SEPARATE COLLECTION:
The path to composting

An analysis of the different models of separate collection

Amigos de la Tierra

With support from:

ZERO WASTE EUROPE

GOBIERNO DE ESPAÑA

MINISTERIO DE AGRICULTURA Y PESCA, ALIMENTACIÓN Y MEDIO AMBIENTE

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The documentation presented in this report comes from information gathered through surveys conducted by Friends of the Earth Spain on relevant agents involved in bio-waste management. The discussion that follows also refers to public documents and official sources. The publication of this report in English was made possible with Zero Waste Europe's support.

Amigos de la Tierra

ZERO WASTE EUROPE

Who is Friends of the Earth Spain (Amigos de la Tierra) we?

We are an environmental association with the mission of promoting local and global change towards a society that is respectful of the environment, fair and in solidarity.

Our actions, of environmental awareness and education, political pressure,
Cooperation and the implementation of concrete alternatives, planned to affect different levels of society, achieve:

// Promote healthy food and agriculture, which is environmentally and socially just.

// Move towards a clean energy model in the hands of the people

// Achieve efficient waste management and reduce over consumption of natural resources.

We are part of Friends of the Earth International, present in more than 70 countries and with more than one million members. This allows us to coordinate joint campaigns and promote changes from the lcoal to global.

Who is Zero Waste Europe?

Zero Waste Europe is creating a movement aiming at eliminating waste in our society. We empower communities and change agents from around Europe to redesign their relationship with resources, to adapt their lifestyle, their consumption patterns, and to think circular.

Zero Waste Europe engages these groups at two levels:

// Supporting local groups with independent knowledge and streamlined tools to drive change more efficiently

// Structuring the movement internationally to better represent the interests of our communities at the EU level and engage policy makers with a unified voice

We are both a knowledge network and an advocacy group, representing active communities in countries across the EU.

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// INTRODUCTION

Municipal waste includes several streams of materials; from organic waste to domestic appliances and furniture. **If we are to reduce waste's environmental impact, each type must be collected and processed appropriately.**

The organic fraction is the largest single type of municipal waste generated per inhabitant, at **35-45%** depending on the area. However, **in most Spanish municipalities it is not separated, collected and treated in the most appropriate way**, and is usually processed as part of mixed waste, and must subsequently be mechanically separated in treatment facilities.

It is noteworthy that in Spanish waste legislation (Spanish law 22/2011), compost is defined as:

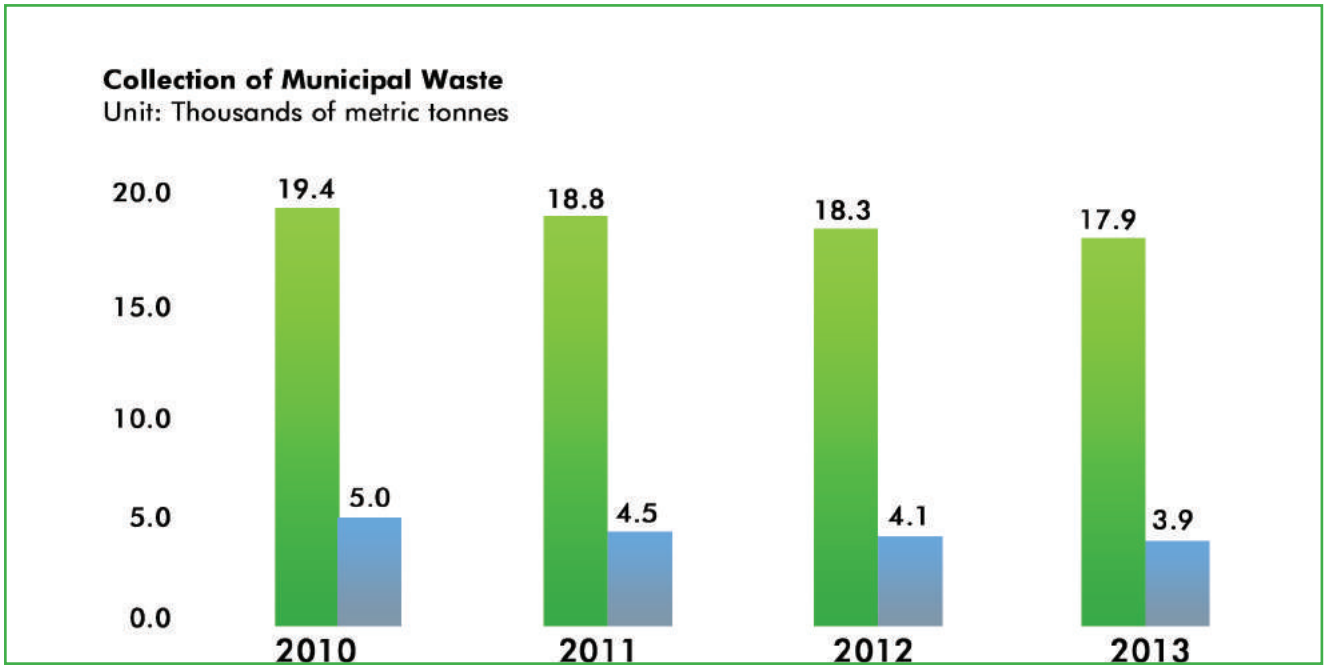
organic matter obtained though biological treatment - aerobic and thermophilic digestion - of biodegradable waste collected separately. Organic material obtained from mixed waste separated by mechanical treatment plants should not be considered compost, but bio-stabilized material, so that the use of non-separate collection waste as a raw material for the composting process should be avoided.

This points clearly towards promoting source-separation of municipal waste.

In 2013, 21.8 million tons of municipal waste were collected in Spain, 2.7% less than the previous year, as shown in Chart 1. (INE – Instituto Nacional de Estadística; Spanish National Statistics Bureau, 2013)

Glass, paper and cardboard, and animal and vegetable waste amount to 65% of all materials that are collected separately. However, only 18% of all municipal waste is collected separately.

Chart 1: Municipal waste collection in Spain 2010 - 2013 (Source: INE, 2013).



EU Directive 2008/98/CE (EU, 2008) updated the framework for waste management in Europe. The directive was incorporated into Spanish legislation with Law 22/2011.

Collection of separated municipal waste 2013 (Unit: thousands of metric tonnes)

Separated waste collection	Quantity	% of total	% variation from prev. year
Total	3,932.9	100.0	-3.6
Paper and cardboard	988.2	25.1	-9.0
Animal and vegetable	844.1	21.5	5.5
Glass	720.9	18.3	-2.0
Other	623.4	15.9	21.8
Mixed packaging	559.3	14.2	-12.8
Wood	105.6	2.7	-19.1
Electrical goods and parts	41.6	1.1	29.4
Plastics	21.6	0.5	-79.9
Metals	21.0	0.5	-39.4
Batteries	7.1	0.1	279.5

	2008/98/CE Directive	Spanish Law 22/2011
Bio-waste	Biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises and comparable waste from food processing plants	Biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises; as well as comparable waste from food processing plants
Waste management	Collection transport, **recovery** and disposal of waste, including the supervision of such operations and the after-care of disposal sites, and including actions taken as a dealer or broker	Collection, transport and treatment of waste, including the supervision of such operations and the after-care of disposal sites, and including actions taken as a dealer or broker
Collection	The gathering of waste, including the preliminary sorting and preliminary storage of waste for the purposes of transport to a waste treatment facility	The gathering of waste, including the preliminary sorting and storage of waste for the purposes of transport to a waste treatment facility
Separate collection	Collection where a waste stream is kept separately by type and nature so as to facilitate a specific treatment	Collection where a waste stream is kept separately by type and nature so as to facilitate a specific treatment

Table 1: Comparison of waste-related definitions in Spanish and EU law

If we compare the aims of the legislation, both European and Spanish, with the results achieved in the collection of municipal waste (shown in Chart 1) it is clear that the objectives are far from being fulfilled. Spanish law proposes that waste generation should be reduced by at least 10% of 2010 levels by 2020, all waste included, and more specifically that "by 2020, the quantity of domestic and commercial waste materials prepared for re-use and recycling; such as - at least - paper, metal, plastic, glass, bio-waste and other streams that can be recycled, shall be increased to a minimum of overall 50% by weight"

It follows that in order to comply with the current regulations and their objectives, and respect the environment, actions that encourage separate collection and the use of the most appropriate treatment options to obtain quality products must be prioritized.

//BACKGROUND & CONTEXT

Friends of the Earth Spain carried out a survey in **six different areas that have implemented separate collection schemes**. The survey consisted of 40 questions including demographic characteristics of the area studied, amounts and types of collected bio-waste, collection and treatment options used, costs, products sold and production process, emissions and carbon footprint information and jobs created.

Table 2 lists the areas studied, the type of waste management used (collection and treatment) and the size of the population served. The areas studied are noticeably different both in the type of management used and in their populations, which makes the interpretation of the results somewhat difficult. The survey results are presented in Annex 1. The answers give us information about specific facilities and schemes, rather than on all of the communities or significantly large geographical entities

Area	Type of management	Population served
Barcelona Metropolitan Area (Barcelona, Catalonia)	Collection in open separate container & industrial processing	Pop 1,604,555
Mancomunidade of Barbanza (La Coruña, Galicia)	Separate collection of dry and wet waste and industrial composting	Pop 86,218
Hernani (Gipuzkoa, Basque Country)	Individuals take care of community composting	Pop 1,400
Pamplona (Navarra)	Collection in locked separate container (key needed). Bio-methanisation and indusrial composting	Pop 333,559
La Rioja (La Rioja)	Collection in container and industrial composting	Pop 17,178
Esporles (Majorca, Balearic Islands)	Door to door collection and industrial processing	Pop 864,763

Table 2: Areas studied and types of collection

// AIM OF THIS STUDY

This study aims to compare several selected areas, based on information obtained from a survey of municipal waste collection systems conducted by Friends of the Earth Spain.

// METHODOLOGY

This section briefly describes the methodology used to analyze the information gathered in the surveys. To make interpretation easier, results are then discussed in the following sections

1// Summary and compilation of the information about the different areas studied.
2// Interpretation of waste generation and collection data; types of waste, amounts and costs.
3// Importance of separate collection, compost production and organic matter needs.
4// Interpretation of the citizen responses
5// Programs for reduction of carbon footprint
6// Extrapolation of data, useful tools for decision-making

//RESULTS

SUMMARY OF SURVEYS AND FURTHER INFORMATION GATHERED

In this section, we will present the data gathered in the surveys in order to facilitate their understanding and further discussion. In addition to the information provided by the questionnaires, some data has been summarized from public documents and further information gathered after the surveys, in order to obtain comparable categories across the different schemes. The surveys were the same for all the areas studied but the answers obtained were not always homogeneous; in some cases some of the questions were not answered, and in some questions the results are not always comparable. The search for more information through the websites of official bodies has allowed us to gather a more complete picture and to present a better interpretation of the data.

BARCELONA METROPOLITAN AREA (BARCELONA, CATALONIA)

COLLECTION IN OPEN SEPARATE CONTAINERS. INDUSTRIAL BIO-METHANISATION AND COMPOSTING

The scheme studied serves the Barcelona Metropolitan Area. Waste is treated in Ecoparcs 1 and 2, located respectively in the Zona Franca (near the Barcelona port) and in the nearby municipality of Montcada i Reixac. 1,604,555 people live in this area, and separate collection takes place through separate street containers, one of which is for the organic fraction only.

Implementation of bio-waste collection in the Barcelona Metropolitan Area began in 2001 in districts housing 30% of the population. At this first stage, bi-compartmental containers were used, with sections for the organic fraction and mixed waste. Subsequently those containers were replaced by separate containers, which improved the results. Door-to-door collection of organic matter for businesses also started in 2001. In 2009 separate collection of the organic fraction became the norm, thanks to a Decree by the regional government - the Generalitat de Catalonia - stating that every municipality, even those of 5,000 inhabitants or less, must provide separate collection systems, including separate collection of the organic fraction. Initially, organic waste was collected daily. At present, collection takes place on alternate days. Containers have a narrow opening in order to discourage misuse and reduce the

presence of non-organic items. Those changes have brought a decline in costs. The AMB (Metropolitan Barcelona Area - acronym in Spanish) estimates that separate collection has increased by 57% in recent years.

According to the survey data, 116,443 tonnes of organic bio-waste were collected in 2015, which equates to 72.5 kg per inhabitant per year, or about 200g per day. Ecoparcs 1 and 2 are, respectively, 5 km and 1 km away from the city (this is the distance from the city to the waste plants, and does not include the distance covered between collection points inside the city). The cost of bio-waste collection in 2015 was €14,584,688; or € 9.1 per person or € 125 per tonne treated. Citizens contribute to the cost through their water bill, but the amount is not itemized in it.

Citizen's satisfaction with the quality of waste collection is **7.4 / 10**. There are plans for information and communication campaigns that may contribute to more participation and awareness.

The Ecoparcs facilities receive materials coming from two sources: businesses waste, in which 7.65% of materials are unsuitable, and **domestic collection**, in which the **unsuitable content amounts to 22%**, one of the highest in the study. This is largely due to people using ordinary non-compostable plastic bags to take the bio-waste to the container. Treatment in the Ecoparcs combines anaerobic digestion with composting, whereas in the installations of Torrelles de Llobregat and Sant Cugat treatment consists of composting only. According to the product definitions established in the Spanish waste Law 22/2011, we find that in 2015 the AMB produced 19,081 tonnes of compost in the facilities of Ecoparc 1, Ecoparc 2, Torrelles de Llobregat and Sant Cugat, and 116,900 tonnes of bio-stabilized material at Ecoparcs 1, 2 and 4.

The AMB has a specific plan to reduce its carbon footprint in which waste management is included. However, the survey did not provide specific information about this plan.

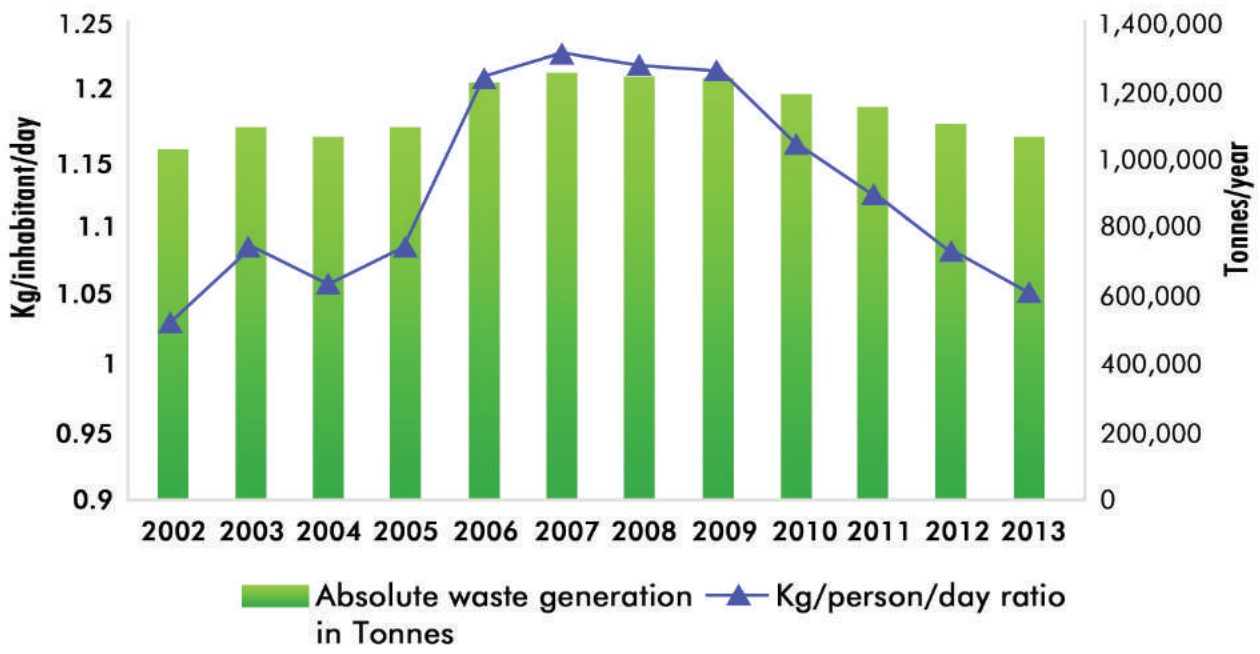
In 2015 19,000 tons of compost were generated

MANCOMUNIDADE OF BARBANZA (LA CORUÑA, GALICIA)

SEPARATE COLLECTION OF DRY AND WET WASTE AND INDUSTRIAL COMPOSTING

Our Galician case study serves a population of 86,218 inhabitants, in 9 different municipalities in the area of Barbanza where bio-waste collected amounts to 9,307 tonnes a year, which equates to 108 kg per person per year and 300 g a day. These figures include more than 20% unsuitable material. All citizens of the municipalities included in the scheme have access to separate bio-waste collection, and this scheme is also implemented in the Nostián area. Other municipalities operate the system of the Galician Environment Agency (SOGAMA) in which packaging waste, paper and glass are separated and the remainder is used for energy recovery. In the SOGAMA system there is no separate collection of the organic fraction. The Municipal Waste Management Plan 2010-2020 (PXRUG, acronym in Galician) which has been underway since 2011, calls for a reduction of 10% in waste generation by 2020 (baseline 2009) and the treatment of 100% of waste so that landfill, which amounted to 53% of waste in 2009, is reduced to 24% in 2020. There has been a decrease in waste generation in the area. This is a common trend in most of the areas studied and in Spain in general, which can be explained in part by the economic crises but also by an increase in environmentally friendly habits. (Figure 2)

In terms of net separate collection (separate collection minus unsuitable material) the SOGAMA system, with no separate collection of the organic fraction, recuperated 9,7% of



materials whereas Nostián and Barbanza (with separate collection for wet and dry materials) recuperated respectively 25.3% and 29.9% (Xunta de Galicia, 2014).

Municipal waste collection takes place in bi-compartmental street containers for wet (organic) and dry (inorganic) waste. Trucks have a compartment for organic waste in the back. People dispose of their domestic waste in ordinary plastic bags, which leads to a high content of unsuitable material. The distance covered by collection trucks daily is roughly 1,181 km, due to there being different circuits and the fact that the population is sparsely distributed.

According to the Xunta de Galicia (2014) the average bag contains 42% biodegradable organic materials, 18% paper and cardboard and 16% packaging waste.

The cost of bio-waste collection in the area is **€43.92 per person per year**, a figure that includes depreciation of equipment and VAT. Citizens pay a yearly municipal fee. The cost, estimated at €407 per tonne, is thought to be less than that of the SOGAMA system, which includes incineration and landfilling, whereas this scheme only involves composting. Separate collection started in 2003 and has been the norm since 2006. **Citizens consider that the quality of separate collection is sufficiently good, giving it a mark of 7.5/10**. Awareness-raising campaigns improved participation, but when they were discontinued in 2006 there was a decrease in the quality of the collected materials according to an analysis the bio-waste collected carried out by the Mancomunidade. There are plans to implement changes but these have not yet been specified, much less implemented.

This waste management system has created **150 new jobs in collection and treatment**.

The Mancomunidade is considering the possibility of applying fiscal incentives and/or disincentives, launching awareness-raising campaigns and encouraging home composting, in order to improve collection and citizen participation.

The Nostian facilities produce compost (14 tonnes) and biogas from anaerobic digestion (6,092 MWh). Barbanza produces compost

(298 tonnes) and biogas captured in the process (298 MWh). It should be taken into account that the Barbanza plant faced restrictions during this period that led to a decrease in recovery and an increase in landfilling. Both wet and dry waste go to the same treatment plant. There is a manual selection line to separate the dry elements, while the wet waste goes through a trommel screen. The biological process consists of composting with pile turning. Originally there was a system of composting tunnels that currently does not work. The production of compost totals 470 tonnes of B and C grade compost a year (RD 506/2013 classification, by heavy metal content), which is sold in bulk for a price ranging from €37 to 46 per tonne and is free of charge for the citizens of Mancomunidade.

The regional government plan for waste (PXRUG 2010-2020) indicates that there needs to be an increase in the separate collection of organic waste and its value recovery through composting. There is a plan to increase the composting capacity to 150,000 tonnes per year, with 14 active plants. This plan would need an investment of somewhere between €110 million and €120 million.

The Mancomunidade does not have a specific program for the control and reduction of its carbon footprint although, as pointed out in the survey, they are considering a system of co-generation. An appropriate biological treatment system would produce biogas that could be transformed into energy.

The system has created 150 new jobs in collection & treatment

HERNANI
(GIPUZKOA, BASQUE COUNTRY)

COMMUNITY COMPOSTING

The system in Hernani involves **community composting for 700 households**, and **home composting for another 700,** serving a total population of 19,700 people. Within the municipality there is a share of the population that does not participate in the scheme and uses the standard **door-to-door collection scheme.**

Separate collection started in 2012. The scheme launched with one community composting unit and **has expanded to 35 units** in order to provide a better service to the population.

30.8 tonnes are collected yearly, which equates to **30 kg per person per year (80 g per day)**, with a **percentage of unsuitable materials of under 2%**. This is to be expected since, in this case, the organic fraction is collected practically pure, and no bag is used, **since the users carry the organic waste to the composting container, with no transport cost or carbon footprint associated**. The cost is cheaper than the previous system (managed by a municipalities association), which was considered expensive. Citizens contribute with a y**early municipal fee of €90.3, with a 40% discount for those participating in community or home composting**. Citizens seem to approve of the system, although there has not been a specific survey on the subject.

The new collection and treatment system has directly created **15 jobs in collection, training and maintenance, and 2 jobs in the composting process.**

The system produces between 220 m3 and 240 m3 of quality compost yearly (A rated by RD506/2013-heavy metal content standards). Compost is distributed free of charge for citizens participating in the scheme and is used by the municipality in public parks and gardens.

There is no specific program to reduce the carbon footprint of Hernani, connected or not to the separate collection scheme.

LA RIOJA (LA RIOJA)

PILOT PROJECT OF COLLECTION IN CONTAINERS - WITH AND WITHOUT KEYS - AND INDUSTRIAL COMPOSTING

The case study in La Rioja is a pilot project carried out between 2011 and 2013. The scheme served a population of 17,178, distributed across 7 municipalities, of which only 50% were estimated to have participated. The experience began with public information meetings talks. The collection of bio-waste figures were: 244 tonnes in the first 6 months of 2011, 414 tonnes in 2012; and 355 tonnes in 2013. Considering the total population, that means, respectively, 28.4 Kg, 24.1 Kg and 20.6 Kg per person per year. But if we consider that only half of the population are estimated to have taken part, the amounts per person would double. Participants used ordinary plastic bags and in some cases no bag. The bio-waste was placed in containers with or without a key. The materials were then taken to facilities at the Ecoparque of La Rioja, 27 km away from the collection area. The unsuitable material content was as low as 2%.

The cost of the collection was estimated to be €215/tonne, which is more expensive than the comparative cost of treatment with no separation of bio-waste (€109 per tonne). The public body paid for the scheme, so the cost was not directly passed on to citizens, probably because it was a pilot program. The citizens accepted the scheme well and were satisfied with it, but it was only in place for two and a half years before being discontinued. Due to the temporary nature of the project, no jobs have been created. The cost factor appears to have discouraged the Government of La Rioja from taking the plan further.

The low occurrence of unsuitable material (2%) meant that **the compost was of high quality**. Despite the fact that it was made available for sale, it was eventually considered to have no commercial value, since it competed in agricultural use with other suitable organic materials available in the area.

The administration is currently working within the La Rioja Waste Plan 2012-2016, which contemplates the collection of organic matter but only for large producers. According to the

"Evaluation of the pilot experience of separate collection of the organic fraction of municipal waste in La Rioja 2011-2013", **the experience was very well accepted by users**. There was a very satisfactory response to the awareness-raising campaign (July and August) although, according to our survey, it is not known if the Government of La Rioja carried out a survey. Estimates indicate that if the organic fraction was to be collected separately it would amount to up 20 kg per inhabitant per year, 3500 tonnes a year from markets and supermarkets and another 500 tonnes a year from restaurants and canteens.

There is no specific plan in the area to reduce carbon footprint. Probably this is related to the scheme being discontinued.

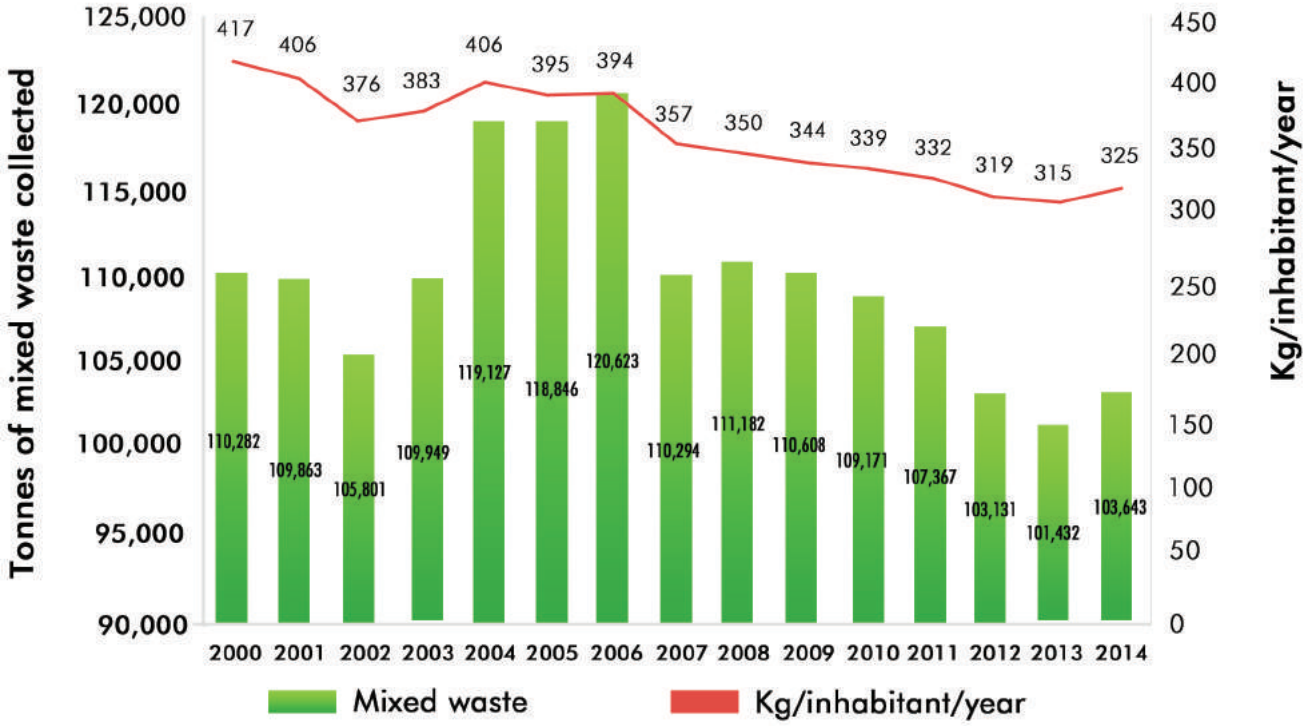


Figure 3: Evolution of waste gebneration in La Rioja (Source: La Rioja Regional Government, 2015)

PAMPLONA (NAVARRA)

COLLECTION IN LOCKED SEPARATE CONTAINERS AND TREATMENT THROUGH INDUSTRIAL BIO-METHANISATION

Collection in Pamplona uses containers, to which only registered users have a key. Of a total of 360,608 inhabitants, 333,559 (92.5%) are registered users.
In the first half of 2016, 4,296 tonnes of bio-waste were collected, which is **25.7 kg per person per year** or 71 g per day. This can be considered a low figure compared to other areas. One possible explanation is that there are people who register but do not actually participate. **The amount of unsuitable material is low: between 2 and 5%**, despite people using ordinary plastic bags, a factor that usually increases that level of unsuitable material. The MCP (Mancomunidad of municipalities in the Pamplona Area, acronym in Spanish), states in its 2016 report that 4,766 tonnes of bio-waste was collected through the implementation of the containers system in 2015, with a very low proportion of unsuitable material.

Separate collection of organic waste in the County of Pamplona was rolled out in phases. The first phase, launched in October 2013, served a population of 20,600. The second phase, in Autumn 2014, reached a population of 81,600, and a third phase, during 2015, covered 231,300 citizens, a figure that had increased to 333,560 by the end of the year. It is anticipated that during the second half of 2016 the entire district of Pamplona could be served. Despite the expanding scope of the separate collection scheme, during the first half of 2015 there was a slight decline in citizen participation, so there is a desire to have more information campaigns aimed at improving participation, especially in rural areas. Home visits are also being considered.

The collected bio-waste is taken 70 km away to be treated using anaerobic digestion. The cost of collection and transport amounts to €730,000 per year **(€2.2 per person and €170 per tonne)**, which is more expensive than the previous waste management system. There is room for improvement in the collection of mixed waste, reducing the frequency to lower the overall cost. In any case the cost of collection and treatment is paid for by the municipality and is not separately passed onto the citizens. User satisfaction with the collection scheme is 7.8 /10 according to a 2015 survey.

The collection system has created 6 jobs.

The Pamplona Area places a high importance in reducing its carbon footprint, has it certified and applies measures towards reducing it.

ESPORLES (MAJORCA, BALEARIC ISLANDS)

DOOR-TO-DOOR COLLECTION AND TREATMENT WITH INDUSTRIAL COMPOSTING

There is door-to-door collection in urban areas including the municipalities of Rotgetes, S'Esgleieta and Esporles, whereas in more remote areas such as Es Verger i Son Cabaspre there is no collection and users must take the waste to Green Points (municipal waste collection points). This area has 4,959 inhabitants, of whom 4,844 are covered by the separate collection scheme. In 2015, 385,540 kg of bio-waste were collected; that is **77.8 kg per inhabitant per year** or 213 g per day, with **1% of unsuitable material**. 72,360 kg of municipal gardening and pruning residues were collected in 2015, and are counted in the bio-waste figure. The total population with access to separate collection in 37 municipalities is 864,763 inhabitants. However, the survey data only covers the population of 3 municipalities.

Separate collection has been in place since 2009 and the population has adapted easily; a contributing factor is that this is, relatively speaking, not a key tourist area so the population does not fluctuate significantly. People use compostable bags which are distributed by the town council for free, and the waste is taken to the TIRME plant in the Son Reus industrial area in Palma de Majorca. Treatment consists of a combination of anaerobic digestion and composting. Trucks cover 16km between the towns and the plant. The total cost of collecting bio-waste is €116,700, which is **€303 per tonne or €255 per tonne including pruning waste**. The amount collected since the implementation of separate collection has fluctuated slightly, although a slight downward trend can be observed.

A 2014 report by the regional government (Environmental Survey of the Balearic Islands, 2014) names separate collection as an important factor to improve recycling, and emphasizes separate collection of organic matter and vegetable compostable waste.

The collection of organic matter increased by more than 800%

According to this report there has been an 854% increase in the collection of bio-waste between 2001 and 2007 followed by an 18% decrease in 2007-2011 (Chart 4), which could be attributed to the crisis. In 2011 the amount of bio-waste collected was more than in the beginning of the campaign (2000), but less than in previous years at 34,683 tonnes or 25.5 kg per person

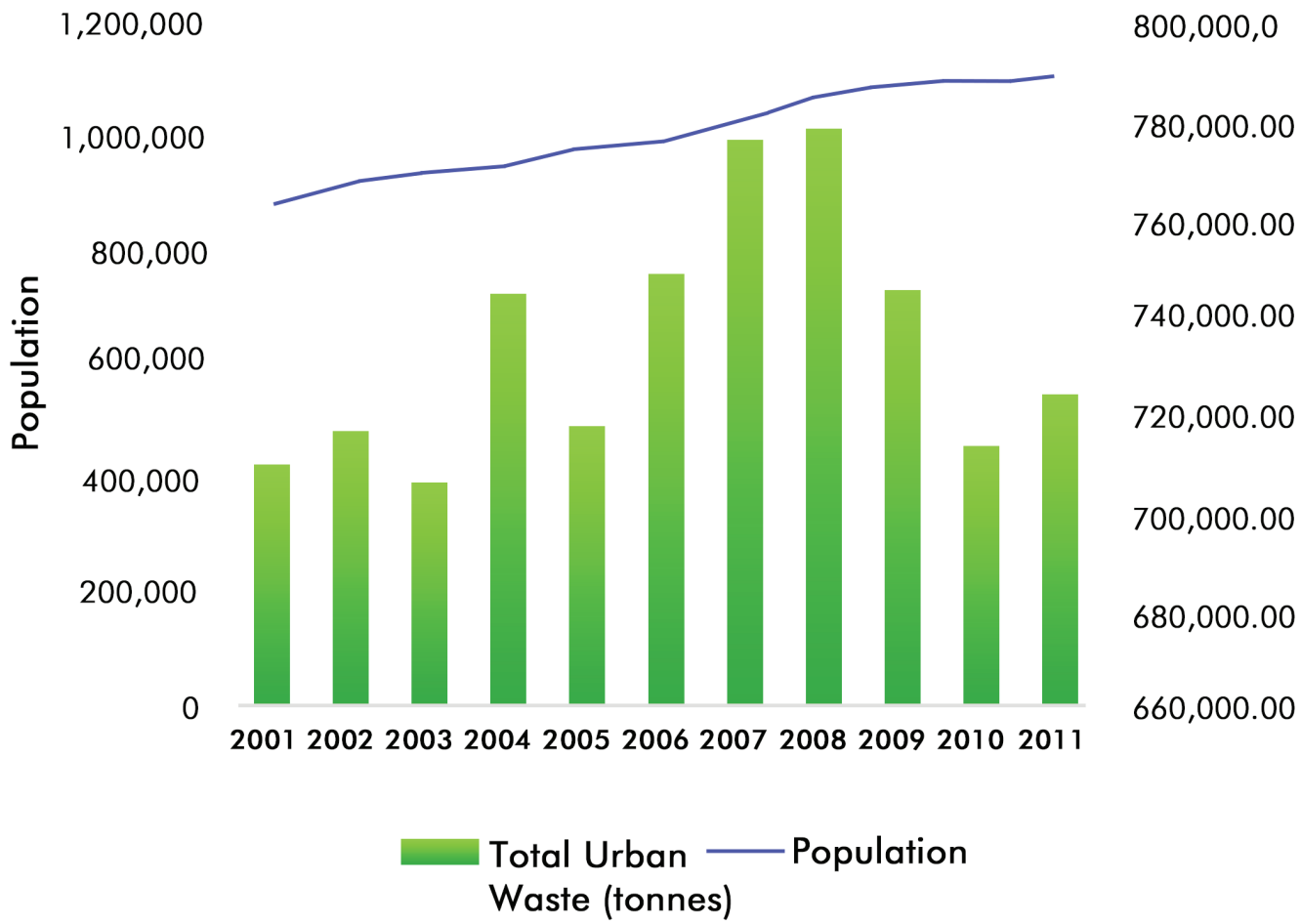


Chart 4: Evolution of municipal waste generation in the Balearic Islands

(Source: Govern del les Illes Balears - regional government, 2014)

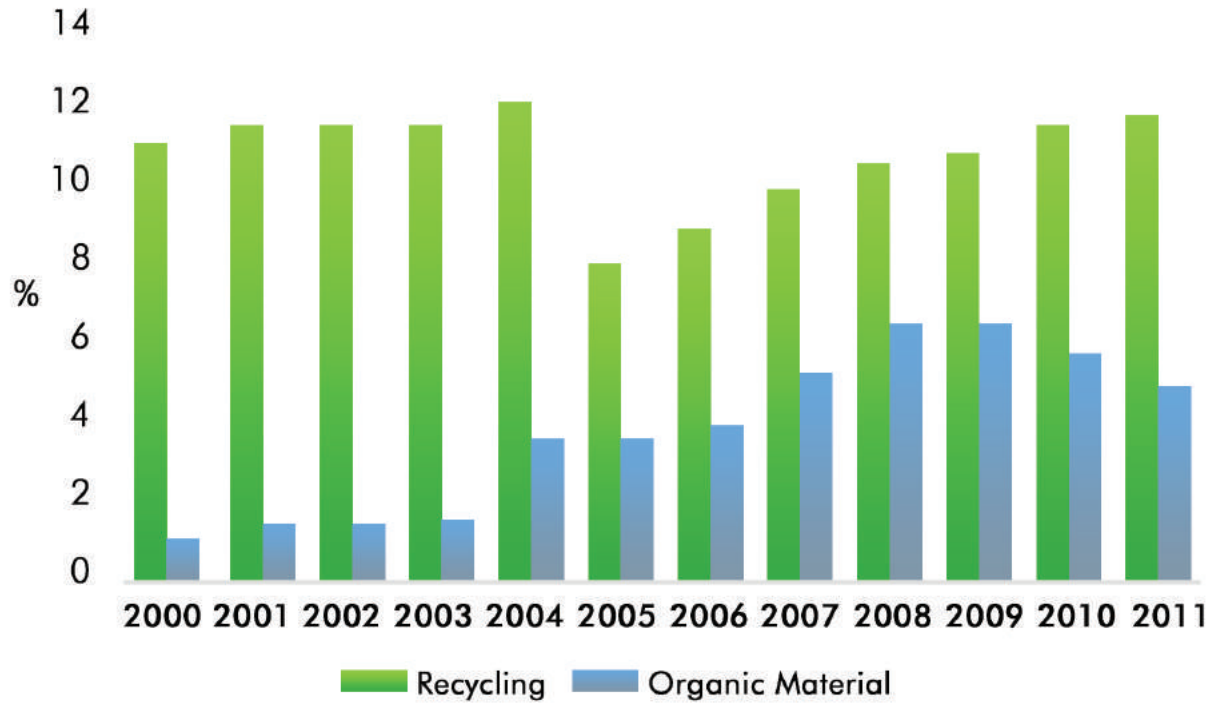


Chart 5: Evolution of separate collection in the Balearic Islands (Source: Govern de les Illes Balears - regional government, 2014)

Each Balearic Island uses different treatment options. In Menorca there is composting of the organic fraction of municipal waste and pruning waste, but in Ibiza and Formentera there are no facilities for biological treatment.

The switch to door-to-door collection has meant an increase in the cost of the service, which at presents runs a deficit. Revenues come from municipal fees, sales of bags to participants and sale of recycled plastics and paper. **The municipal fee is €90 per household per year, and €1 per bag**. The revenue from bags sales was less than initially estimated because citizens bought fewer than expected, since there is considerable "waste tourism" to areas where there are street containers. For commercial areas, bags cost €5, and for isolated areas the municipal fee is higher (€170) although if citizens use the municipal waste collection points they receive a 30% discount.

To improve the waste system for the organic fraction, the possibility of implementing **community composting** is being evaluated in several areas. A new plant is not an option due to space and financial constraints. There is also an idea to have a participatory process that proposes new solutions. Some citizens already engage in domestic composting but the local administration has no control over how it is done.

The information collected in the survey indicates that **33,773 tonnes of bio-waste were treated in 2015**, including both the organic fraction and pruning residues. That number is much higher than the collection figure because it includes other municipalities. The cost of treatment is fully subsidized. The treatment plant produces 11,694 tonnes of **Class B compost sold at the price set by the Consell Insular de Majorca (local authority): €3 per cubic meter.**

No specific work has been planned regarding the carbon footprint, beyond signing up for the Sustainable Energy Action Program (PAES).

DISCUSSION OF THE DATA ON WASTE GENERATION AND COLLECTION

The surveys reflect the different social factors at play in the different areas. **Firstly, there is a difference between purely urban areas and rural or mixed ones**. Waste is treated using very different systems: **home or community composting vs big industrial composting plants**, and influences costs and amounts collected.

Table 3 presents the data on the mass of bio-waste collected per person per year and summarizes some information about costs and amounts collected.
There is a marked variation in the quantity collected per person per year; **from 25Kg per person per year in La Rioja or Pamplona to 108Kg in the Barbanza Area**.

It should be noted that these bio-waste collection figures are well below the total amounts of municipal waste collected (Source: INE - Spanish National Statistics Bureau, 2013) as shown in Table 3 for the regions that the areas studied belong to, and in Chart 6 for all Spanish regions. **The Balearic Islands is the area with the highest generation of municipal waste per person, followed by the Canary Islands**. Both regions are, of course, tourist areas, where waste from tourism is attributed to the local population in per capita calculations. According to 2015 data from the (IBESTAT, Balearic Islands regional statistics office) the Human Pressure Indicator (IPH) for the islands experienced its highest ever increase (84%) in 2015 with 1,093,246 inhabitants on 4 January versus 2,010,520 on 10 August. In the other areas analyzed, tourism pressure is not so relevant. The one other case where one could look at of tourist pressure is that of Barcelona, but the increase of the population in the summer months is not so marked because it is partially offset by the fact that many residents leave their homes during the summer.

There are also differences in the type of collection, which is the other big topic of this study. **Majorca aside, it seems that in the municipalities with a more controlled collection system (Hernani, Pamplona and La Rioja) the quantities collected are smaller than in areas with free access containers (Barcelona and Barbanza)**. The amount of unsuitable (non-organic) material in the organic fraction is probably a factor here: **in those areas with a low unsuitable materials figure, collection per person is lower (except, as mentioned, in the case of Majorca).** The presence of unsuitable material is higher where there is free access to containers due to there being less control of the materials that are deposited. If the unsuitable material constituent is deducted from the yearly collection figure and only bio-waste was considered, we would be looking at **50 kg per person in Barcelona, 86 kg per person in Barbanza, 43 kg per person in Hernani, 24 kg per person in Pamplona and 76 kg per person in Majorca**. therefore, deducting the unsuitable materials the differences are not as big as would initially appear.

Less control of the collection system leads, undoubtedly, to a lower efficiency and reduced quality of the collected waste. To evaluate which of the two models is better, it is necessary to consider both technical and economic factors.

Some more general data for the case of Pamplona: in 2015, 1992 families generating 1,498 tons of waste used home composting, and 732 families generating 261 tons participated in community composting (MCP, 2016).

The Case of Majorca (door-to-door) is noteworthy because there is both a high bio-waste collection figure and a low percentage of unsuitable material.

Collection costs are also very different across schemes. Table 3 shows the figures of cost per collected per tonne, and per year per person. Except in Hernani, where cost is a flat rate of €90.3 per year, with a subsidy of 40% and does not have a collection cost, because citizens themselves take the bio-waste to the community composting point.

The collection costs per tonne are highest in Barbanza, followed by Majorca and La Rioja. Then comes Barcelona, and last Hernani and Pamplona, with the lowest figures.

The responses to questions about the economic impact of bio-waste separate collection tell us that in Barbanza and Hernani the scheme is clearly considered to be saving money compared to the previous system, whereas in the rest of the cases, except in Barcelona, the cost is higher, either because the system incorporates door-to-door collection or simply because waste is collected separately.

The collection cost per person is highest in Barbanza (€44 per person), followed by Majorca (€24 per person). In Barcelona, Pamplona and La Rioja the cost is less than €10 per person.

Looking at the marked differences in cost of collection of just these six case studies, we can see that there are multiple factors that affect this variable, from collection routes to public subsidies. **This wide range suggests that there is room to reduce the cost differences between areas.**

The data show that the percentage of unsuitable material is one of the factors that increases costs. In Barcelona and Barbanza, where it is more than 20%, collection cost is high because there is waste in the container that is not compostable, but is collected and occupies space in containers and trucks, only to be separated in the treatment plant. This means that the size and quantity of containers are higher than optimal, as is fuel consumption of the number of collection trucks.

Another factor which should be taken into account is the distance from collection points to treatment facilities and collection routes. The survey shows that in urban areas, like Barcelona, treatment plants are closer to collection points, whereas in Barbanza trucks have to cover a great distance to collect and transport the waste.

Area	Barcelona (AMB)	Barbanza	Hernani	La Rioja	Pamplona	Esporles
Type of collection	5 containers	Dry/Wet separation	Community compost scheme	5 locked containers	Pilot scheme	Door-to-door
Amount of bio-waste collected annually	72.5 kg/person	108 kg/person	30 kg/person	25.3 kg/person	25 kg/person	77 kg/person
Cost of collection	€9/person/year €125/t	€44/person/year €407/t	€90 yearly fee	€2.2/person/year €170/t	€8.9/person/year €215/t	€24/person/year €303-255/t
% of unsuitable material	7.65 % commercial 22 % domestic	> 20 %	< 2 %	2-5 %	2 %	1 %
Urban waste collected per person (INE, 2013)	Catalonia: 488 kg/person/year	Galicia: 393 kg/person/year	Basque Country:528 kg/person/year	Navarra: 437 kg/person/year	La Rioja: 410 kg/person/year	Balearic Islands: 727 kg/person/year
% bio-waste over total waste INE	14.9 %	27.5 %	8.3 %	5.9 %	6.1 %	10.6 %

Table 3: Collection Data

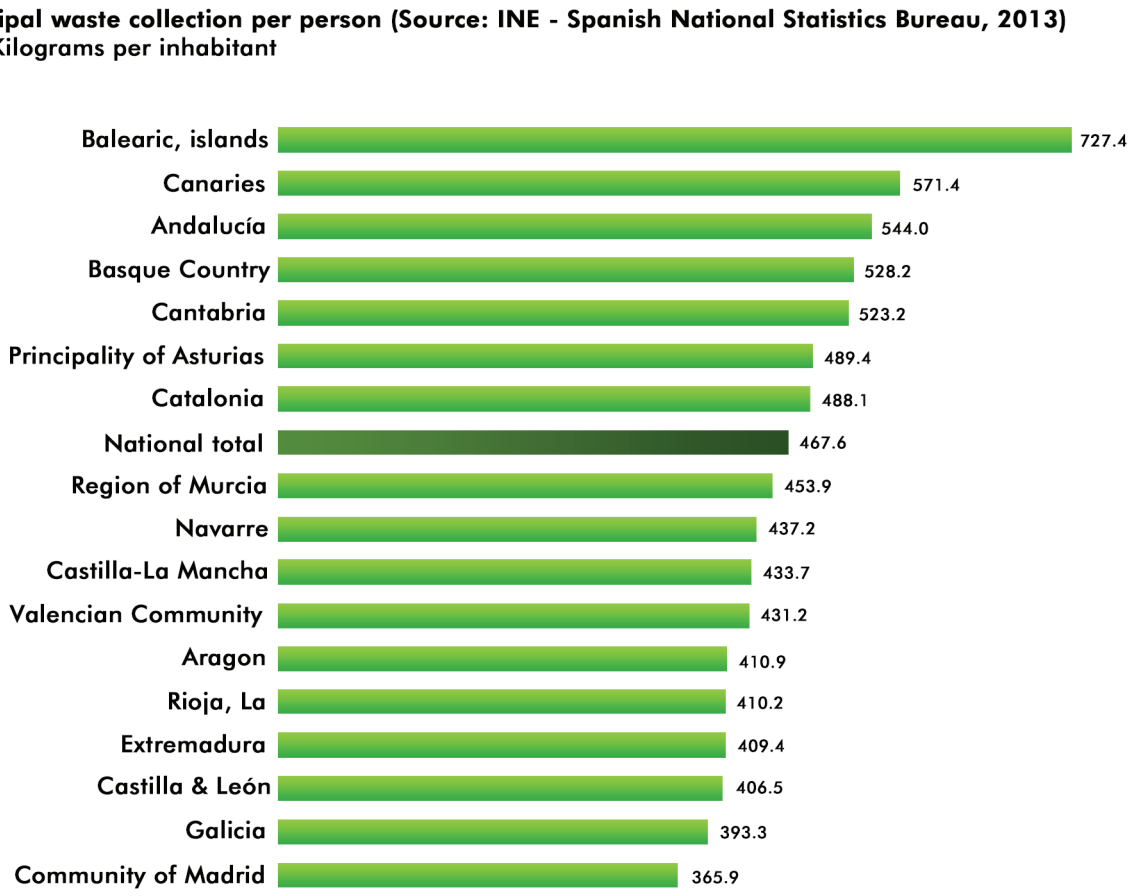


Chart 6: Municipal waste collection per person (Source: INE - Spanish National Statistics Bureau, 2013)

THE IMPORTANCE OF COLLECTION, COMPOST PRODUCTION AND NEEDS FOR ORGANIC MATTER

The quality of the compost is determined by two main factors: **the quality of the input material and the efficiency of the process** (composting only or a combined cycle that includes methanisation).

Briefly, let us bear in mind that the **objectives of composting include obtaining a stabilized and sanitized material, reduction of mass and volume, and obtaining a product with an acceptable quality that can be used as organic matter**. Whether some of these objectives can be achieved depends on the **quality of the initial product**, its unsuitable material and polluting agents content. Composting entails a reduction of mass, thereby increasing the concentration of pollutants; substances such as heavy metals that are not biodegradable. Above certain levels of these substances the use of the resulting compost may be limited by legislation. On the other hand, another fundamental aspect of the process is to achieve a **stabilized product**, which entails a reduction in the content of degradable organic matter and an increase in the proportion of resistant organic matter, making the material stable. The degree of stabilization that is possible depends on the process carried out, not on the initial material.

In summary, a good bio-waste, free of contaminants plus an adequate process, can generate quality compost. If the quality of the bio-waste is good but the process is not adequate, we would not get a stabilized product, but it would probably be free of pollutants. And if the quality of the bio-waste is poor the quality of the product will be compromised by the presence of pollutants, but there should be, at the very minimum, an adequate stabilization process with an acceptable reduction of degradable organic matter, even if the product is only to be disposed of.

The quality of the compost depends on the quality of the organic fraction, and the main factor affecting that quality is the **unsuitable material content**, because it **affects the composting process both at the chemical and physical level.** The efficacy of separate collection is therefore a key factor. According to the 22/2011 law on waste and contaminated soils, the term "compost", in the case of municipal waste, can only be applied to material originating from the separate collection of the organic fraction, and not from mixed collection. This is another reason to promote separation. **Improving the quality of separate collection must be a priority**, since it would provide a cleaner product, with less unsuitable material, more content in organic matter and nutrients and less pollutants (López et al., 2010; Huerta-Pujol et al., 2011). Table 3 shows the percentage of unsuitable material present in the schemes studied by the survey.

In Table 4 we find the results of the survey regarding treatment of bio-waste. It should be noted that much of the information required is unknown or not provided. It is difficult to ascertain data on treatment costs and product generation; sometimes the records are not clear enough, or do not provide relevant or comparable data. While we know that the cost of bio-waste treatment was 100% subsidized in the case of Esporles, the actual figure is unknown.

The unsuitable material content in the bio-waste is a key factor in the data collected about the treatment system. The presence of unsuitable materials influence both the quality of the product that results from processing (in terms of both physical and chemical properties) and the composting process, because they occupy space and limit the ability to maintain conditions needed for good composting such as air flow or porosity.

The data available on compost production is also limited and, in general, not very specific. The amount of compost is measured in different units; in Hernani the figure is provided in m3. We could infer, using a theoretical compost density of 0.55 tonnes by m3, that the mass equivalent would be 124-132 tonnes. At the Esporles plant, the very high figure is probably due to the fact that sewage sludge is also composted in the plant, and is likely to have been included the calculation.

Despite the paucity of information provided by the survey, what we do see is that the amounts produced vary greatly because of the difference in the facilities and the population served. There are also big differences in the sale price of the compost, ranging from free in the case of Hernani to €46 per tonne in Barbanza. Given the lack of information about the characteristics of the compost, it is difficult to make an adequate assessment of its quality, but it would be logical to assume that the compost obtained in Hernani, from a separate and highly pure collection, will have a higher quality than that of other areas where there are more unsuitable materials in the input.

The survey does not provide a description of the characteristics of the compost beyond, in some cases, its RD506 / 2013 classification. If the characteristics of the compost generated (especially in terms of organic matter content) and the quantities generated were known, we could approximate a description of the inputs and the level of organic material needed to obtain quality compost. Another point to consider on this issue is that although well-made compost is an ideal organic matter, it competes with other organic materials (sewage sludge from treatment plant, manures, etc.) Availability of such products, their price, the distance to the source that provides them and the amount of organic matter needed in the area would affect the price that compost can be sold for.
There may even be cases in which a land owner receives subsidies for applying a certain material instead of paying for it.

In any case, it is always important to have tools to evaluate the quality of the compost, which inevitably includes knowing its composition.

Area	Barcelona (AMB)	Barbanza	Hernani	La Rioja	Pamplona	Esporles
Type of collection	5 containers	Wet-dry	Community composting	5 containers with locks	Pilot program	Door to door
Type of treatment	Methanisation & composting	Composting with turned piles`	Community composting	Methanisation & composting	Composting	Methanisation & composting
Treatment cost						Subsidised 100 %
Compost production		470 t/yr	220-240 m^3/yr			11,694 tonnes
Compost quality (RD506/2013)		Classes B & C	Class A			Class B
Market		Venta a granel. €37-46/t	Free		Sold	Bulk sale €3/m^3

Table 4: Treatment

OUTREACH AND INFORMATION PROVIDED TO CITIZENS, PARTICIPATION AND RESPONSE

Citizens' participation has been proven to be key in the success of separate collection, as it contributes to a better quality of collected waste (less unsuitable content) and system efficiency. To achieve it, there needs to be good planning, and appropriate awareness-raising actions that include not only providing information and training, but also promoting participation.

There has been extensive work in campaigns for home composting, but more work may be needed on general issues, where the entire population is included regardless of whether they have the capacity to engage in home or community composting. It should also be noted that in urban areas there is generally little green space available and people live in apartment buildings, whereas in rural areas the situation is very different, so the implementation of certain systems may be easier in the latter.

Answers to the survey indicate that in general the population is satisfied with the collection system implemented in their area. In the case of Barcelona, Barbanza and Pamplona, the municipalities have conducted surveys on the issue, whereas in the other areas there is no evidence that municipalities have obtained specific information from the citizens.

However, the fact that the population is satisfied with the implementation of separate collection of bio-waste does not necessarily indicate that they actively participate in the schemes. In Barcelona or Barbanza there are containers for the organic fraction but also there are others for collection of mixed waste. The high presence of unsuitable content in these two schemes clearly indicates that other residues are deposited in the organic fraction container. In the case of Barbanza, unsuitable content increased markedly once the awareness campaign was discontinued.

In general, the surveys also reflect the importance of awareness-raising campaigns and of the promotion of citizens' involvement in the scheme. In some cases, as in Barbanza, the idea of implementing economic incentives or disincentives in order to improve the collection process is being considered.

All that considered, it would be useful to formulate more specific surveys that detail both the level of satisfaction and of participation. It would also be necessary to work on efficient ways to motivate citizens, designing awareness raising activities at different levels.

Citizens' participation is greatly influenced by awareness-raising campaigns, and there is variation as to how these are implemented from one area to another. In the case of the AMB (Barcelona), several campaigns have addressed different aspects of waste management. On the bio-waste issue, there is a network[1] of domestic composting with a blog and a Facebook page, where users can share ideas. In Catalonia a significant number of campaigns have been carried out by the local administrations and by the Agència de Residus de Catalunya (regional waste authority) aimed at raising awareness and implementing actions such as domestic composting and the promotion of separate collection.

In the case of Galicia, a variety of information on awareness-raising activities aimed at improving the management of resources and other environmental issues can be found on the

1 (http://www.amb.cat/es/web/medi-ambient/residus/prevencio/activitats-i-campanyes)

SOGAMA website.[1]

On the web page of La Rioja Government you can find a section for campaigns carried out during the pilot composting project, including the information and outreach materials used.[2]

1 (http://www.sogama.es/es/info/campanas-programas-y-cursos)

2 (http://www.larioja.org/medio-ambiente/es/residuos/residuos-urbanos/contenido-residuos-urbanos/campana-piloto-recogida-selectiva-residuos-organicos)

CARBON FOOTPRINT

Carbon footprint measures the total greenhouse gas (GHGs) emissions associated with a given activity (the lifecycle emissions of a product, service or organization) expressed as equivalent CO_2 units (CO_2eq) released into the atmosphere. In the inventories presented by the various signatory countries to the Secretariat of the United Nations Framework Convention on Climate Change, information is given on the level of the following GHGs (gases that have a direct effect on global warming): carbon dioxide, methane, nitrous oxide, perfluorocarbons, hydrofluorocarbons, sulfur hexafluoride and nitrogen trifluoride.

The European Union has proposed reductions in GHG emissions across all sectors of the economy. In 2014, EU member states agreed to reduce GHG emissions to 40% of their 1990 level by 2030, and the planned program for the period 2021-2030 aims to focus - as general objectives within the EU - on transport, buildings, agriculture, waste, land use and forestry.

Spain recognizes the following sectors as having an impact on GHGs emissions: energy, combustion in manufacturing and construction, transportation, combustion in other sectors, industrial processes, use of solvents and other products, agriculture, land use and forestry, and **treatment and disposal of waste**.

Municipal waste management is clearly an activity that generates GHG emissions, both via transport and in the treatment process itself. The scale of emissions depends on waste generation levels and management. It should be pointed out that waste management both generates and eliminates GHG emissions, so in order to assess the carbon footprint associated with waste treatment, we must look at:

// Direct impacts: emissions from treatment facilities

// Indirect impacts: emissions outside of treatment facilities but associated to the operation (electricity generation, manufacturing of reactive agents, water…)

// Avoided impacts: emissions that are prevented by the recuperation of materials and energy, which can substitute other energy sources or raw materials in different sectors of the economy.

Records of GHG emissions in the waste sector in Spain show a clear increase in the period 1990 - 2011 (Table 5) associated with an increase in waste generation and landfilling. In contrast, the forecast for the coming years promises a decline linked to new regulations, such as Law 22/2011 on waste and contaminated soil, which, among other considerations, aims at reducing greenhouse gas emissions.

Evolution 1990 - 2011

	1990	1995	2000	2005	2007	2008	2009	2010	2011
WASTE (Gg CO_2-eq)	7,323	8,934	10,763	11,721	12,588	13,121	13,478	13,776	13,901

Projection 2013 - 2020

	2013	2014	2015	2016	2017	2018	2019	2020
WASTE (Gg CO_2-eq)	14,199	14,100	13,916	13,699	13,483	13,279	13,091	12,912

Table 5: GHG emissions in the waste sector. Evolution 1990 - 2011 and projection (Source: MAGRAMA Agriculture Food and Environment Ministry, 2014b).

To achieve this reduction, the Ministry of Agriculture, Food and Environment (MAGRAMA, acronym in Spanish) has proposed seven measures, one focusing on reducing waste generation, and the rest on reducing landfill. The proposed actions include several proposals on selective collection and bio-waste treatment systems. If all bio-waste and other vegetable waste were to be treated, be it community composting or bio-methanisation plants, instead of going to landfill, there would be a **100% reduction** compared to the baseline data. In all cases, changes in how collection is carried out, including collection frequency, would be an important factor. In the case of methanisation, we should take into account that waste would be used to obtain renewable energy rather than compost.

Table 6 presents results of carbon footprint associated with municipal waste treatment in Catalonia, detailing impacts at different levels. The footprint associated with separate collection is much smaller than that of other treatment options like energy recovery (ER) or landfill (CD). This is due to the added differences in footprint from avoided, direct and indirect impacts. However, the figure for separate collection is lower than the previous year, which can be attributed to a decrease in collection, particularly in cardboard and paper.

Waste stream	Direct impact	Indirect impact	Avoided impact	Total carbon footprint
Separate collection	48,607	9,492	-434,214	-376,115 (+68.375)
MW+IFMW to MBT	53,978	31,440	-191,241	-105,822 (-71,096)
Energy recovery	242,296	13,360	-116,957	138,698 (-50,177)
Waste to CD	1,137,280	11,360	-26,755	1,121,885 (-52,224)
TOTAL	1,482,162 (-99,556)	65,652 (+10,432)	-769,167 (-15,998)	778,647 (-105,122)

Table 6: Carbon footprint of municipal waste treatement in Catalonia in 2012 $C0_2$ - eq. (Source: Farreny and Martínez, 2013). Between brackets, variation between 2011 and 2012.

Figure 7 shows that direct GHG emissions from waste management in Europe have increased slightly since 1990 but the tendency is towards less growth, as can be expected since the rate of recycling has increased. Avoided impacts have increased notably, especially those associated with recycling, although is worth mentioning that there has been a modest decline in incineration. Overall, controlled landfill disposal is the main cause of direct GHG emissions and recycling is primarily responsible for its decline.

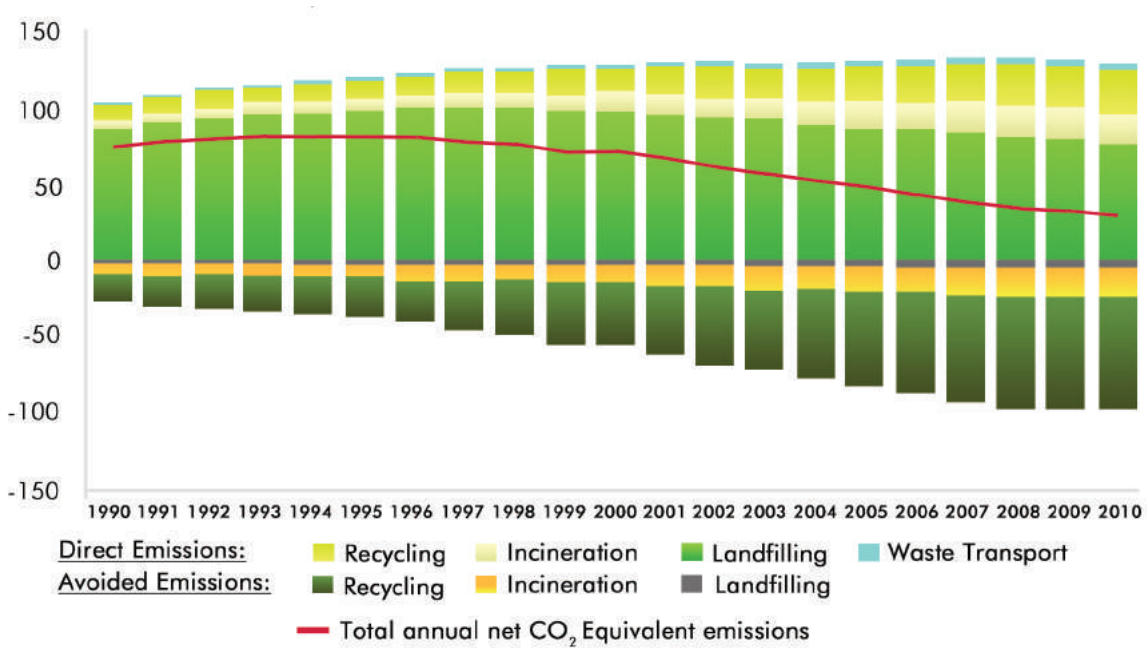


Chart 7: GHG emissions from municipal waste management in EU, Switzerland and Norway (Source: European Environment Agency, 2013)

Friends of the Earth Spain (2013) has produced reports into the carbon footprint of waste management. Table 7 summarizes the information of the carbon footprint of different types of waste management, looking at the impact from transportation/fossil fuels and consumption of electricity and water. As we can see the carbon footprint from **the consumption of electricity for incineration is the highest.** The impact of transport depends on factors such as proximity, the type of truck (capacity and fuel consumption) and the quantity of waste to be transported. In all cases the footprint regarding water consumption is much lower than of that of transport and electricity. If we look at the the total values of CO2 generation per kg of organic waste (not total waste), the Son Reus incineration plant in Majorca is clearly the one with a highest footprint.

MAGRAMA uses **emission figures of 70 kg of GHGs per tonne of waste in landfill and 330 kg GHGs per tonne of incinerated waste and landfill** as reference values in its methodology for Climate Projects (Office of Climate Change). The latter figure is close to the one found in the Friends of the Earth Spain study of the Son Reus incineration case. However in the case of landfills the figure is not similar.

	Transport	Electricity	Water	Total (CO_2 per kg bio-waste)
Incineration (Environmental complex of Cerceda La Coruña)	9.8	41.4	0.75	99.4
Areosa Landfill (Environmental complex of Cerceda La Coruña)	9.8	12.0	0.00923	28.7
Nostián Composting plant (A Coruña)	8.7	22.7	0.014	22.7
Ca Na Putxa Landfill (Ibiza)	1.3	1.4	-	10.7
Son Reus Incineration (Majorca)	1.3	71.3	0.248	235
Methanisation Plant Son Reus (Majorca)	1.1	67.8	0.953	69.8
Son Reus Composting Plant (Majorca)	1.6	49.3	0.053	51.1

Table 7: Carbon Footprint of different facilities. Transport and resource consumption (FoE Spain, 2013). If not otherwise indicated, data are in *kg CO_2 per tonne of waste treated.*

The information obtained from the carbon footprint section of the Friends of the Earth survey is limited to whether there are plans related to the carbon footprint, and whether these include waste management. Additional information available online and other technical documents have been used to complement the survey information. According to the surveys, **only the Metropolitan Area of Barcelona (AMB) and the Region of Pamplona have existing plans for assessing and reducing the carbon footprint that specifically refer to waste**. In the other schemes studied, the surveys indicate no such plans.

The following section discusses the information obtained from public sources, mainly the web pages of the relevant bodies, in reference to the Barcelona Metropolitan Area and Pamplona.

BARCELONA METROPOLITAN AREA

The AMB (Barcelona Metropolitan Area, acronym in Catalan) specifically talks about its carbon footprint and "the emissions of all the facilities and services it manages" on its website[1]; therefore emissions both from waste treatment facilities and from collection systems are included. The AMB has been accredited under the UNE-ISO 14064-1 Certification Standard for the period 2011-2013, which scrutinizes processes to measure and reduce the entity's carbon footprint. The four Ecoparcs, as well as the Besòs energy recovery plant, the TMB (public transport system), sewage treatment plants and many other companies and municipal services have had their emissions audited for the certification process.

The AMB report on its carbon footprint (AMB, 2016) states that its total emissions, including direct and indirect emissions, were 1,095,517.35 tonnes CO2eq for 2011, 1,045,677.74 for 2012 and 1,069,004.01 for 2013. Emissions from waste management for the same periods were 817,506.32 tonnes of CO2eq for 2011, 762,808.45 for 2012 and 779,650.63 for 2013.

The AMB has committed to reduce emissions by 10% (compared to 2011 levels) by 2015. The data for 2014 and 2015 are not yet available, but with the implementation of new measures it is expected that CO2 emissions will decrease.

Other sources consulted (Farreny and Martínez, 2013) indicate that the AMB's carbon footprint for municipal waste management for 2012 was 274,287 tonnes of CO2-eq, which equates to 85 kg CO2-eq per person. The AMB figures include all types of waste management facilities, from transfer stations to composting plants.

1 (http://www.amb.cat/es/web/medi-ambient/sostenibilitat/canvi-climatic/petjada-del-carboni).

MANCOMUNIDAD OF THE COUNTY OF PAMPLONA

The GHGs emissions figures for the MCP (Mancomunidad of the county of Pamplona – Spanish acronym) have been certified by AENOR – the main Spanish certification agency - and comply with the UNE-EN ISO 14064-1-2012 standard. Certification aside, the MCP has been monitoring their carbon footprint since 2013 (MCP, 2016) and registering their data in the MAGRAMA voluntary national carbon footprint register (RD163 / 2014) since 2015.

The GHG emissions associated with waste management were 39,109.10 t CO2e per year for 2013; 42,493.8 for 2014; and 36,541.4 for 2015. The reduction in 2015 is noted as a very positive development. According to the MCP, its total emissions for 2015 (all sources) was 57,588 t CO2 per year. Of that figure, disposal of bio-waste in the Gongora landfill accounts for 31,469 tonnes of CO2 per year, diesel for urban public transport (buses) adds 14,035 tonnes of CO2 per year, and fuel for waste collection trucks another 3,317 tonnes CO2 per year. To reduce the figure related to bio-waste, separate collection of organic matter is being encouraged.

To reduce the carbon footprint, the MCP is considering measures like community composting, improving separation of organic matter via containers and the addition of hybrid buses to the municipal public transport fleet. With community and home composting, 657 tonnes of the organic fraction and 1,103 tonnes of vegetable waste could be removed from the collection routes and 409,10 tonnes of CO2 emissions per year could be avoided. Separation of organic matter in its container would allow an estimated further reduction of 4,621 tonnes of waste, which would reduce emissions by 2,746 tons of CO2 per year.

The separation of organic matter in a fifth container would reduce emissions by 2,746 tons of CO2 per year

THE SITUATION IN THE REST OF THE AREAS

No specific actions or plans to reduce the carbon footprint associated with municipal waste management have been found.

In Galicia, there are 10 strategic lines but none of them are specifically aimed at reducing the carbon footprint. However, the Waste Management Plan of Galicia (Xunta de Galicia, 2014) does include certain measures towards reducing GHG emissions by decreasing the amount of bio-waste that ends up in landfills. There are no GHG emissions figures available, although these are expected to be used as monitoring indicators in future.

In the case of Hernani or in the Comprehensive Waste Management Plan of Gipuzkoa 2017-2030 (Diputación Foral de Guipuzcoa, provincial body, 2016) there are no specific measures to reduce the carbon footprint. The regional plan does mention that emissions should be reduced, but there are no references to data or expected reduction values.

The La Rioja Waste Plan (La Rioja Government, 2015) states that reducing greenhouse gases to comply with regulations is desirable, but does not specify measures to that effect either in general or for emissions generated by municipal waste management.

In the Balearic Islands, other than the data in the study carried out by Friends of the Earth Spain in 2013, the available information (Government of the Balearic Islands, 2014) only mentions that disposal in landfill and incineration of waste generate GHG emissions. Figures are not given.

//EXTRAPOLATION OF DATA AND TOOLS FOR DECISION MAKING

The information the survey gives us about the areas studied describes very different scenarios on various levels, such as the type of area, population, collection systems and bio-waste treatment used. This diversity serves as an illustration of the variety of options available, but also means the observations may not be easily comparable and it is difficult to see common trends.

It is difficult to draw comparisons between the metropolitan area of Barcelona, where people mostly live in apartment buildings, and Galicia, where typically there is a far lower population density.

As for the collection methods, the type used is not directly linked to the cost. For example, in the case of the Barbanza area, where bio-waste is collected in a street container, the cost is higher than in the door-to-door collection scheme of Esporles. In 2008, the association of Catalan municipalities that used door-to-door separate collection published a study (Coll et al., 2008) analyzing the different ways that door-to-door collection can be implemented as well as the economic factors behind this. The study concludes that, from an economic point of view, the cost of a door-to-door collection system, once the costs of collection and treatment and the revenues it generates have been taken into account, should not be higher than that of separate collection with containers. It may even be cheaper. The type of municipality is a relevant factor. Door-to-door collection is probably the most appropriate method in areas with a low population density, where small trucks can collect at each house. This type of collection may be more complicated in densely populated urban areas with apartment buildings, but in such areas measures to ensure the active and conscientious participation of citizens are needed, or separation will not be done properly.

There is no doubt that selective door-to-door collection helps with control and with lowering the presence of unsuitable material, resulting is a better quality of bio-waste. This, in turn, determines what can be done with the compost since, as discussed in previous sections, the unsuitable materials hinder biological processes, generates rejections in treatment plants and must be managed properly, which increases the costs.

In some of the municipalities studied, the local administration manages the collection and treatment, and no expense is directly passed

on to the citizens. This is welcome, but systems should also have a way to ensure that the population continues to participate actively, and knows the cost of the system, so that it can be successful.

Related to that, another important observation is that systems must have mechanisms that sustain them over time. For example, in the case of La Rioja, the experience was limited to a pilot program that lasted only 3 years, whereas the other schemes studied are ongoing. Any scheme should incorporate control and monitoring tools and action plans that can address deviations from the initial plan; i.e. having measures ready to be applied if, for example, the percentage of unsuitable material should be higher than anticipated. Such action plans could be a transferable tool – with adaptations to the particularities of each area and scheme.

The studies consulted on the environmental impacts generated by waste management seem to indicate that domestic or community composting, in which transportation and energy consumption are non-existent, help reduce the carbon footprint. It cannot be expected that all bio-waste is processed in this way, because such schemes need a great deal of space. However, the convenience of having small facilities closer to the places where waste is generated – reducing the energy used in transportation - could be examined.

//GENERAL OBSERVATIONS AND CONCLUSIONS

The information gathered by the study has allowed us to evaluate various aspects of bio-waste management in different types of communities. Collection has been the issue surveyed in more detail.

Because of the different characteristics of the areas studied, the data is quite dispersed, so **comparisons cannot be very exhaustive** and it is difficult to reach general conclusions. However, **the data does allow us to highlight the nuances in how different schemes work**. With a view to future research, it would be useful to improve the content of the survey to enhance the quality of the information provided using this study as a baseline to start from.

The main objective of the survey was to obtain information on the quality of the collection, but it would also be useful to examine users' perceptions, and the motivations for their participation (or lack of participation) in the scheme.

We know that the best waste is that which is not produced, so initiatives aimed at reducing waste generation in any sector are important. The present study is on bio-waste and in this sector consumer habits, especially related to food waste, leave more room for improvement. However besides reduction, it is necessary to have adequate ways to manage waste.

Waste contains about 40% of organic matter, which often goes into the mixed waste fraction. The characteristics of this type of waste, and the fact that it is very difficult to recover it mechanically at the treatment plant, compromises the quality of the product and the biological process. To improve participation in separate collection, it would be necessary to **estimate the capacity of current facilities and need for future ones, preferably well distributed, small-scale facilities, for a lower transportation impact.**

Systems that use biodegradable bags, or no bags, present better results due to a lower unsuitable material content. Given that there is a legislative framework on waste at EU, national, regional and local levels, there could be a bigger effort in promoting the participation in separate collection and exploring multiple ways to go beyond models where citizens participate voluntarily (or not), in the schemes and towards schemes where a more active role is the norm.

The results of the survey show that **awareness-raising campaigns have a positive impact**, but maintaining citizens' participation up seems to be an unresolved challenge. In the absence of campaigns, the quality of bio-waste collection declines. There should also be work on understanding why sometimes campaigns do not have the desired effects. In some areas, despite many campaigns, the bio-waste quality is still not good enough and the content in unsuitable material is high. **To have appropriate actions to encourage citizens' participation, the reasons behind this should be understood and communicated.**

The amount of bio-waste per person in areas with home or community composting is lower than in areas with collection. This is partly because there is no unsuitable material in the organic fraction being counted as collected bio-waste; **in areas with community composting schemes, the organic matter is quite pure. When analyzing collection data, we should keep in mind that in some cases the amount of bio-waste collected includes a significant portion that is not bio-waste.**

With regard to compost production, it is difficult to obtain comparable data. In most cases, there is no quantification of compost production or information on where it goes or how much it costs to produce. There is also little information on the production system, although it should be

noted that this was not the focus of the survey. Even so, it would be useful to gain information on costs and yields, and the process conditions (with or without vegetable material, duration, problems, etc.) in the industrial, home and community scale.

It would also be advisable to know the quality of the compost - RD506 / 2013 standards - since that is closely linked to the quality of the waste used as an input, and is therefore an indicator of how effectively the separate collection is working.

As a final summary, Figure 9 presents a model of how participation can be influenced by its own positive or negative feedbacks, based on the information collected. The aim is to evaluate the possible paths to better participation. In areas where participation and awareness is high, the material collected will have a good quality and so will the product obtained; users will see how it is used and the positive value of their actions. If, on the contrary, citizens are not aware of the issues or have not received good information, they will not separate and recycle well, so that will have a negative impact both in the collection and in the biological process.
A strict control of collection could backfire and result in waste tourism, which would ultimately have a negative impact on the carbon footprint.

In the end, a low-quality product is likely to lead to the user not valuing the scheme and justifying his or her decision not to participate.

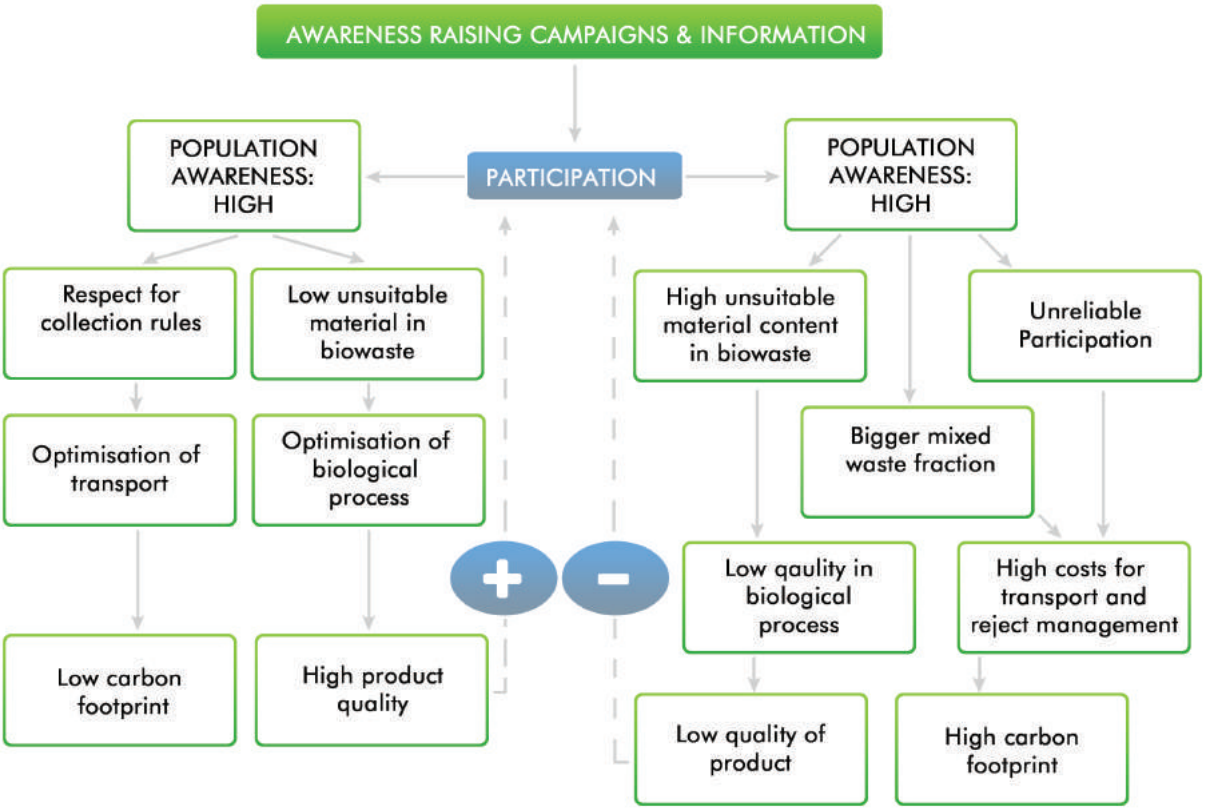


Figure 9: Possible effects and consequences for participation in waste management

It has been shown that community and door-to-door composting models, which involve greater citizen participation, result in the least unsuitable material content and a lower economic cost.

//PROPOSALS

After having discussed the data and conclusions, in this section we will propose some ideas for further research and recommendations on how to improve the quality of separate collection and encourage citizens' participation.

1- Ensure that **information and awareness-raising campaigns** reach all people. Identify the causes of low participation and establish relevant actions to address them.

2- Develop a **monitoring and control system** including surveys and indicators that would help identify deviations from expected results, and **action plans that help correct any deviations** within a short period of time, so that the scheme produces visible results in the short term.

3- Promote systems of **direct compensation to citizens** - reductions in certain fees for reaching targets in recycling of bio-waste, or collective compensation systems (like improvement on facilities or equipment) if targets are achieved.

4- Promote waste management policy as an issue that will not be politically owned, with **long-term measures** that transcend changes in legislatures.

5- Promote actions towards **compulsory, not voluntary**, participation in separate collection.

6- **Gather success stories, both domestic and foreign, and try to adapt the model that best fits each specific geographical entity.**

7- **Try to avoid a coexistence between separate and non-separate collection, since the costs double and the results are worse.**

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sirga.xunta.gal/barbanza

Friends of the Earth Spain (Amigos de la Tierra): is an ecological assiciation with the mission of promoting local and global change towards a society respectful of the environment, just and united.

Zero Waste Europe: Is creating a movement aiming at eliminating waste in our society. They empower communities and change agents from around Europe to redesign their relationship with resources, to adapt their lifestyle, their consumption patterns, and to think circular.

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