Maestro para el Manejo integral de los residuos sólidos en la Mancomunidad de ayuntamientos del Gran Santo Domingo. BID. 2013.

Project For Institutional Capacity Development On Nation-Wide Solid Waste Management In Dominican Republic

Manual for Intermediate Treatment and Recycling

MAY 2017

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INTRODUCTION

One of the main problems of the human race is that the needs are unlimited, while the natural resources available in the environment for their satisfaction are limited, finite. The need to balance the environmental impacts of human activity is increasingly evident. On the other hand, it is a fact that, in the management of solid waste worldwide, the territories are running out of space for the definitive deposit of the same or find serious opposition of the population to its installation; So that more and more, they look for alternatives that, while protecting the resources, allow to extend the life of the final disposal sites.

The problem of solid waste in the vast majority of countries, and particularly in certain regions, is worsening as a result of rapid population growth, concentration in urban areas, industrial development, changes in Increase in the standard of living; As well as due to another series of factors that lead to pollution of the environment and the deterioration of natural resources. The Dominican Republic does not escape this reality. The municipalities face the problem of the increasing volume of waste generated, which, in the majority, end up becoming garbage, the final destination of which is open pit Dumping Sites; Thus losing the opportunity to take advantage of important resources.

To all of the problems raised, recycling is a good alternative, since, on the one hand, it reduces the waste that goes to the final disposal and contributes to optimize the costs of waste management; While, on the other, it rationalizes the use of natural resources and protects the environment with small but essential activities that can be started from home.

The Ministry of Environment and Natural Resources started in January 2014 the "Project to Strengthen Institutional Capacity in Solid Waste Management at National Level - FOCIMIRS", with the support of the Japanese people, through the Cooperation Agency Japan for a period of three years. During the project discussions, the need to prepare support materials to support municipalities in the preparation of their GIRS plans was identified. Hence, consideration will be given to the preparation of manuals that address all the stages of waste management, as well as other complementary aspects of vital importance in order to ensure a sustainable integrated management of solid waste.

This is how the "Intermediate Treatment and Recycling Manual" was born, with the aim of providing the municipalities with a tool that allows them to develop their capacity to develop strategies and programs within their municipal plans, incorporating intermediate treatment and recycling activities that will improve the current conditions of solid waste management. In addition, this manual instructs on the importance of raising awareness and encouraging citizens about the separation of solid waste in the generation source, as a key player in its integral management, promoting the "recycling culture", through the strategy of the 3R's: Reduce, Reuse and Recycle.

PART I

1 GENERALITIES

1.1 Background and Current Situation of Recycling in the Dominican Republic

1.1.1 Background

Although, in an informal way, the activity of recovery of materials has been carried out in the country for many years, at least since the founding of the "National Glass Factory in San Cristóbal", which bought objects of glass, To incorporate them into the productive process.

The segregation and recovery of materials is not carried out on a large scale and as in many other countries in LAC, Asia and Africa, have been the informal segregators, now called grassroots recyclers, who have done an intense work of "catching" the materials Of commercial interest In spite of the informality, with the passage of the years has been forming an intense circuit of recycling at national level, where the Waste Pickers, intermediaries wholesale, retailers and diverse companies take part. The latter mainly purchase materials such as metals (iron, steel, copper, aluminum, brass, zinc, tin, lead, nickel), glass bottles, plastics, paper, cardboard and metals; Which are then sold, inside and outside the country, as raw material for the manufacture of new products or simply to be reused, as in the case of glass bottles.

Dominican Republic, between 2013 and 2015, exported a total of 1,149,925 tons of recovered materials of various types, in the amount of US $ 408,724,328.00 (CEI-RD), as shown in figure 01. The exported materials were iron and Steel, aluminum, copper, plastics, fabrics, lead, glass, zinc, platinum, tin and acrylic sheets, among others. Graph 01 presents the evolution of exports of waste materials during the period indicated.

The recipient markets for these materials were mainly: China (Taiwan), Vietnam, People's Republic of China, South Korea, Bangladesh, Thailand, India, Malaysia, Singapore, Puerto Rico, Italy, Pakistan, Indonesia, United States, Netherlands, Spain And Brazil.

Figure 1 Export of recyclable materials 2008 - 2015

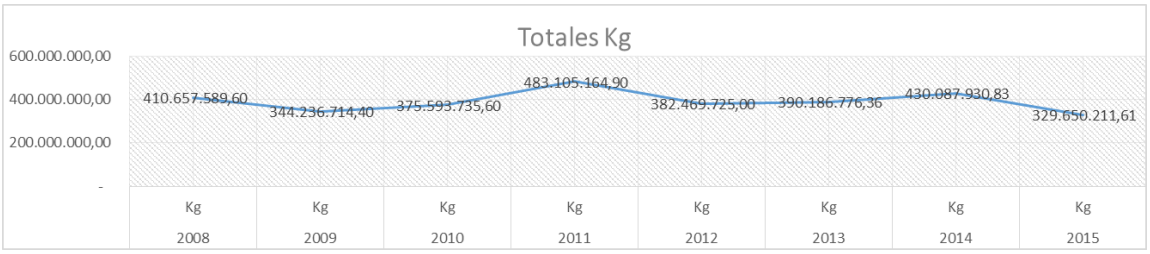
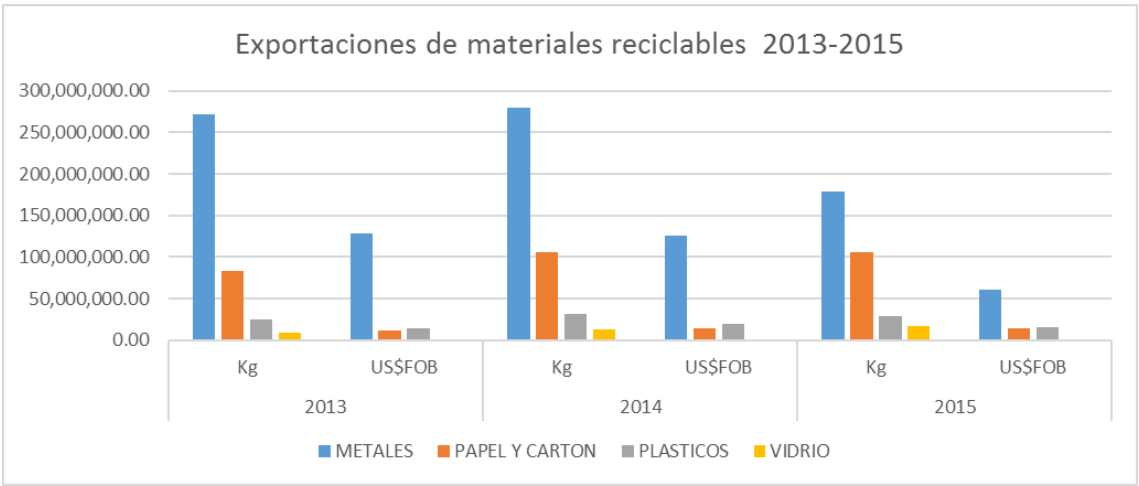


Figure 2 xx

Own elaboration - FOCIMIRS Project. Source: CEI-RD

As can be seen in the graphs, the quantities exported have remained fairly stable, except for 2015. This is due to the generalized fall in prices of these materials, due to the drop in black gold prices. From which it is deduced that the activity has managed to maintain itself through the time.

Metals are the most important component, both in weight and monetary value. The detail of exports for the period 2013-2015.



Own elaboration - FOCIMIRS Project. Source: (CEI-RD) - 2016.

Figure 3 Detail of exports of waste materials 2013 – 2015

During 2011, an important study was carried out in the Municipal Association of Gran Santo Domingo - MGSD, called ***"Master Plan for the Integral Management of Solid Waste in the Municipal Association of Gran Santo Domingo",*** in which the prices of recyclable materials are presented by then.

Table 1 Prices of recyclable materials in the MGSD

MATERIAL	UNIDAD	COSTO - RD $	COSTO US$ (1)
Plástico	libra	3.00	0.08
Cartón cajas	Unidad (Según tamaño)	10.00 - 70.00	0.26-1.80
Hierro	kilogramo	12.00	0.31
Aluminio	libra	24.00	0.62
Bronce	kilogramo	75	1.92
Calamina	kilogramo	13.00	0.33
Cobre	kilogramo	110.00	2.82
Vidrio	Unidad	1.00	0.026
RESIDUOS VOLUMINOSOS			
Abanico	Unidad	50 a 300	1.28-7.69
Aire Acondicionado	Unidad	500 a 600	12.82-15.39
Nevera	Unidad	200	5.12
Lavadora	Unidad	200 a 50	5.12-1.28
Vehículos y plantas	Unidad	410	10.51

Source: Master Plan for the Integral Management of solid waste in the Municipality of Gran Santo Domingo municipalities. (1) Exchange rate RD $ 39 = 1 US $

According to this study, the price of materials varies seasonally, not only in the Dominican Republic, but also in international markets. Compared with the international prices of recyclable materials, prices in the country are in some cases higher than in others and below. As a reference and as an example, a comparison was made of some prices of certain materials, such as those indicated by the Paraguay Investment and Exports Network (REDIEX) for 2010, as shown in the table below:

Table 2 Price comparison of recyclable materials in Paraguay and RD

Materiales	Precio US$		Comentarios
	Paraguay	Rep. Dominicana	
Plastico	$ 209.00	$ 176.00	Mas barato en RD
Hierro/Acero	$ 144.00	$ 310.00	Mucho mas caro en RD
Cobre	$ 2,960.00	$ 2,820.00	Ligeramente mas barato en RD
Aluminio	$ 1,168.00	$ 1,364.00	Mas caro en RD

Made by FOCIMIRS Project. Source: Investment and Exports Network (REDIEX). Paraguay - 2010.

This indicates the need to establish a permanent reading of price variability in the reuse market to maximize the economic benefits of recycling.

The following table presents an estimate of potentially recyclable solid waste volumes generated throughout the MGSD. These figures provide a notion of the generation scales that are currently taking place in the municipalities that make up the MGSD.

Table 3 Generation of potentially recyclable waste in the MGSD

Tipo de Residuo Sólido	Promedio General	Generación Total al 2012 (T/día) (1)
▪ Cartón	1.8%	86.2
▪ Papel	6.2%	296.9
▪ Tetrapack	0.9%	43.1
▪ PET	1.5%	71.8
▪ Polietileno de Alta Densidad - PEAD	5.2%	249.0
▪ Otros plásticos	2.9%	138.9
▪ Vidrio	5.1%	244.2
▪ Material Ferroso	0.5%	23.9
Total de residuos comercializables (inertes)	**24.10%**	**1,154 (420 mil ton/año)**
Total de residuos biodegradables	**57.7%**	**2,763.3**

Source: Master Plan for the Integral Management of Solid Waste in the Municipality of Greater Santo Domingo. Average of the 5 quintiles. (1) Average total generation in 2012 is 4,789 T / day.

As can be seen in the table above, it is assumed that 57.7% of the waste is biodegradable. Given the preponderance of this type of waste, its reuse would represent an activity to prioritize in the Municipal Association of Gran Santo Domingo. On the other hand, these data indicate the great potential for recycling that has developed in the country.

A number of recycling projects or related initiatives have also been developed, most notably:

- The SABAMAR project (2002-2006), which sought to establish effective mechanisms for the collection and disposal of domestic solid waste in areas of difficult access to the DN, through 3 complementary activities: creation of micro-enterprises of waste, sensitization of Users and the strengthening of institutional management capacity for MSW management. This project led to the creation of five foundations that still persist and are dedicated to the recovery and sale of recyclable materials.
- Waste separation programs in the Municipal District of Las Placetas (2009) and in SAJOMA (2010), with the support of GTZ.
- The Campaign "Classificando Aportas" of the Ministry of Environment and Natural Resources in alliance with ECORED and the LMD, launched during

the celebration of the "National Recycling Week" initiative that began in 2013.

1.1.2 Current situation

The generalized fall in the prices of materials at international level, especially since 2015, due to the drastic decrease in oil prices, has negatively affected the activity of recovery of materials, as can be seen in figure 01. The decrease is even more drastic in the FOB value, going from US $ 160,977,595.9 to US $ 93,520,098.51, representing a decrease in monetary value of 42% versus 23% in the amount exported.

In the country there are industries dedicated to the transformation of different materials, either through their crushing and / or compaction, which are then exported to be used as raw material in other countries. However, given the situation presented, with regard to companies engaged in recycling itself or collateral activities, many have closed their operations, large and small, mainly those processing plastic materials.

In another order, despite the situation, different initiatives and projects continue to be developed at the national level, in terms of recovering recyclable materials to enter the productive cycle; Implemented by public institutions, under the auspices of international cooperation agencies, the private sector and nongovernmental organizations (NGOs). Here are some examples:

- Ministry of Environment and Natural Resources: 3Rs programs with government institutions, initiated in February 2015. Participants: Ministry of Industry and Commerce, General Directorate of Customs, Dominican Agrarian Institute, National Lottery, General Directorate of Passports, National District Prosecutor's Office and Minister of Agriculture.
- Atabey Innovation Center and Ministry of Environment and Natural Resources: "Clean Point" Program in the areas of Villa Francisca, Los Ríos and Espaillat.
- CEDAF develops programs with educational centers: 3Rs "I recycle with Clean Points" programs and the "I am Ecoefficient" program with the support of Banreservas, Banco Popular and ARS Universal,. They are called LA RED 3Rs. JICA also supports 3Rs programs. On the other hand, it has initiated with the Ministry of Education -MINERD, the project "Eco-sustainable Schools".
- CEDAF: "Neighboring Green" Project in the sectors of Paraiso, Serrallés and Yolanda Morales.

- ECORED implements an "Inclusive Recycling" project in 3 municipalities (SDE, Samaná and SPM), which covers pilot sectors, including 22 Educational Centers.
- 3Rs Programs in Educational Centers: Colegio Calasanz, Movearte. Don Bosco,
- GTZ and the Council of Climate Change: "Project of Value Chain and Co-processing".
- Materials recovery plant at Duquesa dump in Santo Domingo Norte.
- LAVO INVESTMENTS: Installation of a mechanized separation plant at the Rafey Eco Park, in Santiago.
- Grupo Punta Cana: Recycling and Incineration Center, where different types of recyclable and even organic materials are recovered, used as biomass for boilers. Residues from aircraft arriving at the airport are also incinerated.
- VICINI Group: Operates the biomass plant Bio Energy, which uses bagasse, a byproduct of the processed cane, for the production of electric energy. It is located in Ingenio Cristóbal Colón, San Pedro de Macorís.

Since this Manual has been prepared under the FOCIMIRS Project, executed by this Ministry, more details on the **"Clean Point"** program are included

The "Procedure for the Recovery of Commercially Recyclable Multilateral" issued by the Ministry in the year 2015, a "Clean Point (LP)" refers to all infrastructure, equipment, tank, container, etc., allowing the recovery of Recyclable multimaterials with commercial value ", including the collection center. Said procedure establishes the following steps for the recovery of the materials, as shown in the following figure:

Source: "Procedure for the recovery of multimaterials with commercial value". Minsterio de Medio Ambiente y Recursos Naturales - 2015

Figure 4 Steps for the recovery of multimaterials with commercial value

Los proyectos de separación y recuperación de materiales cuentan con alianzas de empresas recicladoras, las cuales compran el material para fabricar otros productos o empresas intermediarias que los empacan para fines de exportación. A continuación un listado de algunas empresas relacionadas a la actividad del reciclaje, que a la fecha, se encuentran operando en el país.

Table 4 Recycling Companies in Dominican Republic - March 2017

Business	Location	Material received	Products
Moldeados Dominicanos S.A. (MOLDOSA)	Santo Domingo	Newspaper, non-satin paper, cardboard	Egg containers, cupholders and disposable trays.
Recycler of the Cibao	Santiago de los Caballeros	Plastic Bottles, Gallons, Housings, Cardboard	Packed plastic bales for export
RERBA	Santo Domingo	Paper and paperboard	Bales of paper and paperboard for export.
PLASTIFAR	Santo Domingo	Foam (clean waste)	Glasses, plates, sherbet, containers
CAPOBIANCO Ecological Solutions	Santo Domingo	Plastic containers of oil for vehicles, irrigation pipes, plastic covers	Interior and exterior urban furniture (containers) and various containers.
Antillean Metals	Santiago de los Caballeros	Iron scrap	Iron for export
ECOSERVICES	Higüey	Plastics, cardboard, glass, metals, used cooking oil and motor oil (mineral), used batteries.	Packs of plastic, cardboard and compacted metals and ecological batteries
Green Love	Santo Domingo	Paper, plastic, Tetra-Pak, glass, carton, clean foam,	Bales of compacted materials

Made by FOCIMIRS PROJECT. Source: Ministry of Environment and Natural Resources, Directorate of Solid Waste and Municipal Affairs - 2017

There are also foundations and some NGOs that receive different materials for later sale, among the foundations are: ESCOBA, FUCOSAGUSCIGUA 27, FUNDSAZURZA, FUNDEMAPU and FUNSACO. These operate in Los guandules, La ciénaga, Guachupita, February 27, La zurza, La puya, among other neighborhoods and sectors.

1.2 Legal framework

There is no specific legislation in DR that regulates, encourages and encourages the recycling activity. However, within certain laws there are provisions relevant to that activity. The two main ones are the "General Law on Environment and Natural Resources" (Law 64-00) and the "Law on the National District and Municipalities" (Law 176-07).

Law 64-00 establishes among the functions of the Secretary of State for Environment and Natural Resources, to establish the policies and regulations for this activity, as well as to establish incentives for it. In Chapter VI, Articles 106 and 108, respectively, ratifies the operation of systems of collection, treatment, transportation and final disposal of non-hazardous solid waste, by municipal councils; and establishes the implantation of systems of classification of "wastes" in the public institutions.

Law 176-07 establishes within its powers, the responsibility of municipalities in the management of waste. Specifically in Chapter 1 "On Competencies", article 19 states: regulate and manage the protection of public hygiene and sanitation to guarantee environmental sanitation, in addition to offering cleaning services and public adornment, collection, treatment And final disposal of solid waste.

Also within the framework of application of Law 64-00:

a) **Standard for Environmental Management of Non-Hazardous Solid Waste.** (NA-RS-001-03 - Replaces RE-DM-01) June 2003:
   - In point 3, "Of the principles", section 3.4 indicates: Programs and projects of reduction in waste origin will be incorporated in the management. The recovery and recycling will be taken as basic management measures in the final disposal process.
   - In section 5, "Specifications on generation, storage, collection, transport and recovery of waste", section 5.7 refers to the "General Provisions for Reuse, Recovery and Recycling".

b) Policy for the Integral Management of Municipal Solid Waste. February 2014.

   Among its lines of action are:
   - Promote the formalization of solid waste segregators or recuperators, popularly known as "Waste Pickers".
   - Encourage recovery and recycling.
   - Encourage the formalization of existing recycling centers and the creation of new.
   - Promote in the population alternative forms of sustainable management of solid household waste.

- Propose the incorporation in the school curriculum of the concepts related to integral waste management.

c) Procedure for the Recovery of Multimaterials with Commercial Value, which establishes the responsibilities of the different actors involved, the alternatives of recovery and the steps to follow.

It is worth indicating that, although Law 218-84 does not refer to recycling itself; However, its content limits the promotion of this activity, as it prohibits any type of garbage from entering the country. In its text, practically "common trash" equals hazardous waste, such as sewage sludge and toxic industrial waste. It is worth noting that in 2015, the Korean company SOLTEX, installed in SPM was forced to close its operations because, under this law, it was not possible for this Ministry to grant an environmental permit to bring the country bottles PET plastic, washed and fumigated, from nearby countries, with the aim of completing the quantity required for its installed capacity, because in the country there was no logistics that would allow a greater recovery of these bottles. Under Article 204 of Law 64-00, this law could be reviewed and determine if a partial repeal.

1.3 Recycling: Basics

The activity known as recycling refers to the action of recovering solid waste, in order to reintegrate them into a productive cycle, using them as raw material for the production of new final or intermediate products, are the same or different from the type of waste gave rise; Thus achieving socio-economic and ecological benefits.

The "Standard for Environmental Management of Non-Hazardous Solid Waste" defines recycling as "the transformation of materials segregated from waste, within a production process, to be incorporated as raw material into the production cycle".

It is clear then that Recycling of waste materials is the transformation of solid waste, within a production process, giving rise to new products, either for its initial purpose or for other purposes. In this sense, composting is a recycling process, as is biomethanization; But not incineration with energy recovery. In this last one does not take advantage of the material itself, if not the calorific power

that contains, for the purposes of energy utilization. On the other hand, ash is not a new product, but a by-product of the incineration process.

This standard also defines the concept of Valorisation: it refers to a set of associated actions whose objective is to take advantage of the resources contained in the waste, without endangering human health and without using methods that could cause harm to the environment .. Under this concept fall the four processes: recycling, composting, biomethanization and incineration.

Urban solid wastes are recyclable according to the physical characteristics they contain and the quality of the materials. In the Dominican Republic, approximately 85-90% are recyclable, according to different characterization studies carried out in different parts of the country, including those carried out by the Ministry of the Environment, within the framework of the FOCIMiRS project, in the municipalities of Azua, Moca and Sánchez. Also the study of the MGSD yielded figures included in this range.

Given the above, it could be safely stated that recycling is a key component of GIRS, making it practically impossible to apply a comprehensive management system, without considering actions for recycling.

Within the theme of recycling, it is important to define some associated activities, linked to what is called "recycling chain or circuit". These include:

Treatment: process of physical, chemical or biological transformation of solid waste to modify its characteristics or to exploit its potential and from which a new solid waste with different characteristics can be generated.

Under this concept enters any method, technique or process, whose purpose is to change the physical or chemical nature of any residue, either to neutralize it, recover energy, take advantage of its material resources, transform it into another one that is easier and safer to transport , Store or dispose; Or in another of smaller volume. It includes the valorization, as it has been defined, but also mechanical treatments like the mechanized or manual separation, magnetic separation, crushing and compaction, among others.

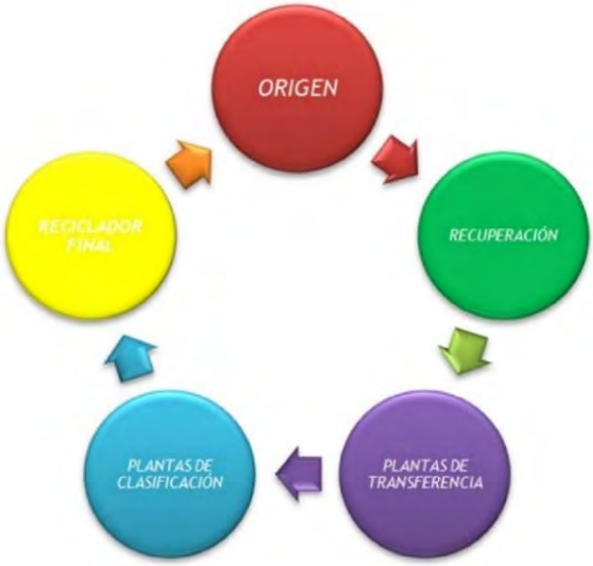
Storage: is the action of temporarily retaining the waste, prior to its delivery to the collection service for its subsequent recovery or final disposal.

Harnessing: it is any industrial or manual process whose object is the recovery

or transformation of the resources or utilities contained in the waste.

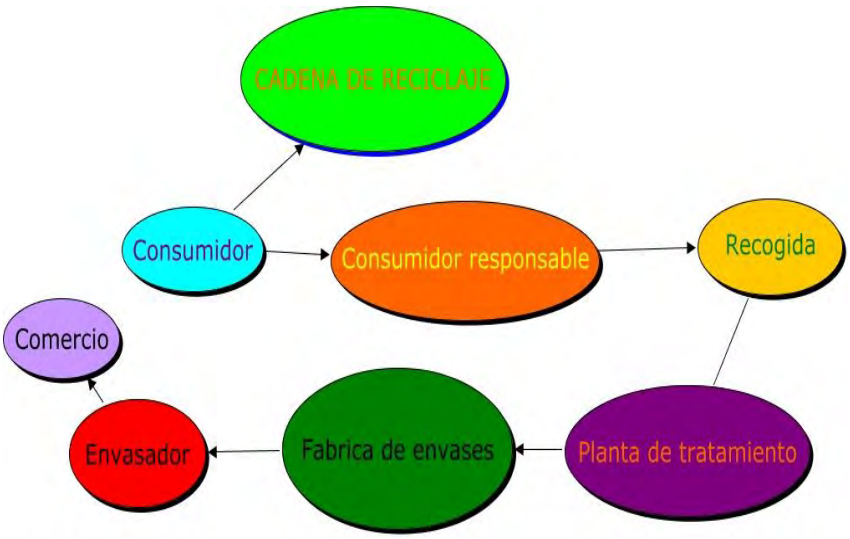
Composting is the process by which organic waste is biologically decomposed under controlled conditions to the point where the final product can be handled, stored and applied to the soil without adversely affecting the environment.

The recycling chain will depend on the activities that the municipality has decided to address within its management plans, hence the same will be different for each locality:



Source: www.google.com.do/search?q=cadena+de+reciclaje

Figure 5 Example of recycling chain that incorporates a treatment plant



Source: www.google.com.do/search?q=cadena+de+reciclaje

Figure 6 Example of recycling chain with separation at the source

1.3.1 Classification of solid waste

Waste can be classified according to different characteristics or criteria.

Depending on their chemical nature, the waste can be organic and inorganic. According to physical nature, they are classified as dry and wet.

Organic refers to materials that decompose naturally and do not take long to degrade. These residues, including certain food residues, can be processed by composting and converted into soil improver or compost for plants. In general organic waste is also known as wet.

Inorganic waste refers to those materials that, because of their chemical characteristics, do not decompose naturally or take a long time to degrade, such as plastic, glass and metals. It is worth noting that although paper and paperboard have an organic origin, and are not easily degraded, for the purposes of their recovery, it is included within the recyclable inorganics, together with the other materials mentioned.

Depending on their origin or source of generation, there are many types of waste. In this order, the Dominican norm establishes the following types:

Commercial: waste generated in commercial and commercial establishments, such as warehouses, warehouses, hotels, restaurants, cafes and market places.

Domiciliary: waste that by its nature, composition, quantity and volume is generated in activities carried out in houses or in any similar establishment.

Agricultural: those generated by the raising of animals and the production, harvesting and mowing of crops and trees, which are not used to fertilize the soil.

Biomedical: those generated during the diagnosis, treatment, provision of medical services or immunization of humans or animals, in research related to the production of these or in the trials with biomedical products.

Construction or Demolition: those resulting from the construction, remodeling and repair of buildings or the demolition of pavements, houses, commercial buildings and other structures.

Industrial: waste generated in industrial activities, as a result of production processes, maintenance of equipment and facilities and treatment and control of pollution.

The classification presented according to hazards is similar to that indicated in the current legislation.

According to their management competence, municipal waste is the responsibility of the municipal authority and those that must be managed by the generator itself.

Municipal waste, also called urban waste, is solid or semi-solid waste from urban activities in general. They may have residential or domestic, commercial, institutional, small industry or sweeping and cleaning streets, markets, public areas and others. Its management is the responsibility of the municipality or other government authority.

1.3.2 Hierarchy in waste management

Although this topic is better developed in the "Guide for the Formulation of a Comprehensive Municipal Solid Waste Management Plan - MISWMP " of the FOCIMiRS project, given the topic at hand, it is worth referring to the hierarchy of waste.

The hierarchy refers to the type and priority order of treatment that a waste should receive. This order of priority ranges from prevention / minimization / reduction to final disposal without danger.

In order of importance, the priorities are:

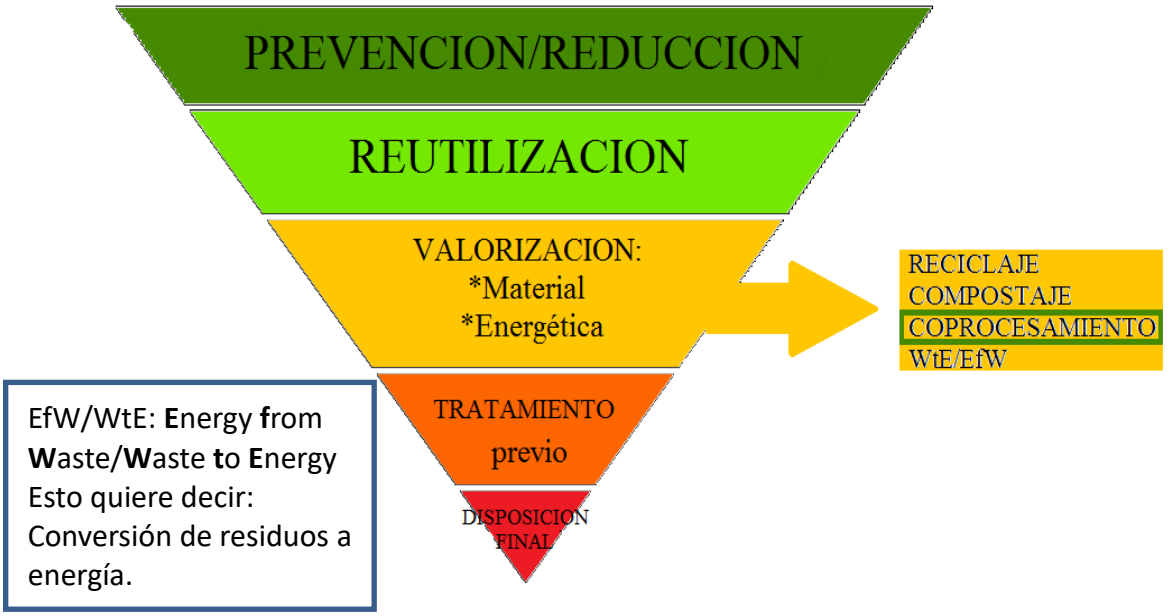
- Prevention / Reduction: avoid, minimize and reduce the amount of waste / debris.
- Reuse
- Recycling
- Valorization of organic matter (composting and biodigestion)
- Energy recovery (conversion of waste to energy)
- Final Disposal (after treatment if required)

The objectives of the hierarchy are:

- Contribute to the rational use and conservation of natural resources, limiting their exploitation.
- Reduce pollution to protect the environment and human health.

In our country, the hierarchy that arises in the "Draft General Law of Solid Waste",

currently in the National Congress, is indicated in Figure 7.



Source: Guide for the formulation of a GIRS Plan - FOCIMiRS.

Figure 7 Intervention hierarchy in the matter of SR, according to "Draft Law of integral management of solid waste and coprocessing".

The hierarchy in waste management is based on the recovery and exploitation of valuable resources contained in the waste / waste materials, favoring a "Society with Healthy Cycle of Materials" (SSCM) based on the 3Rs, a society with a sustainable environmental cycle or with circular economy. Recycling is at the heart of this hierarchy.

1.3.3 Recycling processes

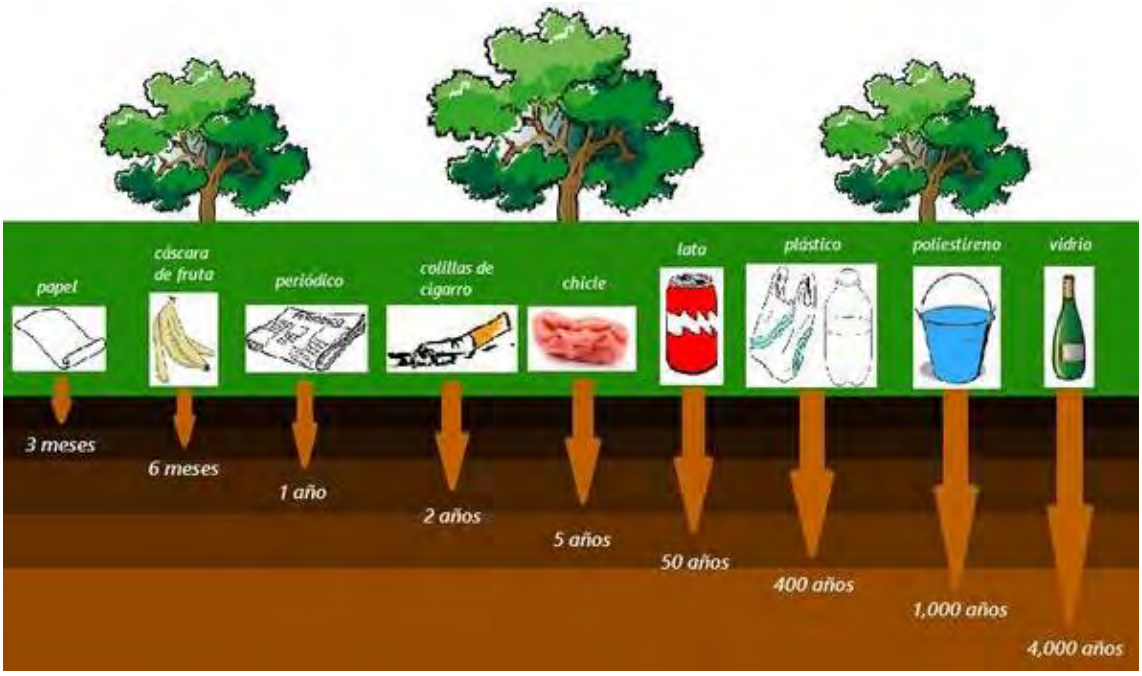
The goal of any recycling process is the use of waste. As a commercial activity, it is an element of high added value in any production chain, since it constitutes a cleaner production strategy (P + L), coupled with payment for an environmental service (PSA). It leads to significant savings in production (especially in energy, water and raw materials), promoting sustainable development.

As already indicated above, the **Treatment** refers to any method, technique or process, whose purpose is to change the physical or chemical nature of any residue, either to neutralize it, recover energy, take advantage of its material resources, transform it into another Is easier and safer to transport, store or dispose of; or in another one of smaller volume.

In order to determine the type of treatment that is economically feasible in each

case, the first step is a Characterization Study (see Characterization Manual - FOCIMiRS) to determine the composition, ie to know the types of waste generated in the municipality and in what proportion or percentage. Knowing these values, you can plan to take actions, according to the type of material and quantity produced.

The time of decomposition of materials is one of the factors that has determined the need for governments to resort to recycling programs. An ill-disposed solid residue will take time to decompose as shown in the following table:

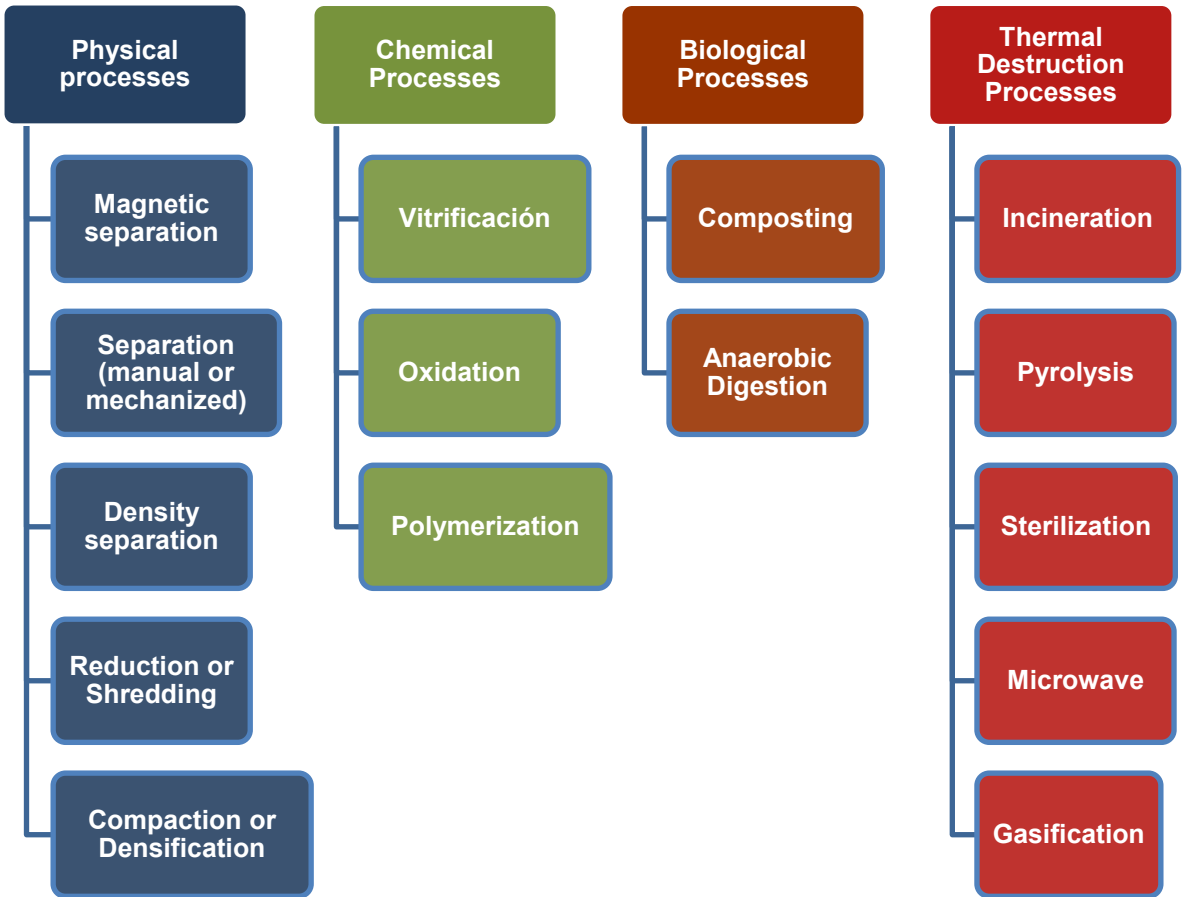


Source: Grupo Universitario Ecoucab/ Universidad Catolica Andrés Bello, Venezuela.

Figure 8 Approximate decomposition time of some materials.

Once the process (s) for the treatment of waste has been defined, the goals to be achieved with each one must be specified, either to be treated under the responsibility of the municipality as a commercial activity or under socioeconomic development programs for the population Poor or to be sent to recycling companies that are responsible for their treatment.

For waste treatment, a range of processes can be chosen, as shown in Figure 9:



Source: Presentation by Guillermo Encarnación - second edition of the "International Course for strengthening the implementation of the GIR with a focus on 3Rs". Mexico 2013

Figure 9 Types of solid waste treatment processes -USW

On the other hand, it is vitally important to define a citizen education and awareness campaign, so that people know, understand and support the project, giving details of it.

1.3.4 Symbols used for recycling

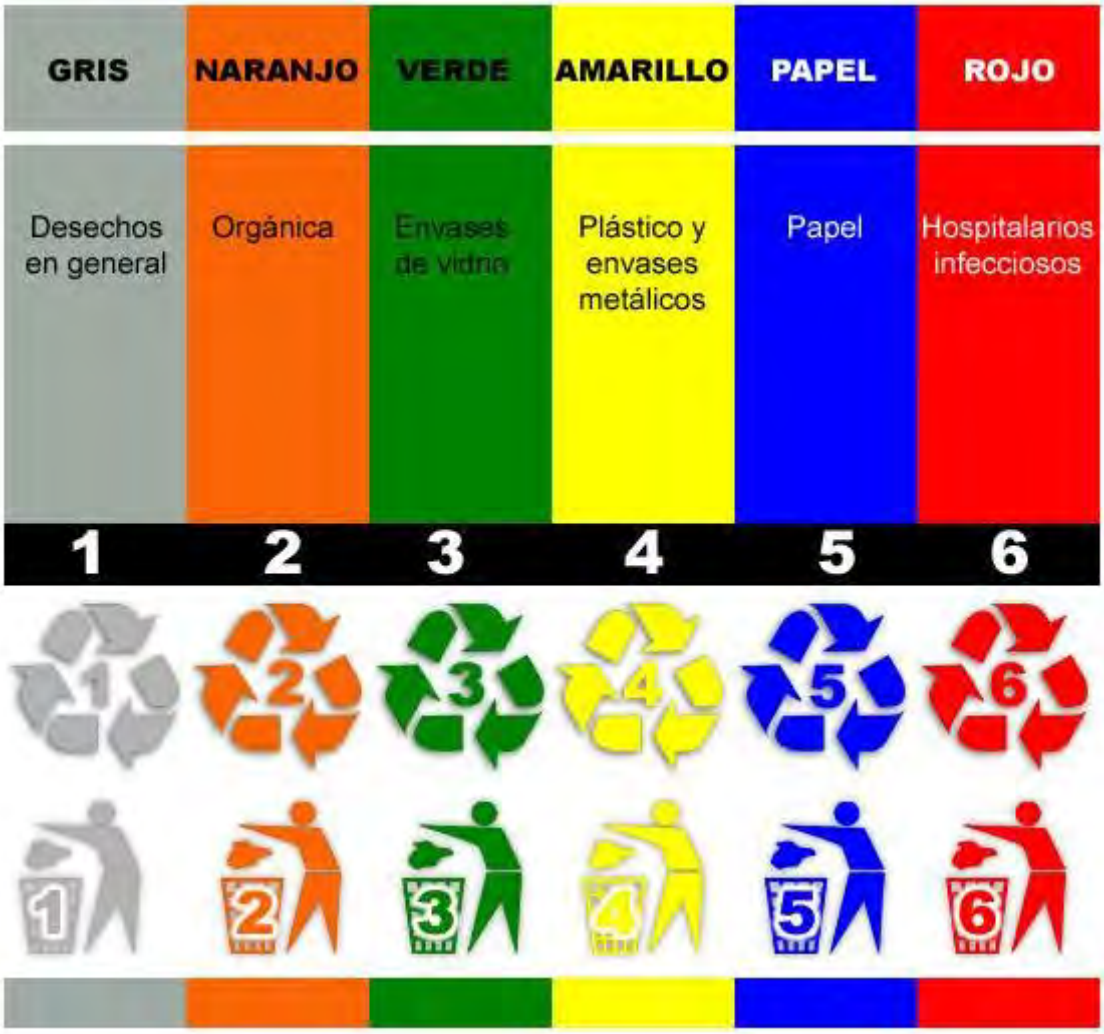
Although they have not been standardized globally, it is important to teach the symbols of recycling and to know the ones that come in the labels of the products, so that in the execution of the programs the community are aware of what type of material is treated and where they should carry it. Figure 10 shows the symbols that may come in a labeling or packaging:

Source: Image taken from internet:https://www.google.com.do/search?q=simbolos+de+reciclaje

Figure 10 Recycling Symbols

1.3.5 Colors used in containers for recyclable materials

In a general sense, each country establishes its standards of separation and the colors with which they will identify the containers for separation. However, most internationally certain colors have been established to identify such containers or delivery containers.



Source: Image taken from the internet: http://www.inforeciclaje.com/colores-del-reciclaje.php

Figure 11 Colors for sorting recyclables.

They are generally defined as follows:

- Blue color: corresponds to paper and cardboard waste. Not all papers are recycled in the country. Normally, paper is recovered (bond), newspaper and glossy paper (that of magazines and commercial propaganda).
- Color yellow: corresponds to the plastic waste in its different characteristics. There are plastics that have more demand than others to be recycled here. For example, PET or No. 1 transparent, is highly quoted for the fiber industry to make textiles. Examples of plastic materials: bottles of water, gallons of water and chlorine, bottles of oil, detergent containers and products for cleaning and cleaning, among others. In spite of being a same material, the characteristics of each type of plastics are different, reason why each one is

recycled separately. One type of plastic could prove to be a pollutant to the other. In developed countries, citizens are obliged to separate different types of plastics. Such is the case of Japan, Germany, Belgium, Holland, among others.

- Green color: corresponds to glass waste in its different characteristics. There is no industry in the country to recycle glass. However, companies such as the National Brewery and the bottled soft drink industry have a packaging return protocol. The glass is separated by color (green, brown, transparent, etc.). Examples: beer bottles, soda bottles, oil bottles, among others.
- Color orange or brown: corresponds to organic waste (kitchen and garden waste) that decompose naturally and does not take long to degrade. Also included in this category are the napkins we use on the table.
- Red color: corresponds to the hazardous waste that needs a special treatment. Examples: hospital waste not assimilable to domestic waste, chemical waste, pathogenic waste, among others.
- Gray color: corresponds to waste that is not covered by any of the previous classifications.

It should be noted that in planning the strategies of the recycling plan, they should be associated in the simplest way, so that the population assumes the colors for classification.

1) Plastic Recycling

There are different types of plastic and to classify them is used a coding system that is internationally approved and is used by the industry to identify them.

Source: Image taken from the internet: http://kerchak.com/diferentes-tipos-de-plastico/

Figure 12 Labeling of different types of plastic

There are plastics that are more in demand than others to be recycled. Not all plastics are easily recyclable. However, more and more technologies are being developed in order to integrate them into a productive cycle. On the other hand, plants in operation that process PET bottles from PET 100% recycled already exist, that is to say, that from PET crushed plastic, new PET bottles are made, without the integration of virgin plastic resin. However, this is not applicable at all. In certain products and processes of plastic as well as of other materials, there are technical limits that prevent the use of a greater proportion of recycled material in the elaboration of the new product.

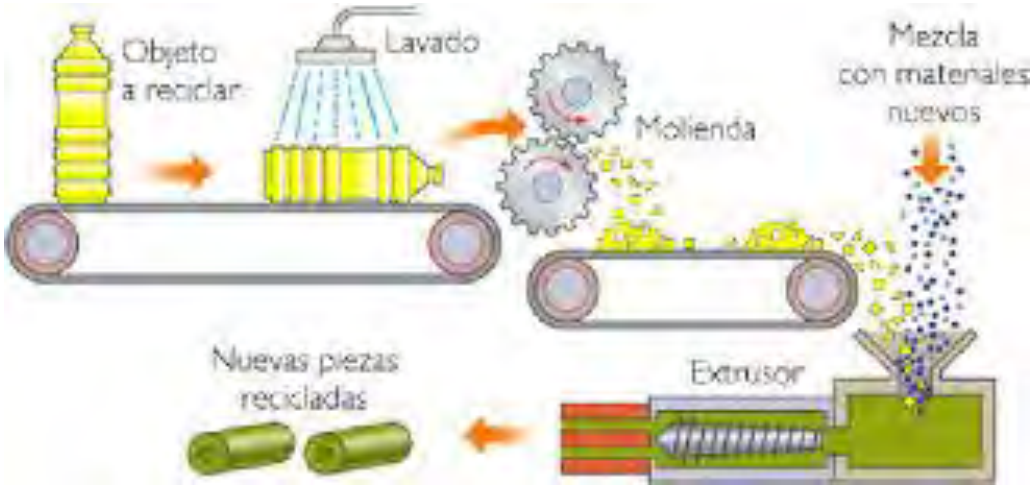
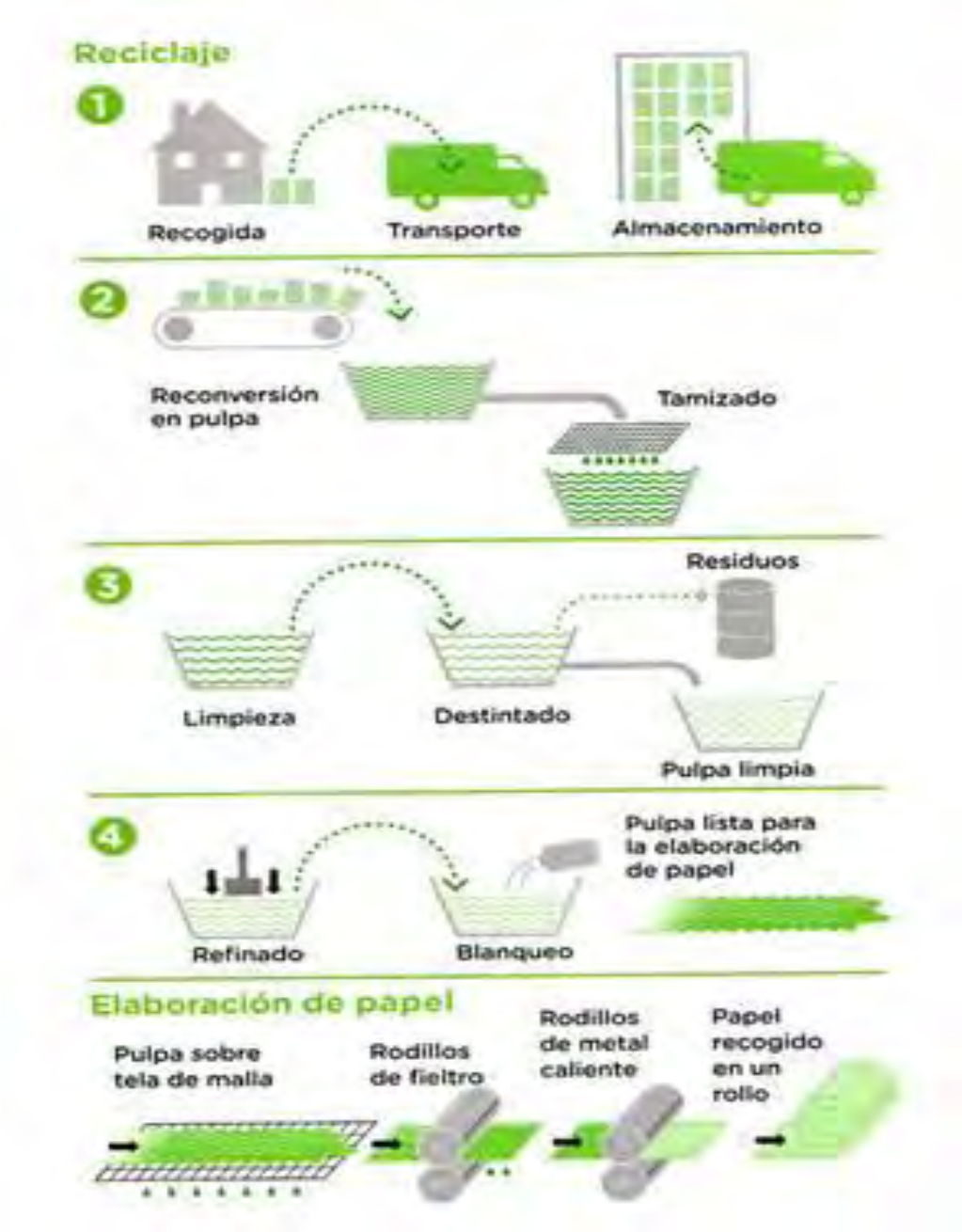


Figure 13 Plastic recycling process

2) Recycling Paper and Cardboard



Source:
www.google.com.do/search?espv=2&biw=1366&bih=662&tbm=isch&sa=1&q=cadena+de+reciclaje+del+papel+y+cartón&oq=cadena+de+reciclaje+del+papel+y+cartón

Figure 14 Recycling process of paper and cardboard.

3) Recycling of Glass

Glass is one of the few materials that has no limits on the number of times it can be recycled, without losing quality. Something similar happens in paper recycling.

Unfortunately, the "National glass factory", which operated in San Cristóbal.

Figure 15 Sample Glass Recycling Chain

4) Recycling of Metal

Metal residues are among the most sought after. The range of metal products is very wide. Metallurgical companies often recycle many of the metal waste. The metals that are most in demand are copper, aluminum and iron. In the country, many of these wastes are exported to be recycled in other countries, constituting the most important fraction of recyclable materials exported.

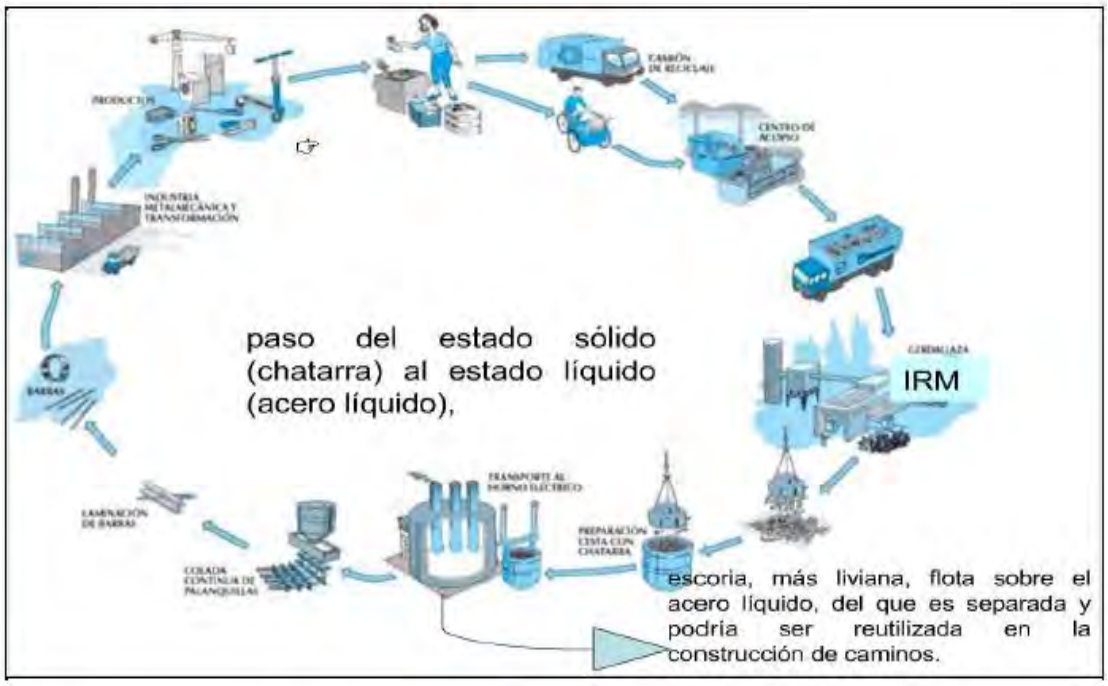


Figure 16 Metal Recycling Process.

1.3.6 Separation, temporary storage and delivery

The **separation** consists in classifying the solid waste at the point of generation (households, trade, institutions, etc.), according to its type in the corresponding container (temporary storage), according to municipal regulations.

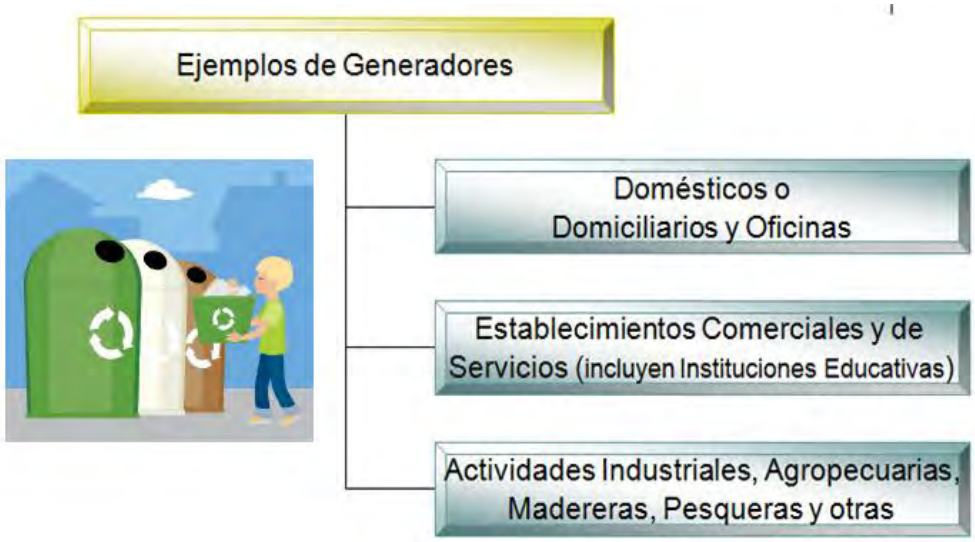


Figure 17 Scheme of a waste separation station at the source

Temporary **storage** is a critical stage of a recycling plan, since if from this step the citizens do not assume the separation program, the segregation process

must be carried out after collection, either in a transfer station or in the FDS. If this happens, the recyclable materials must be subjected to a washing process, prior to their incorporation into the production cycle, which would increase the cost of the recycling process and, therefore, the plan itself. Table 5 shows the different minimum characteristics that each material must have, so that they have a greater value in the market.

Table 5 Specifications that must have materials for sale

Waste	Purchase Specifications
Paperboard	Dry
	Cleansed
	No staples, no ties or loops
Paper	Dry
	Cleansed
	No staples or gums
	Separated by type
Plastic	Cleansed
	No waste mix
	Separated by type, for certain processes
	Ground
	Granulometry required
Cans	Clean
	Not mixed with other waste
	Compacted
Glass Waste Paperboard Paper	Cleansed
	Without tags
	Separated by color
	Separated by type, for certain processes
	Ground
	Granulometry required

The **delivery of the materials** by the population, according to the requirements established by the municipal authority, especially at the beginning of the plan and until people assume the activities implemented as daily activities, will depend on the success of the education strategy used, Punctuality in the

schedule and frequency of collection, the effectiveness of the collection and transportation system, as well as the control and monitoring of the plan.

1.3.7 Composting: Important recycling alternative

Composting is the only treatment that allows the recovery of nutrients from organic waste and incorporate them completely into the ecosystem. In this way, the application of compost is a benefit to the soil: above all it provides organic matter (usually deficient in this component), improves its structure, maintains moisture and protects against erosion. This latter factor is of great importance as it is causing significant loss of fertile soil, and an increase in global desertification.

Fuente: Manual del compostaje en casa. Barcelona- 2000.

Figure 18 Cycle of organic matter in nature (1), and in composting (2).

The decomposition of organic matter is an essential process for life, which occurs continuously in nature and spontaneously. For the same reason, composting is the ideal way to recycle and return the organic remains to the place where they originally came from.

Compost is the product resulting from the composting process.

Composting can be done naturally (though with human intervention) and industrial. The latter is carried out on a large scale in an industry, through the use of equipment that accelerates the natural process of decomposition of organic matter. Natural composting can be done anywhere (schools, universities, farms and even in homes). In the latter, homemade mulch are used. This type of composting is called domestic or home. In the "Manual for Environmental

Education and Citizen Participation" -FOCIMIRS, there is a section dedicated to this topic, which explains how to do home composting. The municipality may also decide to install a facility dedicated to the composting of organic waste generated in its territory, either through a natural or industrial process, after the corresponding study. The resulting compost can be used as a soil improver in parks and public spaces. This is the case, for example, in Singapore.

Advantages of composting

Composting can represent a major step in the recycling of domestic waste, in order to reduce the volume of waste that is to be disposed of, especially if the organic fraction is predominant, as in RD; without forgetting that it is the cheapest and most beneficial option from the point of view of environmental health. Among its advantages are:

- It is a treatment within reach of the community, which can be carried out with little effort, not only at the municipal level, but also at home level.
- Significantly reduces the weight and volume of "trash" bags that reach final disposal sites. On the other hand, it limits the fermentable products, responsible for the bad odors and liquids present in those bags.
- The resulting product is an excellent soil improver or compost (depending on compost quality) for plants. On a large scale, it helps to reduce the use of chemical agents for agriculture, which deteriorate soil quality.
- In the long term and in a global way, it contributes to the reduction of planting costs, as it improves soil quality.
- It is a responsible way of contributing to the overall reduction of waste that is destined for disposal or incineration. Both represent a high economic cost for the city and the citizen.

Composting process

The first step in the composting process is to have an adequate amount of organic waste. These materials will give us the organic matter, minerals and microorganisms so that, under the proper aeration and humidity conditions, the decomposition reactions take place. From this pile of waste, the different groups of microorganisms will begin to work, breaking the molecules from the simplest to the most complex, transforming them into compost. In fact, it is a natural

process, similar to what happens when in a forest fall the leaves of the trees and become humus. We, through composting, only try to provide the right conditions to accelerate the process.

Source: composting manual at casa_Barcelona, 2000.-

Figure 19 Composting process.

Source: composting manual at casa_Barcelona, 2000.-

Figure 20 Decrease in weight and volume of organic waste during composting

During the process, as a consequence of the oxidation of carbon to CO2, energy is produced in the form of heat, which is retained in the mass of waste being transformed, so that the material is heated, reaching 75ºC In the inner areas of the pile.

The greater the amount of waste that is composed, the greater the energy released, favoring the rise in temperature. This aspect of the process is very important because the high temperatures reached sanitize the material, that is, the pathogens, protozoa and seeds that are harmful to health or crops are destroyed. If the process develops correctly, when the molecules have decomposed, the microbial activity decreases and the material temperatures are

lowered again to balance with the environment.

The main players in composting are microorganisms and, in order to help them work in the best conditions:

- Prepare a mixture of spongy waste.
- Provide organic matter of diverse composition (different types of kitchen waste, mixed with pruning waste and garden)
- Have sufficient oxygen (air) (aerate the mass).
- Have a suitable degree of humidity (water must be added).
- Have an adequate temperature.

Waste suitable for composting

The materials that can be used for composting are residues of organic origin. They are mainly grouped in residues produced in the kitchen and those produced in the garden. The following table summarizes the different residues and their effects on the composting process:

Table 6 Residuos apropiados para compostaje y sus efectos

RESIDUO	EFECTO
COCINA	
• Restos de verdura y fruta	• Descomposición rápida. No genera problemas
• Restos de carne y pescado o marisco	• Pueden causar olores o atraer insectos o animales
• Huesos	• Descomposición lenta. Mejoran la estructura
• Pasta y arroz hervido	• Causa compactación si se incorpora mucha cantidad
• Cáscara de huevo	• Descomposición lenta. Aporta calcio
• Productos lácteos	• Pueden causar olores en mucha cantidad
• Posos de café y bolsas de infusión	• No genera problemas en cantidades habituales
• Ceniza de madera no tratada	• Aporta minerales al compost
• Serrín	• Descomposición lenta. Absorbe humedad
JARDÍN Y HUERTA	
• Recortes de césped	• Puede producir compactación, si no hay equilibrio en la mezcla de materiales
• Restos de poda, piñas, hojas secas	• Descomposición lenta. Mejoran la aireación
• Restos de cosecha de la huerta	• Descomposición rápida

Fuente: Composting Manual at casa_Barcelona, 2000.-

PART II

2 PLANNING

For the planning of a recycling project, the first step is to define a program by considering a long-term objective other in the short / medium term, the activities that must be carried out to meet these objectives, the target materials, ie those that Should be separated, based on the results of the characterization study, previously performed.

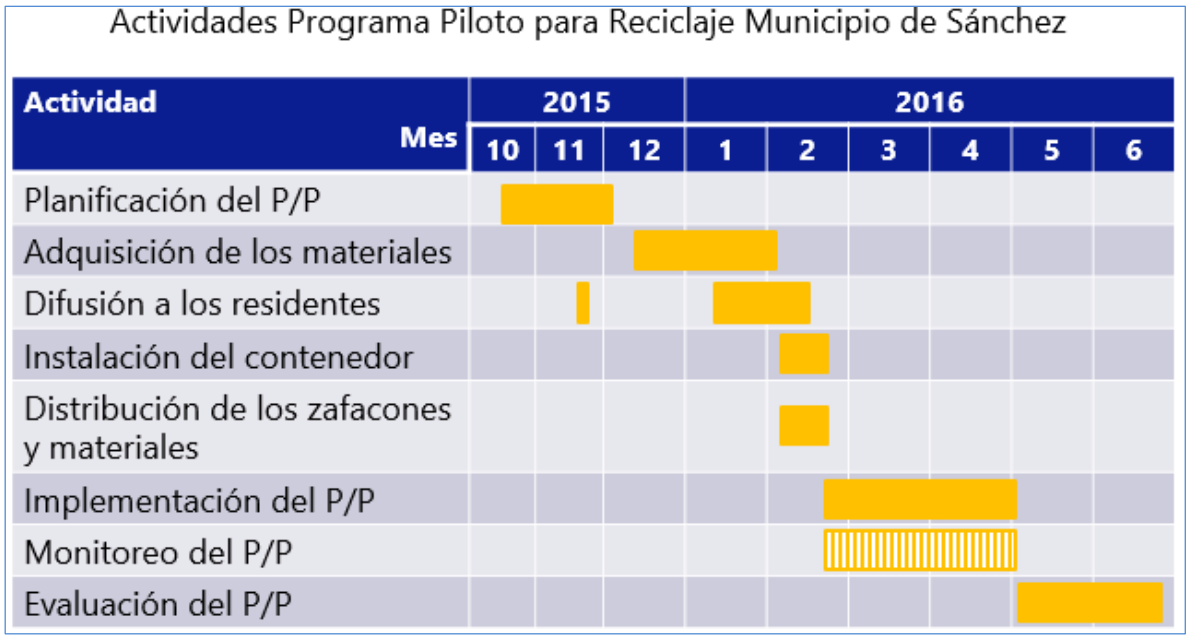
A very important initial decision is to define the steps to be taken in the recycling project and the components of each of them: How will the separation of the target wastes from the rest of the waste be carried out? Who will be in charge of each task? What will be the destination of the separated waste? Among other crucial questions.

The most important guidelines to consider are:

- Define low-cost collection solutions, so that the process can be extended to the whole city within a reasonable time and do not need to go back for economic reasons.
- Define an efficient separation-classification project, so that the input of the collectors who collaborate in the process can be improved.
- Focus on a process with a low rejection rate, in order to respect the effort of the residents who support the selective collection, if there is one.
- Define a recovery structure, in accordance with the needs of the market and the limitations of the municipality.

Planning is not simply a written document, but should help to facilitate the activity and make it more effective. It is necessary that the planning effort develops a program according to available resources and provides guidelines to workers, community leaders and citizens. It must develop a timetable, ie a description of logically ordered work tasks and the allocation of a duration and the necessary resources.

Table 7 Schedule of activities Municipio de Sánchez, FOCIMiRS, 2016.



Program Elements

While each recycling program is specific to each community, each city builds a system according to its needs and the specific problems of the area. However, there are common elements that need to be considered in any program, including:

- The composition of waste.
- Availability of markets for recovered materials.
- The economy of the region.
- Community involvement.
- The political climate of the community.
- All components of a recycling program could be considered as the links of a chain of activities that make recycling possible in a community. All components must be interrelated. Normally we can consider that a program of recycling consists of five links:
- Awareness of the population
- Collection systems
- Treatment
- Commercialization
- Acquisition of raw material

2.1 Strategies for a recycling program

For some residents, their participation in the programs will be in order to help conserve the environment. For others, it will be an activity that is done looking for an economic incentive. In that sense, the strategy must include the two citizen thoughts. On the other hand, the strategy of communication and dissemination should be planned, as if it were a marketing professional. Convincing the population requires effective advertising and marketing techniques. It is about "selling" an idea.

Among the recycling strategies are:

- To structure a program of fiscal incentives for recycling, either by sale of materials or by activities of reduction in origin (generation of less waste).
- Separation program in schools and neighborhood associations.
- Establish clean points, where the population can carry the segregated materials.
- Create competitions with participating schools in recycling programs, as well as between different sectors or neighborhoods.
- Citizen education campaigns.

Municipalities must create simple strategies and to which they can give due follow-up. The same will be adjusted, according to the limitations that are in its application.

2.1.1 Structure and execution of the recycling program

In order to structure a recycling program, it must be taken into account that the program must have a budget for execution and follow-up.

The planning stage defines the processes to be executed, the types of target materials to be recovered. It can be structured as follows:

- Citizen Education Plan
- Recycling strategy
- Execution of the recycling program
- Follow-up plan

In order to carry out the recycling program, the program structure and strategy to be used to comply with the activities proposed in the plan must be already

established and thus comply with the stated objective.

For the implementation of the program, the following aspects must be clear:

- Target Area
- Recyclable materials target
- Methodology to be used: containers, door-to-door collection, collection points.
- Select the households to participate and how they will be instructed on recycling plans.

2.2 Material recovery plant -PRM [1]

A material recovery facility accepts materials, whether they are mixed or separated to be processed and stored for sale and subsequent use as feedstock. The main function of a PRM is to maximize the amount of recyclables processed, conditioning the materials that will generate the highest possible revenue in the market. PRMs can also function to treat wastes that become a source of fuel for energy production.

It is important that recycling facilities only accept materials that have been specifically segregated from the waste stream by the generators for recycling purposes. Facilities that accept products containing a high level of contaminants, in addition to limiting their efficiency, could be subject to extensive regulatory permits and close supervision. Therefore, facilities should work in cooperation with carriers and / or local governments to maintain an acceptable level of public education, so that participants are aware of which materials are acceptable and which are not acceptable. To optimize efficiency in design and operations, the system to be used must be well defined, as should procedures and practices. These are essential practices:

- Have systems and procedures to identify and confirm that only the expected products enter the PRM.
- Incorporate operational efficiency to achieve the optimal processing of commodities.

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[1] The technical considerations raised in this Manual were taken from the document "Elements for the organization of selective collection and design of classification centers". Tetra Pak-Manual Collection. Selective Brazil. 2008

- Maintain operational efficiency to ensure that recovered commodities meet market specifications.
- Operational adaptability to adjust work systems and procedures to new requirements while maintaining efficiency and effectiveness in operation.

Operational efficiency focuses on the use of resources (labor and capital), in the classification and treatment of materials. It focuses on reducing sorting and treatment costs while maintaining (or increasing) the desired flow of materials. Measures that improve efficiency with a short-term ROI can be implemented, for example, removing some specific material at the beginning of a sorting line to help you more easily see and retrieve certain materials on the line. Or, with a longer return on investment, for example, buying a baler to reduce the costs of transporting the materials to the market.

Producing the desired result and meeting customer expectations is an example of operating efficiency. This often translates into higher incomes, positive long-term relationships with markets, and a lower likelihood of reduced incomes or the rejection of raw materials. Operational effectiveness can also be applied at the micro level within an operation. For example, during training of workers, instruct that doing a good job in grading will improve the quality of the materials sent to the packer; This in turn will help improve the efficiency in the packaging operation, with less time spent sorting the products being packed or having to reprocess the products to meet market specifications. Finally, the reduction in the time of execution of the tasks, will increase the profitability of the process and the benefits for all.

Operational adaptability refers to the ability to adapt to changes in customers or companies. This will benefit the marketing of the commodities obtained.

2.2.1 Design, Location, Characteristics and Considerations for PRM

The first decision in a material recovery plant will be to define the solution that will be adopted to structure the selection process. You can choose one of the following processes:

- Mechanical operation
- Manual processing, with separation tables and storage.

The choice between mechanical operation or manual separation techniques

depends to a large extent on the costs of manual sorting, since in many places the cost of personnel is very high, and it is time-consuming to handle large volumes of materials. Workload represents one of the most costly components of a PRM, making it an important decision factor.

There are advantages and disadvantages between capital costs when considering the possibility of using mechanical separation processes versus manual processes. Most long-term cost analyzes show that the automated process is more cost-effective than the manual process. However, the socio-economic conditions of the specific country, region or locality, as well as market conditions, in one way or another, will guide the decision of one or the other option. Where labor is cheap, it might be more advantageous to adopt manual systems; Otherwise, in places where labor is expensive. If the specifications of the market demand a high degree of quality, it might be more advantageous to lean towards a mechanized system, since, in a manual system, the operation would require a lot of time, significantly reducing the efficiency of the process.

Whether or not mechanical grading methods are used and to what extent mechanical grading is to be implemented will depend on a number of factors including, but not limited to:

- Type of incoming material
- Performance of facilities;
- Specifications of marketed materials and expected revenues;
- Design / structure of the facility;
- Labor available
- Local labor costs

Once the solution to be used is defined, the location and design of a material recovery facility must be carried out, taking into account efficiency and safety considerations. This means addressing issues such as: location selection, site characteristics, local land use requirements, permits, design and layout of facilities, lay-out, operation, employee / visitor safety . If the PRM is to be located in an existing structure or attached to a transfer station or final disposal facility, the characteristics of existing buildings should also be analyzed.

The stages involved in the design of the facility, regardless of the type of process adopted, will:

1. Conceptual design
2. Evaluation of the markets (to know the real possibilities of sale of recovered material) and economy of the operation (to know the profitability of the same).
3. Development and collection of data necessary for the design (to calculate the volume of material that would be received during the daily operation, weekly storage, sizing of the different facilities within the PRM, etc.).
4. Detailed system engineering design
5. Diagram of the location of each component: location of machinery, personnel, warehouse, service facilities, etc.
6. Acquisition of equipment
7. Construction of the installation
8. Treatment of materials
9. Commercialization

The commonly used mechanical classification methods include technologies such as screens, blades and air classifiers, magnets (suspended magnets, magnetic drums, magnetic head pulleys (both stationary and portable units) and current separators. Various raw materials and material flows are typically based on different physical properties, such as size, weight, density or magnetic properties. Others, such as paper grading, are based on differences in stiffness.

Recycling equipment manufacturers continue to design, test and implement new methods to more efficiently classify recyclable materials into separate streams in order to improve existing equipment.

2.2.2 Plan the stages of work

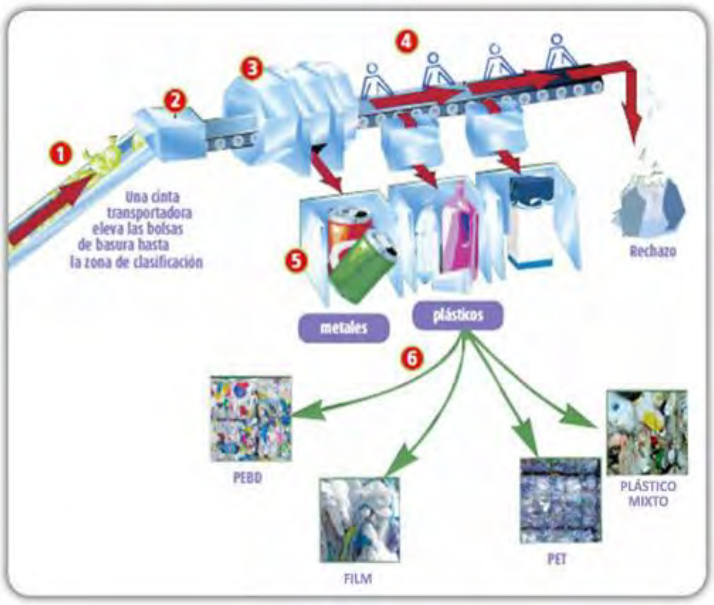
For the project of a Material Recovery Plant, it is essential to define in advance the work process to be adopted and, therefore, the flow of the materials that will be processed.

The following figure illustrates the various activities and sequence in which they are performed in a typical manual recovery project, with a warehouse and selection tables:

Source: Elements for the organization of the selective collection and design of the classification centers ". Tetra Pak-Manual Collection. Selective Brazil. 2008

Figure 21 Sequence of activities in a manual operation PRM.

The following figure shows the sequence of some activities of a mechanized plant:



① A conveyor belt raises the trash bags from the containers to the sorting zone.

② In a breaker the bags are opened releasing their contents in the classification tape.

③ A tunnel with large magnets pre-selects the metals.

④ The selection of the rest of the materials can be done manually.

⑤ The selection of the rest of the materials can be performed mechanically.

⑥ The same plastics are separated into different families or types, which are stacked forming what in the sector are called plastic bullets

Source: www.cicloplast.com/index.php?accion=rutadelreciclado&subAccion=reciclado-envases

Figure 22 Sequence of activities in a mechanical operation PRM

2.2.3 Organization of the space and volume of the classification center

Once the work process is defined, it is necessary to carefully plan the appropriate spaces and volumes for the conditions of each area, considering the waste stream that the facility must process and the expected sales pace. It is important to take into account that the sale of the materials is more advantageous in greater volume and, therefore, the storage spaces should enable the best marketing condition, according to the reality of each region.

The following table shows some considerations to follow for the sizing of the installation:

Table 8 Conditions to consider for dimensioning a PRM

TYPE OF EASE	CONDITIONS TO CONSIDER
Warehouse of materials to classify	Predict the volume of several days of collection.
Classification Sections	Provide sufficient numbers for the storage of subcategories of already classified material.
Warehouse of materials to distribute	Provide storage capacity for weekly production, considering the delivery of the materials of greatest output.
Warehouse of other materials	Provide specific spaces to place remaining materials: metals, glass, among others.

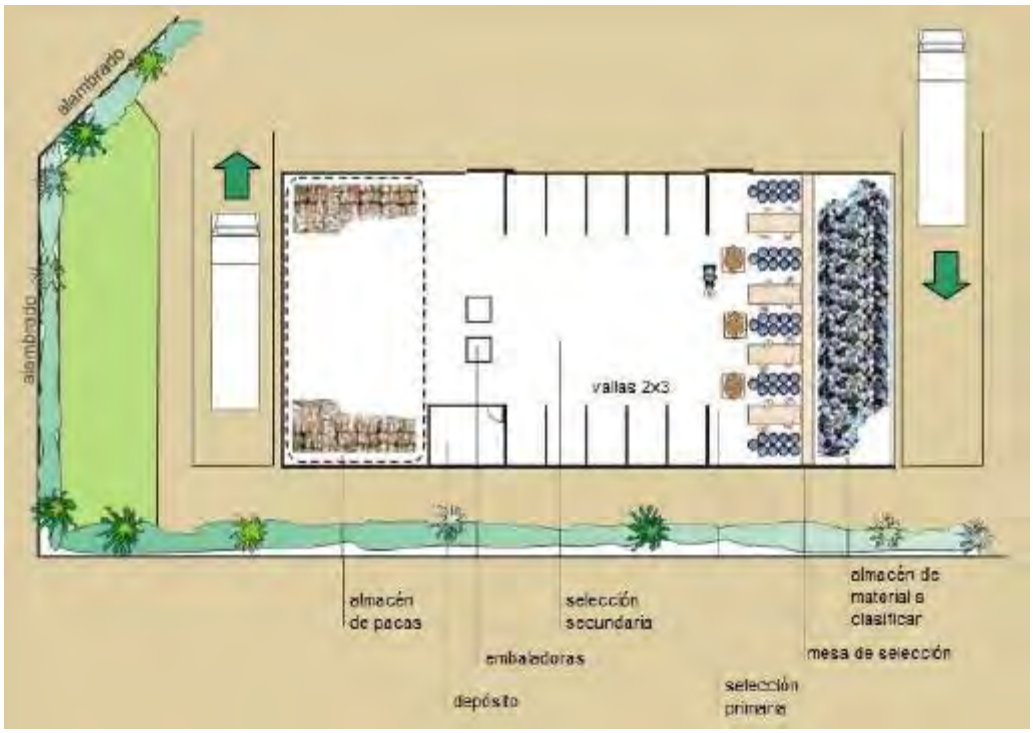
Source: Elements for the organization of the selective collection and design of the classification centers ". Tetra Pak-Manual Collection. Selective Brazil. 2008

1) Organization of work teams

The total volume of materials to be processed in a facility will depend, to a large extent, on the number of people involved in the selection center. For example, an average worker is able to separate approximately 200 kilos of material per day, and another that packs the material, will manage to pack 600 kilos per day. This will determine the waste capacity that can be processed weekly in the PRM.

2) Organization of operations in the PRM

According to the workflow adopted, the organization of the PRM is derived. We will use the following figure as an example:



Source: Elements for the organization of the selective collection and design of the classification centers ". Tetra Pak-Manual Collection. Selective Brazil. 2008

Figure 23 Space distribution of a PRM.

For the previous figure two tasks have been established:

Primary selection: at this stage up to 16 types of materials can be separated into drums, bags and bags placed near the classifiers.

Secondary selection: at this stage some types of materials are classified (paper, plastic, metal).

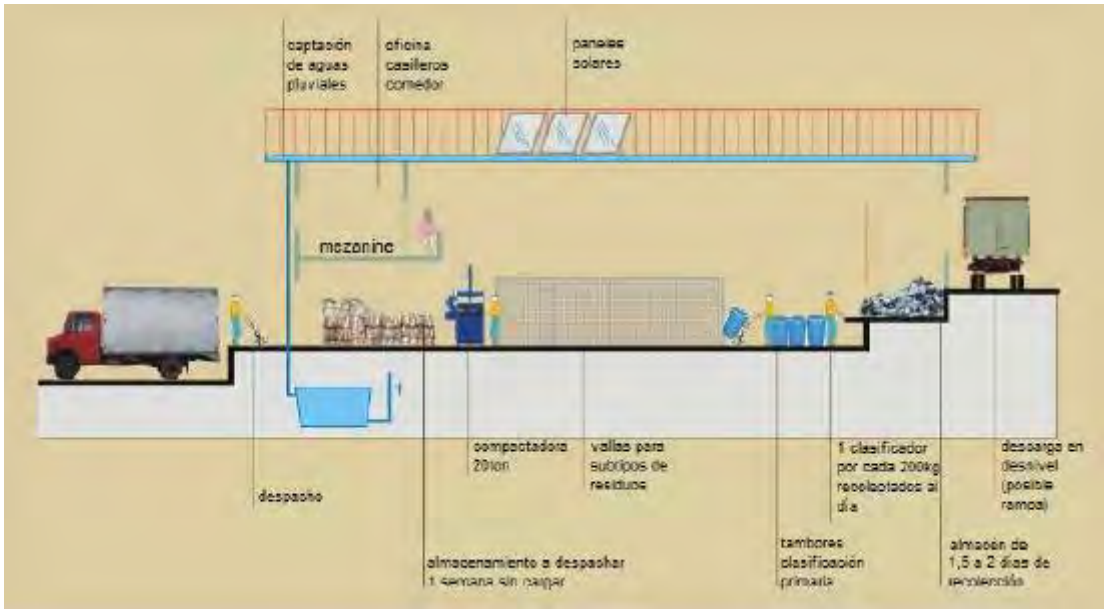
In cases like this, in which the PRM is not mechanized, for the internal mobilization of loads, it is convenient to use manual equipment such as forklifts, trolleys, among others. The following table shows some of these simple equipment:

Table 9 Useful equipment for the operation Manual of a PRM

EQUIPMENT TO BE USED IN A MANUAL OPERATIONAL PRM		
Equipment	**Characteristics**	**Type**
Press Compactor	Capacity up to 20 Tons	
Balance	Capacity up to 1,000 kg.	
Platform truck	Ideal for two (2) axles with capacity up to 300 kg.	
Hand Truck	Capacity up to 150 Kg.	

Source: Elements for the organization of the selective collection and design of the classification centers ". Tetra Pak-Manual Collection. Selective Brazil. 2008

It is important that the flow of the materials is defined according to the terrain topography, making use of gravity to define the working areas. For example, whenever possible, the slope of the ground should be used to organize a downward flow of materials, as shown in the following figure:



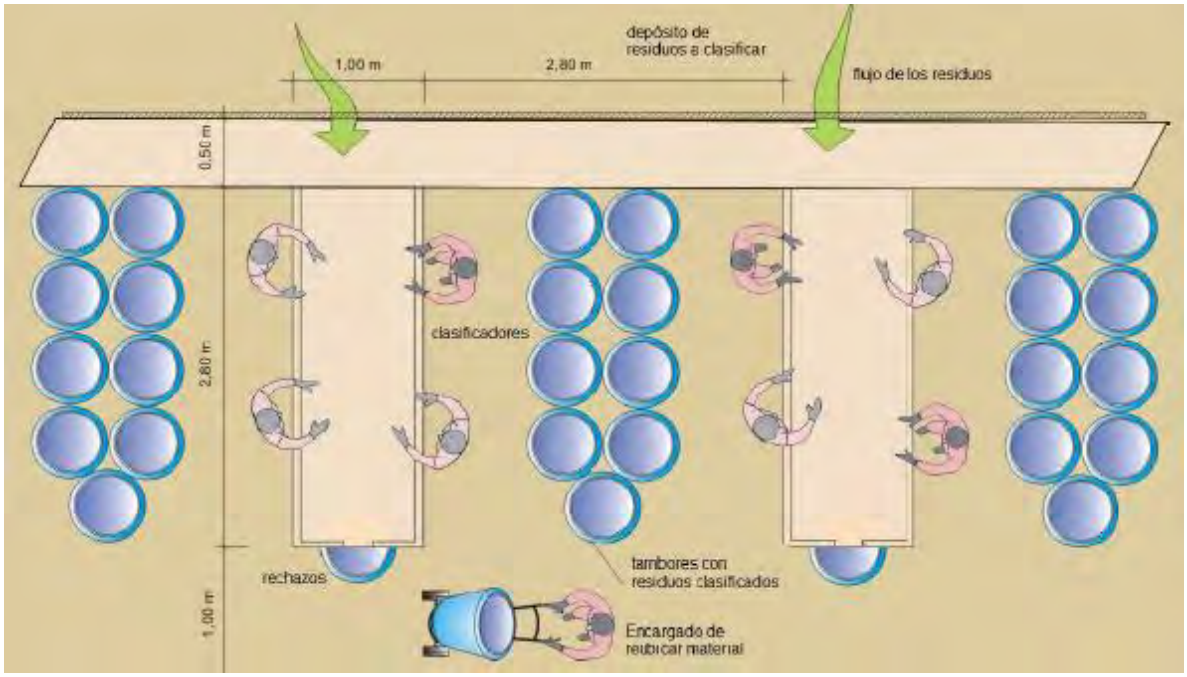
Source: Elements for the organization of the selective collection and design of the classification centers ". Tetra Pak-Manual Collection. Selective Brazil. 2008

Figure 24 Optimum Flow Diagram in a PRM.

Taking into account the dozens of types of materials that are obtained in a PRM, the organization of the classification area is a fundamental element that will influence the efficiency of the plant as a whole. The number of types of materials that result from the separation must be defined, according to the characteristics of the market in each locality. It is useless to separate materials that will later be marketed as if it were a single type, and it is more advantageous to market the more segregated materials whenever possible. In any case, the following must be taken into account:

- Placing of the most common materials in drums or tanks.
- Placing of less common materials in sacks suspended on drums or tables.
- Perform the sub-classification of metals and plastics at the time of placing them in the containers.

Another important point is the location of the work tables (layout), which should facilitate classification. Each classifier must have a drum or tank in which to deposit each type of material.



Source: Elements for the organization of the selective collection and design of the classification centers ". Tetra Pak-Manual Collection. Selective Brazil. 2008

Figure 25 Distribution of the working tables in a PRM.

2.2.4 Installing a Composting Plant

The first step will be to define whether composting will be carried out at the domestic or municipal level (whether industrial or manual). This will determine the material and / or infrastructure needs that the project will require.

The key factors in deciding a technique are:

- Climatic conditions of the place: strong winds, torrential rains or other extreme climatic events, temperatures below zero (this does not apply as much in RD, but it can not be forgotten that very low temperatures can be found in Constanza).
- Expected process time, according to the type of waste of higher generation.
- Space Requirements
- Hygienic safety required
- Starting material (absence or presence of material of animal origin)

The different techniques are generally divided into closed systems and open systems. Open systems are those that are done outdoors and closed, those that are made in containers or indoors. In both cases, measures for the control of

odors should be considered. It is a reality that the composting process generates unpleasant odors, therefore, it is very important a good selection of the site where the installation is located or simply the place where the process is performed, especially when done outdoors. It is recommended that it be carried out in areas not close to human settlements.

Fuente: M.A. Martinez. Directora planta de compostaje municpal, Nicaragua

Fuente: Manual de compostaje del Agricultor. FAO - 2013

Photo 1 Open compost piles.

Source: composting manual at home. Barcelona, 2000.

Photo 2 Composters made from re-used pallet wood.

Source: Farmer_FAO composting manual. 2013

Figure 26 Closed composter for domestic technique.

Once the site, the waste and the composting system have been defined, the following steps:

1. Collect the waste that will be used.
2. Prepare the waste, that is, have a homogeneous size to encourage decomposition. If it is carried out at the municipal level, it is convenient to have a crushing machine.

Photo 3 Waste crusher machine in the composting plant of Punta Cana, D.R.

1. Mount the structure that has been selected to compost.
2. Flip / rotate the material several times for one month.
3. Water the material.
4. Sift the compost mixture.

PART III

3 OPERATION

This part addresses not only the operation of the physical infrastructure of a material recovery facility or a composting plant, but also the recycling program itself, which will entail an implementation phase, once the phase of planning.

3.1 Implementation of a Recycling Program in the Community

During the implementation of a recycling program, the efforts will focus on achieving the established objectives of the same, for which the following tasks will be prioritized:

3.1.1 Establishment of comprehensive programs to raise public awareness

Participation in recycling programs should increase awareness of other interrelated aspects of solid waste management, such as the payment of the service, the responsibility of taking out the waste at established times and days, among others. In addition, awareness will be perceived as the first necessary step that will lead to the acceptance or rejection of a classification service at source or selective collection. The success or failure of a recycling program depends above all on its adoption by the majority of the members of a community, ideally by all.

1) Prerequisites for public awareness

Nowadays, anyone reading a newspaper, listening to the radio or watching television can get an idea about recycling. On the other hand, in schools, children and adolescents receive messages that are alluding to the issue, as well as in many parts of the country, there are educational centers where programs of separation are carried out, especially of paper. This facilitates the work of raising awareness and awareness. It is no longer necessary to explain what recycling is, the task now is to provoke in the population the commitment to the new actions that will be executed, carrying a global environmental message:

TAKING RECYCLING TO THE COMMUNITY

Although the awareness program arouses interest, it must be continuous. Rather than highlighting the need to protect the environment, we must teach the community what it can and should do to collaborate.

The real challenge in such a campaign is to involve all sectors of the community. The goal is for the community to take the recycling program as its own, from seniors to preschoolers, from the chiripero to the entrepreneur.

2) Awareness of society

Much of the success of a recycling program will depend on the knowledge and participation of the community and the companies involved.

It is essential to implement an effective program to raise awareness and promote good practices in waste management, both in a program that starts and in the maintenance and development of one that is already underway. This must be organized and in accordance with the characteristics and Conditions of its public.

Citizens and businesses in the service area should first be made aware of the need to receive general education on recycling. Participants then need to know some details about what materials are going to be recycled, how they are prepared and how they will be collected. On the other hand, it is necessary to keep the participants informed about the development of the program and its results, so that they feel involved and responsible for it and not mere spectators.

Encourage reduction at source as an educational component and implement school projects to promote the development of environmental awareness among the youngest, as children are an effective way to reach their parents and other family members.

It is fundamental for the operation of the recycling program, the knowledge of the public, of some basic principles of recycling such as: the understanding of the recycling circuit, the value of the materials recovered and the importance of the conditions (clean and Conditioned) of the materials for their placement in the markets. Once the political decision has been made, the community must be prepared for the implementation of the recycling program.

It is desirable that the specific details of the program reach the participants

through direct contact, just before and during the implementation, so as not to run the risk of people forgetting.

3.1.2 Follow-up of the recycling program

After the implementation has started, according to the structure and established procedure, a satisfaction survey must be carried out in order to know the weak points of its execution, in order to study and analyze its causes, with a view to its strengthening.

PROYECTO DE FORTALECIMIENTO DE LA CAPACIDAD INSTITUCIONAL PARA EL MANEJO INTEGRAL DE LOS RESIDUOS SÓLIDOS

ENCUESTA APLICADA A LOS SECTORES DE LOS RIELES, HOJA ANCHA Y PLAY ABAJO, ÁREA PILOTO, DEL PROYECTO DE SÁNCHEZ.

Nombre del Residente:	
Sexo:	

Referencias De Valoración	
1	**Nunca/Muy Malo**
2	**Rara Vez/Malo**
3	**Regularmente/Bueno**
4	**Casi Siempre/Muy Bueno**
5	**Siempre/Excelente**

	Preguntas	**Respuestas**
	✓ **Integración en el proyecto**	
1-	¿Con qué frecuencia deposita materiales reciclables en los cubos?	
2-	¿Con qué frecuencia los lleva a los contenedores especiales?	
3-	¿Le gustaría que como Junta De Vecinos tanto usted como los demás puedan vender sus reciclables directamente o a la Alcaldía?	
	✓ **Satisfacción referente al proyecto piloto**	
1-	¿Cuál es su valoración referente al proyecto piloto de recolección de reciclables?	
2-	¿Piensa que su sector debería continuar con el proyecto?	
3-	¿Usted seguirá siendo parte del proyecto?	
4-	¿Qué mejoras recomienda para el proyecto?	

Elaboration by - FOCIMiRS Project.

Figure 27 Survey applied to the target population, Sánchez. FOCIMiRS-2016.

1) Measuring program effectiveness

A very simple way to assess the effectiveness of the recycling awareness

program is to determine the amount of recyclable materials collected and compare them with the waste stream prior to program implementation.

Table 10 Weekly result format Municipio de Sánchez. FOCIMiRS- 2016

Resultados del pesaje de residuos Semana Junio 17, 2016. Sánchez.

Contenedor(es)	Cantidad Plásticos (Kg).	Cantidad Vidrios (Kg).	Cantidad Metales (Kg).	Total General (Kg).
Contenedor 1 (Play Abajo, frente al Hotel Gri-Gri)	0.5	0.5	0	1.0
Contenedor 2 (Los Rieles, cerca del colmado)	3.5	3.5	0	7.0
Contenedor 3 (Los Rieles, frente a Escuela Prof. Mateo)	10.3	6.5	4.0	20.8
Contenedor 4 (Hoja Ancha, frente a la Clínica UNAP.)	9.5	8.5	0.01	18.01
Contenedor 5 (Play Abajo, al lado del Play de Baseball.)	1.4	7.5	0.5	9.4
Contenedor 6 (Play Abajo, al lado de la Ferretería)	6.5	3.0	2.0	11.5
Total Unitario (Kg).	**31.7**	**29.5**	**6.51**	**67.71**

Done by - FOCIMiRS project

3.2 Operation of the material recovery facility

For the operation of a material recovery facility, the following factors should be continuously monitored:

- Employee Safety
- Employee training
- Friendly practices with the neighbors of the facility, which will include:
  - ✓ Maintenance in perfect condition of the infrastructure, since this will depend a lot on the perception of the citizens about the success of the program.
  - ✓ Collect and drain liquids to a designated area.
  - ✓ Carry out treatment operations indoors or place process equipment under cover, when possible, minimizing odors.
  - ✓ Maintain cleanliness of the site, always avoiding large accumulations of waste, especially unclassified.
- Selling market of products managed to guarantee cash flow.

CONCLUSION

Not all programs apply to all cities. Each one has unique conditions that are associated, largely with cultural customs and in addition, to the quantities and types of materials that are generated, as well as to the method of classification and processing, which must be according to the local budget.

The Dominican Republic has the potential for the authorities to focus their efforts to realize a large-scale recycling program that will allow the installation of a material recovery plant through a public-private partnership (APP); As well as to implement the composting as an alternative, given the high generation of organic waste throughout the national territory.

Today, it is necessary for the Central Government, through the Ministry of the Environment and Natural Resources, through municipalities and together with all of Dominican society, to develop education, awareness and training programs on the subject of recycling, since as island territory, the country is deeply threatened by the great challenge of climate change.

It should be noted that this activity in our country, as in many other countries, is an action vulnerable to market prices, so that there must be legal certainty and a cost structure for the different materials and their processes, So that those involved in this sector have greater guarantees when considering an investment in the different recycling processes.

Recycling is a global trend and is no longer an option, but rather a necessity in DR. Let's set the country in tune with the demands of modern times!!!

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