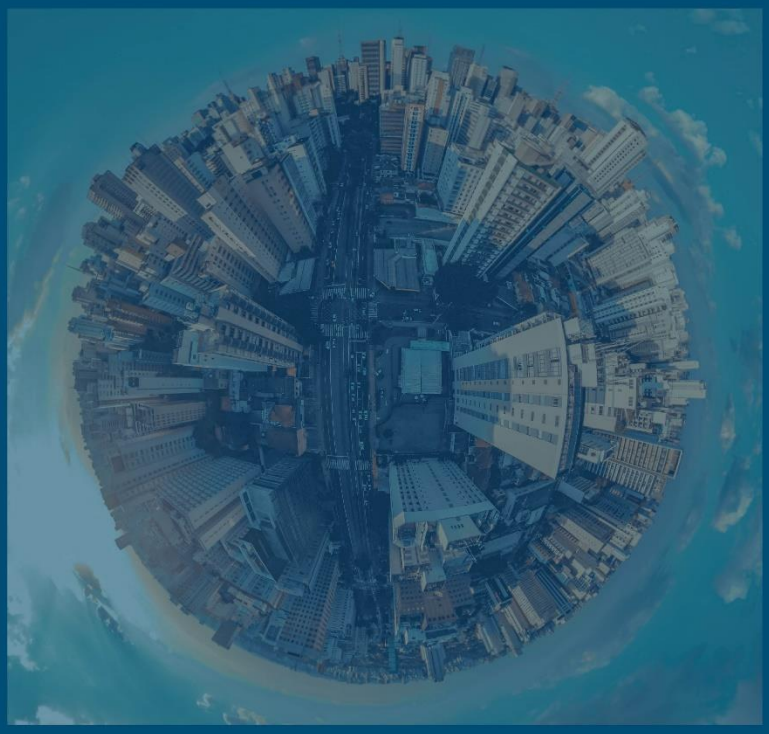
# Diagnosis and characterisation of OMSW report.

# SEVILLA

**LIMPIEZA PÚBLICA Y PROTECCIÓN AMBIENTAL S.A.M.**



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| Abstract | The realization of a diagnosis of the current situation of the flow of organic matter (biowaste + organic matter collected still mixed with the rest fraction), responds to the need to establish a starting point to plan and apply a strategy that allows to achieve the European targets for recuperation, recycling and landfilling. This report presents a diagnosis of the quantity, quality, flows, legal aspects, and current plant treatment of OMSW |
| Keywords | Diagnosis; Biowaste; Seville |
| License |    |

# Contents

# 1. Background

For some time now, our societies have been paying increasing attention to the objective of achieving an improvement in the management of biowaste. This increased attention has been more recently enhanced by the new ideas of the so-called Circular Economy and by the objectives established in the Management Plans for such waste at the European Community level and at the state level.

The separate management of biowaste is considered, by many experts, as the fundamental axis of a correct waste management system in cities, since, by weight, they represent one of the fractions of waste generated.

A large part of this waste stream is still collected, and consequently, it is treated, together with the rest fraction, achieving low recovery rates in current treatment plants, and, therefore, ending up in landfills, which is an impact environmentally important, in terms of land use, leachate created and due to its decomposition potential, the consequent generation of methane and greenhouse effect emissions into the atmosphere.

On the other hand, the presence of biowaste as unsolicited material in the rest of the fractions collected separately, supposes losses of effectiveness and efficiency in terms of the classification and separation of said fractions. The improvement in the management of this fraction is key to achieve:

- Increase the percentage of material recovered from this fraction.
- Comply with the European targets for recovery and recycling of municipal waste (at least 55% in 2025), and disposal in landfill (less than 10% in 2030) established in directives 2018/851 and 2018/850, respectively.
- Comply with the objective established by the 2018/851 directive, of obligatorily implementing the separate collection of biowaste, no later than December 31, 2023.
- Improve the recovery ratios of the rest of the fractions collected selectively, to the detriment of the rest fraction.
- Reduce the carbon footprint of activities related to biowaste management.

The logistics of collecting the biowaste fraction, as well as its subsequent treatment, must be adapted to the reality of each city, so the first step, for a viable and optimal implementation, is to start with a diagnosis that analyzes factors, such as quantity and composition of this fraction, main generators, potential treatments, evaluation of the possibility of introducing new organizational and fiscal instruments, etc., which will determine the design and success of the management scheme for which it is committed.

# 2. Purpose of the document.

The realization of a diagnosis of the current situation of the flow of organic municipal solid waste (OMSW) in the city of Seville responds to the need to establish a starting point to plan and apply a strategy that allows to achieve the European objectives of recovery, recycling and disposal in landfills, in an optimal way.

Upon completion of this diagnosis, it is expected to have a greater knowledge and understanding of:

- Flows of organic municipal solid waste in the city (quantity, composition and generators), their contextualization, with respect to other municipal waste streams, and their future evolution.
- Existing systems for waste collection and main recycling, recovery and disposal facilities.
- Policies and regulations that regulate the management of this waste fraction, as well as trends to take into account, in the future and the state of compliance with said regulations.
- Economic and environmental impact of the management of this fraction in the city of Seville.
- General lines of action necessary to improve the management of this fraction.

# 3. Introduction

## 3.1. Municipal solid waste. Biowaste.

Human activities have always generate waste. In the past, the quantities and characteristics of waste, in addition to the context in which it was generated, did not pose a significant problem since nature was capable of assimilating it.

However, with population growth and the formation of large population centers, the limits of assimilation of the planet began to be exceeded. Waste generation is one of the most complex environmental challenges facing modern societies.

The increase in waste generation on a global scale is continuous. Proper management is essential to minimize negative impacts, both on a global and local scale (Pereira-Fernández et al., 2019). The concept of circularity, of taking advantage of the resources contained in waste, is a necessity, a key challenge, as well as a regulatory obligation for the European Union.

The production of waste, taking into account the current linear economic model (produce, use, and throw away), is linked to economic and demographic growth. This effect can be seen in the following figure, where the economic boom and crisis stages can easily be correlated.

**Generation**

In Europe, the production of municipal solid waste increased from 467kg / per capita in 1995 to 502 kg / per capita in 2019. In the period 2002 - 2007, the production of municipal solid waste per capita has remained slightly stable over time, hovering around 520 kg / per capita. Since 2008, as a result of the economic crisis, the production of municipal solid waste per capita has been declining to reach 476 kg / per capita in 2014 in Europe (Eurostat, 2021). In the case of Spain, the production of municipal solid waste per capita has increased from 505 kg / per capita in 1995 to 646 kg / per capita in 2003. From then on, production has decreased gradually, increasing this decrease from 2008, with the onset of the economic crisis, until it stabilized in 2015, and reached 476 kg / per capita in 2019 (Eurostat, 2021).

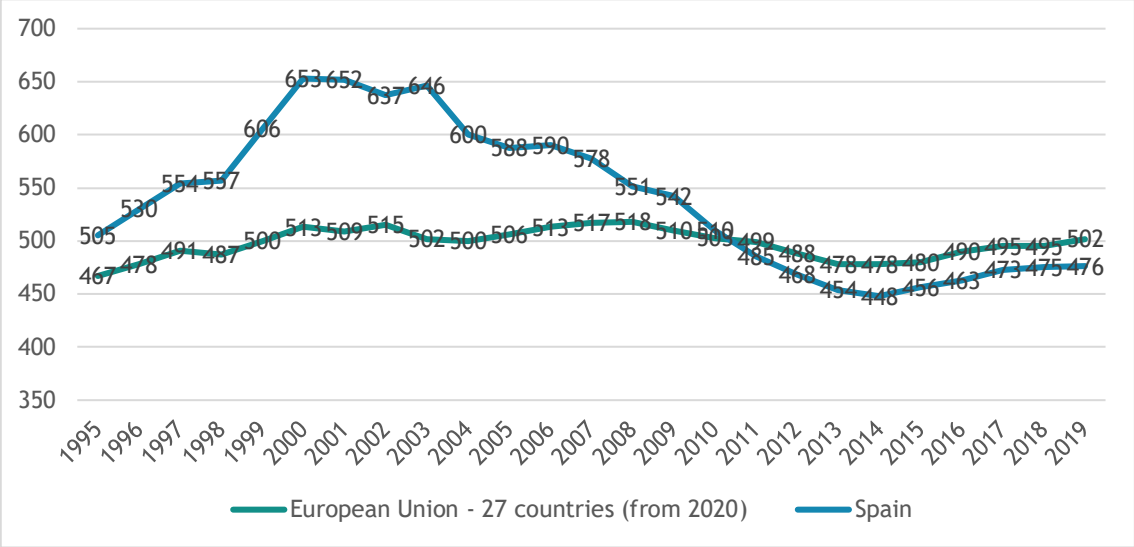


*Figure 1. Evolution of kg of waste per capita in European Union and Spain.*

## Collection

As can be seen in the following table, most of the waste in Spain is still collected mixed, representing, on average, 82.84%, compared to 17.16% collected selectively:

*Table 1.Comparison of mass of municipal solid waste from Spain collected separately VS mixed. (MITERD, 2018). Data from the Annual Report on the generation and management of municipal waste 2018 for Ministerio nisterio para la transición Ecológica y el Reto Demográfico.*

| TYPE | LER CODE | DESCRIPTION | TONS 2018 | % |
|---|---|---|---|---|
| **Mixed waste** | 200301 | Municipal solid waste mixed. | 17.646.563 | 82,84% |
| **Waste collected selectively** | 200101 | Paper and Board. | 1.067.384 | 5,01% |
| | 200102 | Flat glass. | 13.884 | 0,07% |
| | 200108 | Biodegradable kitchen and restaurant waste. | 736.377 | 3,46% |
| | 200201 | Biodegradable waste from parks and gardens. | 273.640 | 1,28% |
| | 150106 | Lightpackaging. | 743.556 | 3,49% |
| | 150107 | Glass. | 820.880 | 3,85% |

| | | |
|---|---|---|
| **Total** | 21.302.284 | 100,00% |

The quantitatively most significant fraction in 2018, selectively collected, was cardboard (5.01%), followed by organic (4.74%, 200108 + 200201), and Glass containers (3.85%).

In the waste that is collected mixed, there is a large amount of materials, which are requested, in the rest of the fractions collected selectively. In the case of the biowaste fraction, which is considered, as a fundamental axis, there is a study at the European level, which places that the average value of this fraction over the total municipal waste is 37% (EEA, 2013).

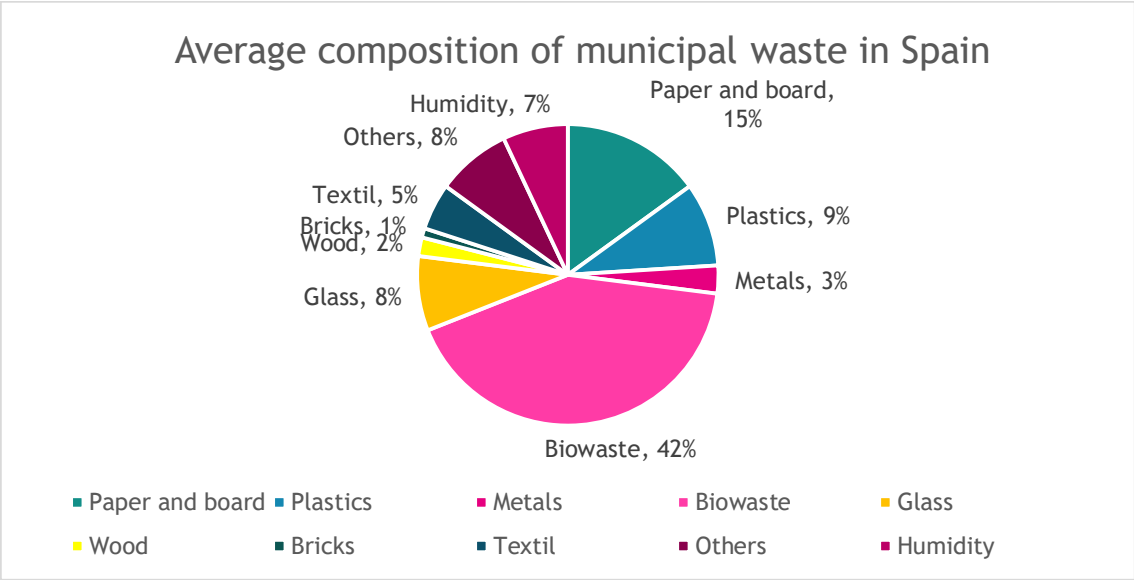


*Figure 2. Average composition of municipal solid waste in Spain (MITECO, 2018).*

An incorrect management of municipal solid waste can lead to environmental impacts such as the production of bad odors, water pollution by leachate, air pollution by the emission of greenhouse gases and other harmful and / or toxic gases by combustion. uncontrolled or soil contamination, harming human health, affecting ecosystems and contributing to climate change.

By law - *Ley 22/2011 de Residuos y Suelos Contaminados*, the competence and responsibility for the management of domestic and commercial waste is assigned to the municipalities, and includes the collection, storage, transport and treatment, including surveillance of these operations, as well as the closure and post-closure maintenance of the landfills. The high number of different operations involved and their coordination make an adequate municipal solid waste management process a complex task.

**Treatment**

The treatments of each waste fraction depend on the separation model at origin. With regard to organic fraction in municipal waste, two types of treatment can be distinguished:

Biological treatment of the organic fraction of municipal waste collected separately (biowaste), which can be carried out by composting, giving rise to compost, or by anaerobic digestion, resulting in digested and biogas. In many cases, the digest undergoes a subsequent composting process, giving rise to compost.

Mechanical-biological treatment of of the organic fraction included in mixed waste: This fraction is subjected to mechanical separation to obtain organic matter, which is subsequently subjected to a biostabilization process by composting, or less frequently by anaerobic digestion, which gives rise to biostabilized material. and biogas in the case of anaerobic digestion (Ministerio de Agricultura, Alimentación y Medio Ambiente, 2016,PEMAR 2016 – 2022).

In Spain, the most widely used treatment is mechanical-biological treatment.

In 2012, the municipal waste management situation was as follows:

- 15% went to recycling materials.
- 14% went to biological treatment
- 11% was destined for incineration. In Spain there are only 6 Autonomous Communities (out of 17 in total), which have incineration plants. These are the Balearic Islands, Cantabria, Catalonia, Galicia, Madrid and Euskadi.
- 60% to landfill (of which 50% were rejects from other treatments).

As it is seen, the management options are very varied, from the type of collection, to the type of treatment that is subsequently given to the waste. Finding an optimal management strategy depends on multiple factors and the context in which the waste management plan has to be developed.

## 3.2. Legal framework.

The main regulatory instrument in the field of waste is Directive 2018/851/ EC (Waste Framework Directive). This Directive reinforces the principle of hierarchy in waste management options. Thus, the best management option for a waste is to prevent it from occurring (prevention) and then, and in this order, the preparation for reuse, recycling, other forms of recovery (including energy) and, finally, landfilling (among others). Likewise, other policies, standards and documents (that emanate from said directive, or from previous versions, or are related) regulate biowaste management.

Here, it have been summarized the most important, and how they affect to biowaste:

*Table 2. Summary of the main European, National, Regional and Local policies and standards that regulate biowaste management.*

| Level | TITLE | Impact on the biowaste flow. |
|---|---|---|
| *European level* | | |
| European | DMR: Directive 2018/851 of the European Parliament and of the Council, of May 30, 2018, which modifies Directive 2008/98 / EC on Waste. | Member States shall ensure that biowaste is either separated and recycled at source, or collected separately and not mixed with other types of waste, by 31 December 2023. Likewise, Member States must apply the most appropriate treatment, including stabilization of the organic fraction of waste, in order to reduce as far as possible the adverse effects of the dumping of such waste on the environment and human health. . |
| European | DVR: Directive 2018/850 of the European Parliament and of the Council, of May 30, 2018, which modifies Directive 1999/31 / EC on the Dumping of Waste. | |
| *National level - Spain* | | |
| National | Law 22/2011, of July 22, on waste and contaminated soils. *Ley 22/2011, de 22 de julio, de residuos y suelos contaminados.* (New Law in progress), | It establishes the definition of biowaste under the European Directive, as well as the objectives of separate collection of biowaste to be used for composting or anaerobic digestion. Domestic and community composting, the correct treatment of separately collected biowaste so as to obtain high quality compost and the use of this one in the agricultural sector, gardening, etc., will be promoted, replacing other amendments. |
| National | Law 16/2002, of July 1, on integrated pollution prevention and control. *Ley 16/2002, de 1 de julio, de prevención y control integrados de la contaminación* | This Law affects the facilities where waste management and treatment is carried out, including biowaste. Its objective is to avoid, reduce and control pollution of the atmosphere, water and soil, by establishing an integrated pollution prevention and control system, in order to achieve high protection of the environment as a whole. |
| National | RD 646/2020, of July 7, which regulates the disposal of waste by depositing it in a landfill. *RD646/2020, de 7 de julio, por el que se regula la eliminación de residuos mediante depósito en vertedero.* | It establishes the conditions under which waste is admitted to landfill facilities, as well as landfill reduction targets, in line with European Directives. |
| National | Spanish National Program for Waste Prevention 2014-2020. *Programa Estatal de Prevención de Residuos 2014-2020.* | Develops the waste prevention policy, in accordance with current regulations to advance in meeting the goal of reducing waste generated in 2020 by 10% compared to the weight of waste generated in 2010, including biowaste. |

| | | |
|---|---|---|
| National | Spanish National Waste Management Framework Plan (PEMAR) 2016-2022 *Plan Estatal Marco de Gestión de Residuos (PEMAR) 2016-2022* | For the waste streams included in said plan, including biowaste, the applicable regulations and objectives, the evolution of management in recent years and the current situation of waste management are described, and the objectives and guidelines are established. and strategic lines to achieve them. |
| National | RD 506/2013, of June 28, on fertilizer products. *RD 506/2013, de 28 de junio, sobre productos fertilizantes.* | It establishes the basic regulations regarding fertilizer products. It defines and typifies fertilizer products, other than "EC fertilizers", that can be used in agriculture and gardening. Determines the nutritional richness and other characteristics of fertilizer products. Regulates the Registration of fertilizer products for the registration of certain products. It defines compost as a sanitized and stabilized product, obtained by aerobic biological decomposition (including thermophilic phase), under controlled conditions, of biodegradable organic materials collected separately. |
| National | Decalogue for the use of biostabilized material and compost not registered in the fertilizer products register. *Decálogo para la utilización del material bioestabilizado y del compost no inscrito en el registro de productos fertilizantes.* | It develops the requirements for the authorization of the application of the biostabilized material, as well as the conditions to carry out said applications, including the characteristics required of the biostabilized material, the frequency of analysis, the conditions related to storage and application in soils. |
| *Regional Level - Andalusia* | | |
| Regional | Law 7/2007, of July 9, on Integrated Management of Environmental Quality. *Ley 7/2007, de 9 de julio, de Gestión Integrada de la Calidad Ambiental.* | It establishes a regulatory framework at the Andalusian level, for the correct development of environmental policy and to update existing provisions to regulate environmental prevention and control instruments, applicable to programs, works projects and economic activities. |
| Regional | Waste plan for Andalusia. Towards a circular economy on the horizon 2030 (PIRec 2030). *Plan integral de residuos de Andalucía. Hacia una economía circular en el horizonte 2030 (PIRec 2030).* | Plan at the Andalusian level, which aims to update the prevention, recycling, recovery and elimination objectives to the new European and national objectives, and on the other, to adapt its structure, contents, validity periods, and frequency of evaluation and review to the provisions of the National Waste Framework Plan (PEMAR) 2016-2022 and the new European guidelines. |
| Regional | Decree 73/2012 approving the Andalusian Waste Regulation *Decreto 73/2012 por el que se aprueba el Reglamento de Residuos de Andalucía* | It establishes the objectives for the selective collection of biowaste in Andalusia. |

| | | |
|---|---|---|
| Regional | Order of July 20, 2007, which regulates the Environmental Accreditation of Compost Quality.<br>*Orden de 20 de julio de 2007, por la que se regula la Acreditación Ambiental de Calidad del Compost.* | It develops the procedures and requirements to obtain the Environmental Accreditation of Compost Quality, through which the quality of the compost obtained by methods beneficial to the environment is made known and offers a guarantee of quality and compliance with product regulations. |
| Local Level - Seville | | |
| Local | Municipal tax ordinance regulating the municipal waste collection and sanitary waste.<br>*Ordenanza fiscal municipal que regula la tasa de recogida de basura de residuos municipales, y residuos sanitarios.* | This Municipal Ordinance reflects the taxes that correspond to the different services provided by Lipasam (Waste management fees), including biowaste. |
| Local | Municipal Ordinance on Public Cleaning and Municipal Waste Management.<br>*Ordenanza Municipal de Limpieza Pública y Gestión de Residuos Municipales.* | It regulates, within the scope of powers of the City Council of Seville, the actions and activities of cleaning the public streets, waste management and control and inspection of equipment for the collection, transport and treatment, incluiding also biowaste. |

The following goals to be met in the field of separate collection of biowaste are extracted from the above regulations:

*Table 3. Goals to accomplish in the field of separate collection of biowaste.*

| Goal | Percentage | When the goal should be accomplish | Policy/standard which support the goal |
|---|---|---|---|
| Mandatory implementation of biowaste collection systems. | - | Before 2024<br>(Before 2021 for municipalities bigger than 5.000 inhabitants) | Decree 73/2012 approving the Andalusian Waste Regulation<br>Directive 2018/851 of waste.<br>New Law of waste management at Spanish level, still in draft stage. |
| Quantities of biowaste collection | 20%<br>40% | 2020<br>2023 | Decree 73/2012 approving the Andalusian Waste Regulation<br>Directive 2018/851 of waste. |

| | | | |
|---|---|---|---|
| Preparation for Reuse and Recycling of Biowaste | 50% | 2019 | Law 22/2011 on waste and contaminated soils.<br>Decree 73/2012 approving the Andalusian Waste Regulation<br>Directive 2018/851 of waste. |
| Municipal waste recycling | 55%<br>60%<br>65% | 2025<br>2030<br>2035 | Directive 2018/851 of waste. |
| Biodegradable Waste Landfilling | 35% | 2016 | Decree 73/2012 approving the Andalusian Waste Regulation<br>RD 646/2020, of July 7, which regulates the disposal of waste by depositing it in a landfill. |
| Landfilling of municipal waste collected. | 10% | 2030 | Decree 73/2012 approving the Andalusian Waste Regulation<br>RD 646/2020, of July 7, which regulates the disposal of waste by depositing it in a landfill.<br>Directive 2018/850 of landfilling |

Although the goals set are at the state level (and even regional and provincial, in accordance with the current regulation), the municipalities play a key role in achieving them for their competence, as they are providers of collection and treatment services, as well as the have monitoring and control powers and obligation to supply information to the regional administrations.

## 3.3. Selective collection of MSW and collection systems in Spain.

In 2002, around 10% of the total waste generated was collected selectively. This figure has increased significantly in recent years, having reached almost 3.7 million tons in 2018 (17.16%).

Taking the example of Andalusia, the most consolidated collection system is selective collection in large capacity containers (770 - 3,200 liters) on public roads, likewise, in large cities; these containers are usually implemented, with side loading systems.

There are also selective collection systems in underground containers and pneumatic collection. The selective collection system, for the most part, is configured in four different types of containers: glass (green), paper-cardboard (blue), light packaging (yellow) and the rest fraction (grey), which includes organic waste, although in some municipalities, they are incorporating a fifth container, for the separate collection of biowaste.

*Table 4. Differents selective waste collection systems or models in Spain (MITERD, 2021).*

<table>
<tr><th>Type 1 – 5 fractions</th><th>Type 2 – Wet - Dry</th><th>Type 3 - Multiproduct</th><th>Type 4 – 4 fractions + Garden waste</th><th>Type 5 – 4 fractions</th><th>Type 6 – 3 fractions</th></tr>
<tr><td>Glass</td><td>Glass</td><td>Glass</td><td>Glass</td><td>Glass</td><td>Glass</td></tr>
<tr><td>Paper and Board</td><td>Paper and Board</td><td>Paper and Board + Light Packaging</td><td>Paper and Board</td><td>Paper and Board</td><td>Paper and Board</td></tr>
<tr><td>Light Packaging</td><td rowspan="2">Light Packaging + Rest</td><td rowspan="2">Rest</td><td>Light Packaging</td><td>Light Packaging</td><td rowspan="2">Rest (+ Organic waste) + Light Packaging</td></tr>
<tr><td>Rest</td><td>Rest (+ Organic waste)</td><td>Rest (+ Organic waste)</td></tr>
<tr><td>Biowaste</td><td>Biowaste</td><td>Biowaste</td><td>Garden waste</td><td>-</td><td>-</td></tr>
</table>

Likewise, most municipalities or associations have a network of civic amenity sites (“clean points”) where, in accordance with municipal ordinances, citizens can deposit other waste, such as bulky waste, textiles, cooked oil used, etc. (Diputación de Sevilla, 2020, PRNPPS).

The waste deposited in the containers is collected and transported by collection trucks, which can be compactors or not, and mainly of side-load or back-load collection. There are other types of compactor trucks, such as front-loading compactor vehicles, although these systems are not common in Spain.

Vehicles can be compartmentalized, so they can collect multiple fractions at the same time, although the most common is that a particular vehicle is assigned to a fraction collection route according to a schedule.

Biowaste constitutes the fraction whose separate collection has increased most significantly in the last six years, doubling in 2012 the tons collected in 2006 (Ministerio de Agricultura,

Alimentación y Medio Ambiente, 2016, PEMAR 2016 – 2022). The mandatory introduction of separate collection of organic matter in all municipalities has fundamentally contributed to this.

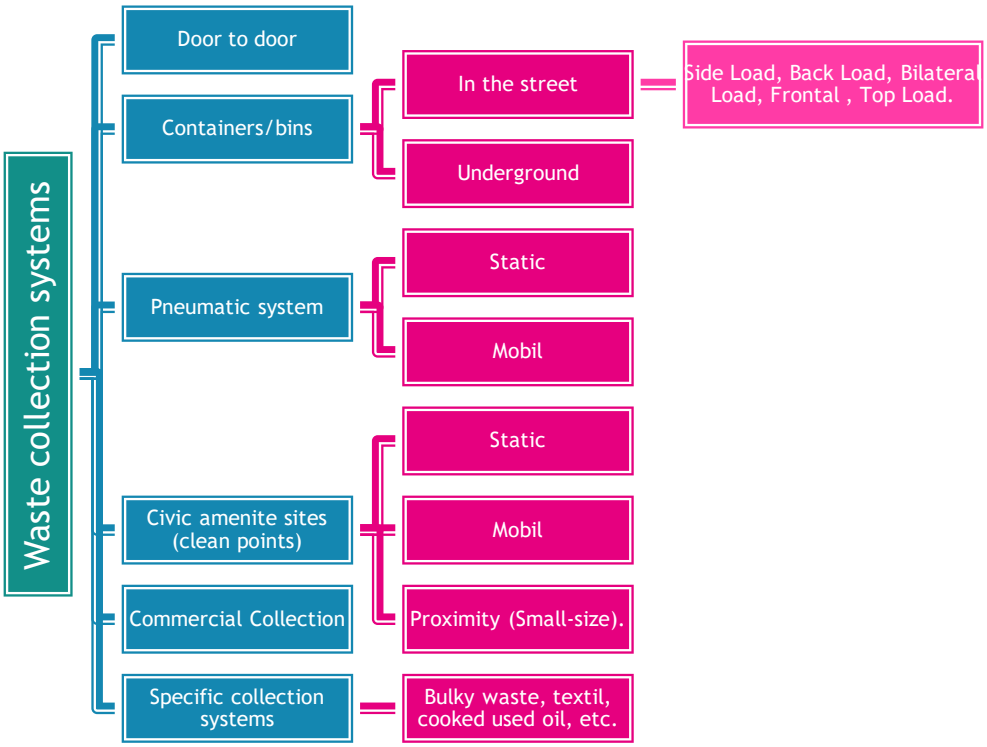


*Figure 3. Types of waste collection systems in Spain (MITERD, 2021).*

# 3.4. Selective biowaste collection.

Biowaste is defined as "*biodegradable waste from gardens and parks, food and kitchen waste from homes, offices, restaurants, wholesalers, canteens, collective catering services and retail consumption establishments, and comparable waste from transformation plants of food* " (*Directive 2018/851*).

Despite the efforts and improvements produced in the field of waste management, even in most European countries, biowaste is selectively collected very marginally, most of them are contained in the rest fraction, so that a large percentage end up being disposed of through landfills or incineration.

*Table 5. Characteristics of biowaste, (MITERD, 2021).*

| **Characteristics of biowaste** | |
|---|---|
| **Humidity** | High (75-85%) |
| **Organic matter** | 75 – 85% |
| **Nitrogen** | 2.5% |
| **Relation C/N** | 17 |
| **Density** | 0.5 – 0.6 t/m3 |

Biowaste is the most unstable fraction of municipal waste, due to its high content of water and organic matter. Currently, the main environmental threat of the biowaste fraction, along with other biodegradable fractions, is leaching, bad odors and the production of methane from waste that decomposes in landfills (EEA, 2020).

Currently, the separation of biowaste from the mixed fraction has low recovery yields, in addition to being expensive, and having as a final result a material, generally, that does not meet the standards to be considered compost, and must be considered as biostabilized material or "soil amendment".

That is why, that it is betting on the strategy of separation in origin of this fraction. The separation from homes can generate a pure material, and of good quality for composting, and therefore, compost production *(*Biowaste*,* 2016), an example of this is the current objective, emanating from Directive 2018/851, of implementation of the selective collection of biowaste in cities before 2024, or the limits for waste dumping, established by Directive 2018/850, also relating to the landfill of biodegradable waste.

In Spain, the law *Ley 22/2011, de 28 de julio, de Residuos y Suelos Contaminados*, establish in its article 24 that the environmental authorities have to promote the separate collection of biowaste. Currently, the selective collection of biowaste is not yet implemented or very incipient in most municipalities.

In accordance with the preliminary draft of the new national law about waste management (which will modify the current Ley 22/2011) currently in process, by which Directive 2018/851 is transposed into the state legal system, it establishes even more ambitious objectives. It establish that all municipalities with more than 5,000 inhabitants must implement the selective collection of biowaste, no later than December 31, 2021.

When the separate collection of biowaste is included in the general selective collection system, the figures for selective collection and recovery of the rest of the fractions increase due to:

- Strengthening the concept of selective collection, for the public and the rest of the generators, in terms of purity and quantity.
- The reduction of the content of organic matter in the rest fraction and other selective fractions, which facilitates the subsequent treatment.
- The rest fraction also reduces its content of organic material and favors its subsequent treatment, according to the waste management scheme and current treatment plant model (plants designed to treat the fractions separately, in order to obtain high percentages efficiency and recovery.

Most cities choose to establish biowaste collection schemes aimed at both large and small generators, implementing specific collection schemes for each one, in order to increase the percentage of selective collection of this waste.

As noted, separate collection of biowaste can help to largely divert this waste stream from landfill or incineration, and reintroduce organic matter into the carbon cycle. Likewise, anaerobic digestion is an alternative treatment that works very well with food waste, in which biogas is generated, in addition to digestate, solid waste with organic load, in many cases it is subjected to a subsequent composting process, giving rise to compost (Junta de Andalucía, 2021, PIREC 2030).

The introduction of selective biowaste collection in many cities means changing the collection model or system. In Spain, the usual collection model is Type 5, as reflected in the ***Error! Reference source not found.***. In some municipalities, there is also the Type 2 model, and the Type 1 model.

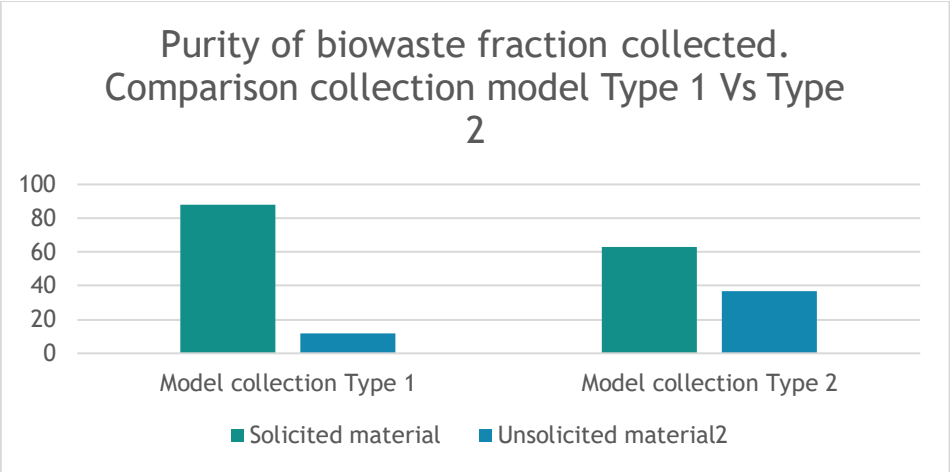


*Figure 4. Purity of biowaste fraction collected. Comparison collection model Type 1 Vs Type 2. Data from PEMAR 2016 – 2022).*

The general trend in Spain is to evolve towards the type 1 model, which several studies conclude that a higher percentage of purity (solicitated material) (PEMAR 2016 - 2022) is obtained.

Regarding the type 1 collection model (5 containers), for the biowaste fraction, 88% of solicitated material is obtained, of which 65% are food waste, 20% garden waste, 2.7% cellulosics and the remaining 0.3% other biowaste.

Regarding the type 2 model (wet - dry), 63% are solicitated material, of which 47% are food waste, 11% garden waste, 3.3% cellulosic and the remaining 1.7% other biowaste (Ministerio de Agricultura, Alimentación y Medio Ambiente., 2016, PEMAR 2016 - 2022)

Associated with the implementation of the selective collection of biowaste, it is essential to provide capacity to citizens and the remains of generators, since, in the first instance, they will do the separation tasks at source.

It is common to carry out communication campaigns associated with the implementation, where instructions are given on how to use the containers, what types of waste to deposit, etc. Likewise, it is also common to distribute for free, in said campaigns, promotional materials that promote said selective collection, such as compostable bags and small-size buckets, usually 7 to 10 liters and aerated.

The bags normally used for the deposit of the different waste fractions, including biowaste, are made of low-density polyethylene, which means that this material reaches the treatment and composting plants, posing a problem in the pre-treatment process. and refining (Korner et al., 2005.) For this reason many local entities promote and recommend the use of compostable bags with potato or corn starch base, which are degraded practically in their entirety through the composting process (ACR+, 2016). Despite this recommendation, in most municipalities, the use of compostable bags is not mandatory, due to the possible risk of discouraging the selective collection of the fraction.

In most cases, this problem is solved, to a greater or lesser extent in the treatment stage, by installing systems such as sieve, tromel, or bag openers, either in the initial stage and / or in the refining stage (Korner et al., 2005).

Likewise, the aerated bins/bucket system, which comes from northern European countries, is based on the use of perforated buckets for household collection of biowaste, combined with the use of compostable bag (EEA, 2018).

The use of this system entails a series of advantages such as:

- Improves the aeration of biowaste, loss of moisture and reduction of leachate generation.
- Reduction of the weight of waste due to evaporation of the humidity contained in the waste.
- Reduction of bad odors due to possible fermentations of the organic fraction, due to a more aerobic balance.
- Makes the collection of the organic fraction more comfortable for households.

Many important Spanish capitals have recently implemented a separate biowaste collection for the first time, among them are: Madrid (Nov 2017), Valencia (Nov 2016), Córdoba (Jul 2017), Seville (Jun, 2017), Zaragoza (Jul 2018) . In most cases, these cities have used the 5$^{th}$ container system on the public street.

Here are some examples of Spanish regions and cities where selective biowaste collection is implemented:

*Table 6. Brief description of biowaste collection schemes implemented in some Spanish cities and regions. Data source: Pereira-Fernández et al., 2019).*

| Regions/Cities | Brief description |
|---|---|
| **Catalonia** | Biowaste collection is extended to practically the entire population, around 98%, and in 84% of the municipalities. Despite this level of |

| | |
|---|---|
| | implementation, according to the Catalan Waste Agency, the real participation only reaches one third of the population served. |
| **Euskadi** | Selective collection of biowaste extended in many municipalities. Most using the fifth container model with control access through a key, or door-to-door collection. |
| **Navarra** | Implementation of biowaste in some areas, since 1993, according to the type 4 model. The widespread implementation in the region is expected by the end of 2021. |
| **Baleares** | Different types of collection system according to each island. Mainly door-to-door collection. |
| **Galicia** | There are two specific areas with differentiated collection of biowaste, associated with a wet-dry / 4 fraction model (Mancomunidad de Barbanza, A Coruña and Mancomunidad das Marinas) |
| **Córdoba (Andalusia)** | Biowaste collection through the wet and dry system (model 2). Containers on public roads. |

In the case of Andalusia, biowaste is not collected selectively in a generalized way in most municipalities, most of the product obtained in composting plants that process municipal solid waste cannot be classified as compost, having to be classified as biostabilized material or soil amendment.

The selective collection of biowaste becomes an important need for the correct recovery of this waste and its maximum use.

# 4. Diagnosis of the current situation in Seville.

## 4.1. Elements, equipment and infrastructure in the field of the waste collection.

The City Council of Seville provides the public street cleaning services, waste collection and treatment through Limpieza Pública y Protección Ambiental S.A.M (LIPASAM), which is 100% public.

Waste treatment is carried out jointly, belonging the City of Seville to the "*Mancomunidad de Los Alcores"* a commonwealth established for the City of Seville and surrounding municipalities for the treatment of municipal solid waste. The waste treatment facility is located at the Montemarta-Cónica, in the municipality of Alcalá de Guadaíra, and the current concessionaire is the company *Abonos Orgánica de Sevilla, SA* (ABORGASE).

In general, the containerization model implemented in the city of Seville is based on four fractions:

1. Selective collection of light packaging (yellow container).
2. Selective collection of paper-cardboard, through:
    a. Mono material collection (blue container).
3. Selective collection of glass.
    a. Green container
4. Collection of rest and organic waste mixed (grey container).

In addition, a door-to-door collection service for commercial cardboard is provided in certain areas of the city where, due to their urban configuration, it is not possible to install containers in the streets. Likewise, door-to-door collection for glass is carried out in some establishments of the "HORECA" (Hotel, restaurants and caterings) channel in the Historic Center.

In recent years, there has been a general commitment to the implementation of waste collection using side-loading containers and the grouping of selective collection containers (yellow, blue and green) in "selective islands", although the city's configuration is sufficiently diverse allowing several alternative collection systems coexisting, beyond this general pattern.

*Table 7. Waste collection systems deployed in the city of Seville.*

| Waste collection systems | Fractions | Containers | Population served 2020 | Population coverage percentage 2020 |
|---|---|---|---|---|
| Pneumatic collection | Rest + organic waste | 688 | 48.398 | 6,90% |
| | Lightpackaging | 344 | | |
| Top-loading and Side-loading containers. [a,b] | Rest + organic waste | 5.273 | 601.514 | 87,30% |
| | Lightpackaging | 2.034 | | |
| | Glass | 2.121 | | |
| | Paper and board | 2.190 | | |
| Back loading containers | Rest + organic waste | 3.367 | 41.484 | 5,80% |
| | Lightpackaging | 436 | | |
| Bins (door to door)[c] | Rest + organic waste | 5621 | | |

[a] The containers for selective collection are grouped into "islands".
[b] Side-loading, bilateral-loading and underground container are unified (there are several types depending on the hooking mechanism of the truck).

[c] The system of bins (door-to-door) is being implemented in the historical center of the city and in the historical center of *Triana* (neighbourhood located in the west of the city). Door-to-door collection is done during the night, daily, and the capacity of the bins usually are 120 litres. The owners of each bins, left ir in the public street for their collection.

In mid-2017, within a broad roadmap for the selective collection of biowaste, the collection of these in large generators, specifically in markets, began and expanding it incipiently to citizenship.

Regarding the collection circuits of the different fractions, the breakdown of the number of services is as follows:

*Table 8. Breakdown of the number of collection services carried out in Seville by workshift.*

| | TYPE OF SERVICE | WORK SHIFT | | |
|---|---|---|---|---|
| | | MORNING | AFTERNOON | NIGHT |
| Rest and organic mixed collection | Backload collection | 3 | 4 | 6 |
| | Sideload collection | 15 | 2 | 11 |
| | Bilateral collection | 1 | | 1 |
| | Sanitary collection | 1 | | |
| | Underground containers collection | | | |
| | Mobil pneumatic collection | 1 | | |
| Paper and board collection | Sideload collection | | 12 | 5 |
| | Toploads collection | | | |
| | Bilateral collection | | | 1 |
| Light-packaging collection | Backload collection | | 2 | 6 |
| | Sideload collection | | 11 | 5 |
| | Bilateral collection | 1 | | |
| Glass collection | Sideload collection | 16 | | |
| | Toploads collection | 2 | 7 | |
| | Bilateral collection | | | |
| Biowaste collection | Backload collection | | 1 | |
| | Sideload collection | | 3 | |
| | Total | 40 | 42 | 35 |

.

More than the 54% of the services deployed for waste collection in the city of Seville belong to the side loading collection system.

Regarding the criteria for the location of the containers, the following objectives are pursued (LIPASAM`s internal Handbook):

- Ensure that the location of the containers presents a homogeneous and orderly appearance throughout the city,
- Facilitate collection operations,
- Guarantee safety, both for users and for the collection staff themselves,
- Cause the least possible inconvenience, and
- Ensure that the orientation of the containers promote their use by citizens.

To do this, the following general principles are taken into account:

- Guarantee safety for users in general and people with disabilities in particular, for road traffic, cyclists, etc., and for the collection service itself.
- Facilitate the operation of the collection,
- Adapt the number of containers, adapting it to the real needs of the population and the characteristics of the area and / or road,
- Minimize as much as possible the inconvenience caused as a result of the proximity of the containers to homes, food and hospitality shops, shops in general, industries,

As well as the specific requirements that follow:

- To guarantee accessible pedestrian routes for people with reduced disabilities through the sidewalks, the containers that must be placed on them will be located as far as possible on the outside, provided that the remaining free width is equal to or greater than 90 cm , or at the distance established by the corresponding application rules,
- There will be no vertical obstacles at any point on the surface that includes a pedestrian crossing or at its entrances,
- The containers will be arranged in such a way as to avoid obstructing the traffic of vehicles, pedestrians, bike lanes, etc.
- The container mouth must be located in such a way as to facilitate its use by citizens,
- may not totally or partially hide traffic and road safety signs (vertical, horizontal or luminous),
- Containers will not be placed in areas that affect the aesthetics of assets of cultural interest or monuments,
- for security reasons, the placement of urban furniture in the places indicated by the competent authority will be avoided,

In general, each user will have a container for organic matter and remains at a distance of 50 meters or less and selective containers at a distance of 100 meters or less,

The containers will be separated into two groups: on the one hand those of mixed waste (organic fraction and rest) and on the other, grouped, those made of paper and cardboard, glass and light packaging (always in this order, according to the direction of movement of the traffic), and biowaste, in those areas which is deployed.

Containers will be placed away from house windows, bar tables and shop windows, a minimum distance of 3 meters.

### 4.1.1. Mixed waste: Organic fraction mixed with rest fraction.

The collection of mixed waste is carried out jointly, in a mechanized way throughout the city. Currently, 11.582 containers are installed according to the needs of each street, area or sector, with capacities ranging between 120 liters (individual bins) and 5,000 liters, being 3,200 liters (side loading collection) the most frequent.

In general, the collection takes place during the morning, from 7:00 a.m. to 2:00 p.m. in most residential areas, and during the night, from 11:00 p.m. to 6:00 a.m. in the City Center and in those other areas of relevant commercial character.

Waste from municipal markets (and waste comparable to households in industrial areas and business parks) is collected from 2:30 pm to 9:30 pm.

In some areas of the City Center and Triana districts, collection has been implemented through individual bins that residents and merchants keep inside their home or establishment, thus improving the appearance of these areas. This system alleviates the difficulties for the installation of containers on public streets, in very narrow zones. The collection of waste by the individual bin system is around 12,000 tons per year, that is, the equivalent of some 25,000 inhabitants.

Likewise, in certain areas of the Historical City Center, there are underground containers, with less visual impact and which make the mobility of pedestrians less difficult in areas of special affluence, although this system raises, in general terms, higher investment and operating costs.

In a large sector of the city, over 70%, waste collection has been implemented with side-loading compactors, with quieter vehicles and with large-capacity containers (3,200 liters), which has allowed to significantly reduce the number of units installed on public roads, avoiding inconvenience to citizens and increasing, for example, the useful space for parking.

Pneumatic waste collection is implemented in the Pino Montano neighborhood (two fixed systems), in the Miraflores area (a fixed system) serving around 45,000 citizens.

To guarantee an adequate level of hygiene in the use of the containers, an interior and exterior high pressure washing service is carried out with hot water.

### 4.1.2. Selective collection

The selective collection is carried out through high-capacity containers installed throughout the city, following the established procedures and criteria, being installed at December 31, 2020, 2.121 for glass, 2.190 for paper and cardboard and 2,814 for light packaging.

For lightpackaging, the most widespread model is the 3,200-liter side loading model on the surface, although collection is also carried out using a fixed pneumatic system, back loading and bilateral system, etc.

For paper and board, the most widespread model is also the 3,200-liter side loading model on the surface, although it is also collected to a lesser extent by means of a top loading and bilateral loading system. Additionally, door-to-door collection of paper and cardboard is carried out in commercial establishments.

Finally, for glass , the side and top loading models prevail, the latter equipped with mechanisms for dumping bins, although there are also bilateral loading containers.

### 4.1.3. Biowaste collection.

The implementation of the selective collection of biowaste in Seville has been developed gradually, according to the following schedule:

- For large generators.
    - Markets. July 2017. Containers for mixed waste are replaced by containers for biowaste and containers for light packaging in the 18 municipal markets. Biowaste separate collection in the city began at these facilities.
    - Hotels. At the end of 2017, containers for separate collection of biowaste were placed in 4 large hotels.
    - Hospitals. At the beginning of 2018, the segregated collection of biowaste was agreed with 3 of the large hospitals, placing a total of 13 back loading containers and 12 back loading bins.
- For Small generators.
    - Containers on the street. In June 2018, a new selective collection system was established in different areas of the city center. According to days of the week, the containers of which are placed by LIPASAM during a time period, and after this, the containers are uninstall. A total of side back loading containers conform this experience.
    - In December 2018, the first side loading route was placed on the streets of the city. This first zone was Sevilla Este, where were installed 152 containers in the Seville East area. In this system, waste can only be deposited after opening with a magnetic card.

- In March 2019, a second side loading route was installed, with a total of 128 containers in the Bellavista, Bermejales, Jardines de Hércules, Heliópolis, Pineda, El Cano and Pedro Salvador neighborhoods.
- In 2020, a third route of side loading containers has been installed in the Area of Marcarena – Norte (84 units).

Currently, there are a total of 723 containers that are collected in four routes: three for side loading and another for back loading, all of them being collected in the afternoon work shift.

Regards to the containers for biowaste installed in the street, these containers were placed together with other selective fractions ones (light packaging, paper and cardboard, glass), conforming an "island" for selective collection with 4 different containers.


*Image 1. Container models of different capacities (2,200 L and 770 L) installed in the city of Seville for the selective collection of biowaste.*

On the other hand, the containers installed on the street have been containers with an electronic lock, in which the citizen has to open the container with a card for this purpose.

Likewise, during the implementation, both large and small generators have carried out communication and awareness actions in order to promote participation in the system and the correct use of containers.

Next, the figures for the number of containers and bins in 2020, for the collection of biowaste in Seville are shown, both in total numbers and broken down:

*Table 9. Units of containers per type. Capacity installed per type.*

| Type of container | Units | Capacity installed (m3) |
|---|---|---|
| Back loading containers. | 91 | 70 |
| Back loading Bins. | 250 | 30 |
| Side loading Containers. | 382 | 840 |
| Total | 723 | 940 |

*Table 10. Units of containers per location. Capacity installed per location.*

| Type of locations | Units | Capacity installed (m3) |
|---|---|---|
| Markets | 308 | 83 |
| Hotels | 8 | 6 |
| Ocio Centers | 6 | 13 |
| Hospitals | 25 | 11 |
| Street | 376 | 827 |
| Total | 723 | 940 |

*Table 11. Breakdown of containers and bins by Municipal Markets.*

| Breakdown of containers by markets | back loading containers units | Back loading bins | TOTAL |
|---|---|---|---|
| Barranco municipal market. | 3 | 0 | 3 |
| Cerro del Águila municipal market. | 4 | 8 | 12 |
| Bellavista municipal market | 3 | 10 | 13 |
| La Encarnación municipal market | 4 | 13 | 17 |
| Las Palmeritas municipal market. | 6 | 18 | 24 |
| Los Remedios municipal market. | 2 | 13 | 15 |
| Nervión municipal market. | 1 | 16 | 17 |
| Pino Montano municipal market. | 5 | 11 | 16 |
| Villegas municipal market. | 6 | 11 | 17 |
| El Arenal municipal market. | 3 | 18 | 21 |
| Feria municipal market. | 3 | 19 | 22 |
| La Candelaria municipal market. | 2 | 9 | 11 |
| Porvenir municipal market. | 1 | 0 | 1 |
| Puerta de la Carne municipal market. | 3 | 18 | 21 |
| San Gonzalo municipal market. | 7 | 15 | 22 |
| Sevilla Este municipal market. | 4 | 2 | 6 |

| | | | |
|---|---|---|---|
| Tiro de Línea municipal market. | 5 | 18 | 23 |
| Triana municipal market. | 7 | 38 | 45 |
| Total | 71 | 237 | 308 |

*Table 12. Breakdown of containers and bins by Hotels.*

| Breakdown of containers by Hotels | Back loading containers | Back loading bins | TOTAL |
|---|---|---|---|
| Ayre Sevilla Hotel | 1 | | 1 |
| Melia Los Lebreros Hotel | 5 | | 5 |
| NH Central Convention Hotel | 1 | | 1 |
| NH Viapol Hotel | | 1 | 1 |
| TOTAL | 7 | 1 | 8 |

*Table 13. Breakdown of containers by Ocio Centers..*

| Breakdown of containers by Ocio Centers | Side loading containers |
|---|---|
| CC Lagoh | 6 |
| TOTAL | 6 |

*Table 14. Breakdown of containers and bins by Hospitals.*

| Breakdown of containers by Hospitals | Back loading containers | Back loading bins | TOTAL |
|---|---|---|---|
| Virgen del Rocio | 3 | 5 | 8 |
| S. Lázaro | 1 | 3 | 4 |
| Valme | 9 | 4 | 13 |
| TOTAL | 13 | 12 | 25 |

*Table 15. Breakdown of containers in the street installed in the City Center.*

| Breakdown of back containers in the street. | Side loading containers | TOTAL |
|---|---|---|
| Santa Isabel | 2 | 2 |
| Cronista | 2 | 2 |

| | | |
|---|---|---|
| Gavidia | 2 | 2 |
| Santa clara | 2 | 2 |
| Vergara | 2 | 2 |
| San antonio de padua | 2 | 2 |
| total | 12 | 12 |

*Table 16. Breakdown of containers in the street installed per collection route.*

| Breakdown of side containers in the street per route. | TOTAL |
|---|---|
| Sevilla Este | 152 |
| Bellavista - Bermejales | 128 |
| Macarena Norte | 84 |
| Total | 364 |

As mentioned above, the containers to collect biowaste are brown with an electronic lock, which is activated through a card with RFID technology. The citizens just have to bring the card close to the container lock and this allows the lid to be opened.

Around 27,860 cards have been distributed in the areas where side-loading biowaste containers have been implanted.

The distribution of cards was carried out:

- Through the information points installed in the areas surrounding the new container route and through informational mailboxes.
- Likewise, citizens can request the card by email or telephone (biorresiduos@lipasam.es and / or 955010010).

*Table 17. Number of cards for acces to biowaste containers given.*

| Collection Route Area | Nº Cards (01-02-2021). |
|---|---|
| Bellavista La Palmera | 10410 |
| Sevilla Este | 3529 |
| Macarena Norte | 13921 |
| Total | 27.860 |

**Forecasts**

It is planned to expand the implementation of the selective collection of biowaste on public streets during 2021 and coming years, specifically:

- **Pneumatic collection:** Through this collection system, some 47,000 inhabitants are served. Pneumatic collection centers can collect up to 3 different waste fractions. Nowadays "organic + rest fraction" and light packaging are collected, so a separate biowaste fraction should be included. It is estimated at 65 mailboxes that would need to be adapted.
- **Side loading collection:** It is necessary to implement 9 additional routes, assuming 1,350 side-loading containers. Likewise, the corresponding communication / promotion campaigns must be planned in each area.
- **Back loading collection:** For this type of collection, the actions needed are:
  - Expand the number of large generators that are collected.
  - Putting into service a door-to-door collection system using individual bins, basically in the City Center, both for hotels / restaurants and for food stores and households.
  - The needs can be classified in 4 new collection routes and 1,500 individual containers and bins of different capacities.

### 4.1.4. Current cost of the biowaste management.

Currently, the selective collection of biowaste is incipient in the city of Seville, circumscribing, as reflected in the previous section, 4 collection routes, one focused, for the most part, on large generators through back loading collection and 3 side loading collection routes, mainly focused on households.

Both services have different characteristics, both due to the type of truck to be used, as well as the personnel resources necessary to carry out the service.

The back loading collection consists of the mechanical emptying of the waste contained in the back loading containers and / or bins, inside the hopper of the vehicle where they are compacted. During the collection maneuver, the driver stops the vehicle as close to the location of the containers and / or bins. The operators move the containers and / or bins to the elevator, which is activated by one of them to dump its content into the collector's hopper and subsequently compact it. The containers and / or bins are returned to their location and left with the lid closed (LIPASAM`s internal Handbook).

Side loading collection consists of the mechanical emptying of the waste contained in the side loading containers, inside the hopper of the vehicle where they are compacted. In the collection maneuver, the driver stops the vehicle right next to the container. With the help of the monitors located inside the cabin, he activates the mechanisms that pick up the container and elevate

it to the compactor, where the waste is dumped. Subsequently, the container is deposited in its same location (LIPASAM`s internal Handbook).

*Table 18. Resources for type of collection. Back loading collection Vs Side loading collection.*

| Type | Machinery | Personnel |
|---|---|---|
| Back loading collection | Back loading waste truck | 1 driver y 2 operators. |
| Side loading collection | Side loading waste truck | 1 driver. |

The following shows, for the year 2019, the estimated cost of biowaste collection in the city of Seville. This estimate has been made in 2019 instead of 2020 beacuse the collection of biowaste, mostly which is related to side loading collections routes, due to the pandemic, the containers were collected less frequently, due to other tasks taking priority, such as those of disinfection, so 2019 is taken as the basis for estimating an approximate cost.

In order to calculate the costs associated with the collection, in addition to the personnel and machinery costs, the general costs related to the provision of the service, the cost of fuel derived from logistics and the depreciation and maintenance costs of he containers are taken into account.

*Table 19. Estimation of Biowaste collection cost in 2019 in Seville.*

| Estimation of Collection Costs in 2019 | Back Loading collection | Side Loading Collection | Total |
|---|---|---|---|
| Personnel €/h | 109.35 € | 39.34 € | |
| Machinery €/h | 36.66 € | 64.00 € | |
| General Costs (Supervision and others) €/h | 35.19 € | 24.90 € | |
| Total service per hour | 181.20 € | 128.24 € | |
| Total service per day | 906.00 € | 641,20 € | |
| Total service/year | 294,978.80 € | 69,119.40 € | |
| Amortizacion truck | 17,020.00 € | 4.410.00 € | |
| Cleaning Interior Container Cost/year | 1,705.12 € | 10,783.90 € | |
| Cleaning Exterior Container Cost/year | 4,089.23 € | 14,300.95 € | |
| Amortization of containers/year | 7,388.75 € | 27,937.17 € | |
| Maintenance of containers/year | 1,523.00 € | 14,900.00 € | |
| Total | 326,704.90 € | 141,451.41 € | 468,156.32 € |

A total cost associated with biowaste collection is estimated at 468,153.32 € in 2019.

On the other hand, to the costs associated with the collection, we must add the treatment costs of this fraction. The cost of treating the biowaste fraction in the facilities where this waste is destined is 15.98 € / ton. In 2019, this amounted to 28,380.48 €.

In total, in 2019, the cost of the complete management of the biowaste collected in the city of Seville was 496,536.80 €.

**Forecasts**

Consequently, taking into account the forecasts for the implementation of selective biowaste collection, the costs of said service will increase, below is an estimate of the budgetary needs required for the implementation of selective biowaste collection throughout the city:

*Table 20. Budget needs for Seville for the implementation of biowaste collection. Others costs such as communications, fuel and maintenance are not included.*

| Type | Investment in containers and machinery | Communication campaign costs | Staff (annual recurring) |
|---|---|---|---|
| Side loading collection | 2,698,300.00 € | 556,650.00 € | 300,000.00€ |
| Back loading collection | 707,850.00€ | 75,000.00€ | 720,000.00€ |
| Pneumatic collection | 300,000.00€ | 50,000.00€ | |
| Totales | 3,706,150.00€ | 681,650.00€ | 1,020,000.00€ |

An investment of 3.7 million € is estimated to be necessary, with an associated cost of communication campaigns of 681.650€ and an annual recurring personnel cost of 1,020,000€.

## 4.1.5. Pruning and gardening waste.

Regarding pruning and gardening waste, the largest generation, in terms of municipal management, is that carried out by the Park and Garden Service (Parques y Jardines) of the Seville City Council, which is managed directly through the City Council itself.

The main waste generated are (Data obtained from internal interview with Parques y Jardínes Service):

- Pruning and gardening remnants (including mowing remnants), around 6,000 tons per year are generated throughout the city.
- Bitter orange, around 3,000 - 5,000 tons per year, this figure being an estimated. To find this figure, the Parks and Gardens Service counts the orange trees collected and estimates the production based on the weather conditions of the year, in addition to taking into account a phenomenon known as "bearing" or alternation of production. In this, certain species regulate the productions, based on what they have spent each year on energy.

Another stream of pruning and gardening waste is collected through the Civic amenity sites “Clean Points” managed directly by LIPASAM. These prunings are of domiciliary origin, and in 2020 they assumed the order of 529 tons.

## 4.1.6. Facilities managed by LIPASAM in the field of waste collection.

Currently, the waste management facilities in the field of collection managed by LIPASAM are the following:

- Transfer station.
- Civic Amenity sites (“Clean Points”):
  - Clean Point "Los Olivos".
  - Clean Point "Los Pinos".
  - Clean Point "Los Naranjos.
  - Clean Point "Las Jacarandas".
  - Clean Point "Las Palmeras" (Opened in April 2021).
- Pneumatic collection stations:
  - Pneumatic collection station "Pino Montano I".
  - Pneumatic collection station "Pino Montano II".
  - Pneumatic collection station "San Diego-Miraflores".

The Seville transfer station is located on a 16,800 $m^2$ plot. It consists of four compaction units, equipped with a double hopper and hydraulic pusher, which allow the simultaneous unloading of eight collection trucks. It has four big-container transfer equipment, with three positions per compactor, which allows the continuous handling of twelve containers of 36 $m^3$ capacity for transport to the treatment plant, after compaction, in order to save logistics. This facility currently processes light packaging waste and organic waste mixed with the rest streams.

For those waste that due to its characteristics should not be deposited in the containers for domestic waste, there are five civic amenite sites located on the outskirts of the city and in areas with easy access and communication.

Citizens can access these points with their own vehicles to deposit a wide variety of waste, with the following limitations:

*Table 21. Waste fractions and quantities allowed in Civic Amenity sites (Clean Points) in Seville.*

| Waste | Limits |
|---|---|
| Absorbers and contaminated material. | 25 litres |
| Used industril oil | 25 litres |
| Used cooked oil | 25 litres |
| Used oil filters | 3 units |
| Used cars batteries | 3 units |
| Lighting equipment (WEEE) | 25 units |
| Disolventes | 25 litres |
| Paint | 25 litres |
| Tóner | 25 litres |
| X-rays and photographic material | 25 units |
| Button Batteries | 5 litres |
| Standard Batteries | 25 litres |

| | |
|---|---|
| Small household appliances (WEEE) | 3 units |
| Large household appliances (WEEE) | 10 units |
| Metals | 10 units |
| Wood | 5 units |
| Pruning and gardening waste | 1 m3 |
| Paper and board | 1 m3 |
| Plastics | 1 m3 |
| Electrical and electronic tools, and others (WEEE) | 1 m3 |
| Mattresses and other bulky waste | 3 units |
| Construction and demolition waste | 15 units (bags) |
| Industrial Glass | 5 units |
| Contaminated empty packaging | 25 litres//3 units |
| Textiles | 50 litres |
| Mercury thermometers | 2 unidades |

The waste collected at the “clean points” is handled by waste management companies authorized for its treatment.

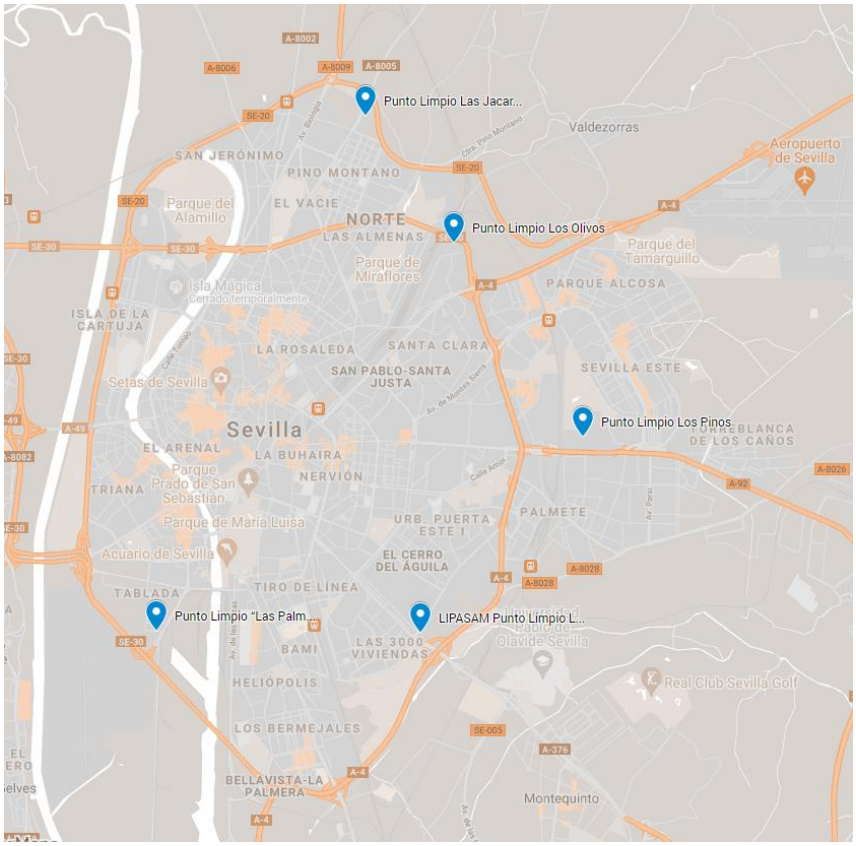


*Figure 5. Location of Seville "Clean Points".*

Regarding pneumatic collection, the waste fractions that are collected by this method are light packaging and organic waste mixed with rest. Likewise, in 2021, it is foreseen to implement biowaste collection separately in some areas.

Its main advantages are that it allows the user to deposit the waste at any time of the day, while minimizing the circulation of vehicles in the area of application and making it possible to collect the waste in an absolutely hermetic way in the inside the Central or at the Collection Points.

The boxes (containers for the pneumatic collection) are connected through a pipeline network with valves that are activated automatically from the pneumatic station. The waste being transported to said station by the action of an air stream created by turbo extractors and that circulates at a speed close to 75 Km/h.

The waste arrive, through pipes, to the station, passing through a diversifier and a cyclone in which they are separated from the air that transports them, falling by the action of gravity to a tank from which a pusher introduces them into a hermetically closed container and that later, once compacted, is taken to the Treatment plant.

In addition to these “fixed systems”, a mobile pneumatic system has been implemented in the historic centre of the city.

## 4.2. Waste collected and current management.

### 4.2.1. Quantities.

During 2020, LIPASAM collected a total of 317,823 tons of waste in the city of Seville. This figure has decreased significantly (-6.6%) compared to 2019 due to COVID -19 pandemia. This decrease breaks the growing trend of the last three years.

These quantities includes waste collected through containers (back-load, side-load, bilateral-load, underground ...), pneumatic systems (both fixed and mobile), door to door, civic amenity sites (clean points), public street cleaning and others special collections.

*Table 22. Quantities (kg) of waste collected in Seville from 2016 to 2020. Breakdown between selective collection and mixed collections. Data from LIPASAM annual management reports.*

| | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|
| Selective collection (kg) | 51,014,973 | 50,712,956 | 55,342,208 | 61,796,894 | 59,704,912 |
| Mixed collection (kg) | 281,850,318 | 275,907,500 | 278,350,830 | 278,545,067 | 258,118,104 |
| **Total municipal waste**(kg) | **332,865,291** | **326,620,456** | **333,693,038** | **340,341,961** | **317,823,016** |

Graphically, the evolution is as follows, taking the year 2006 as the beginning of the historical series:

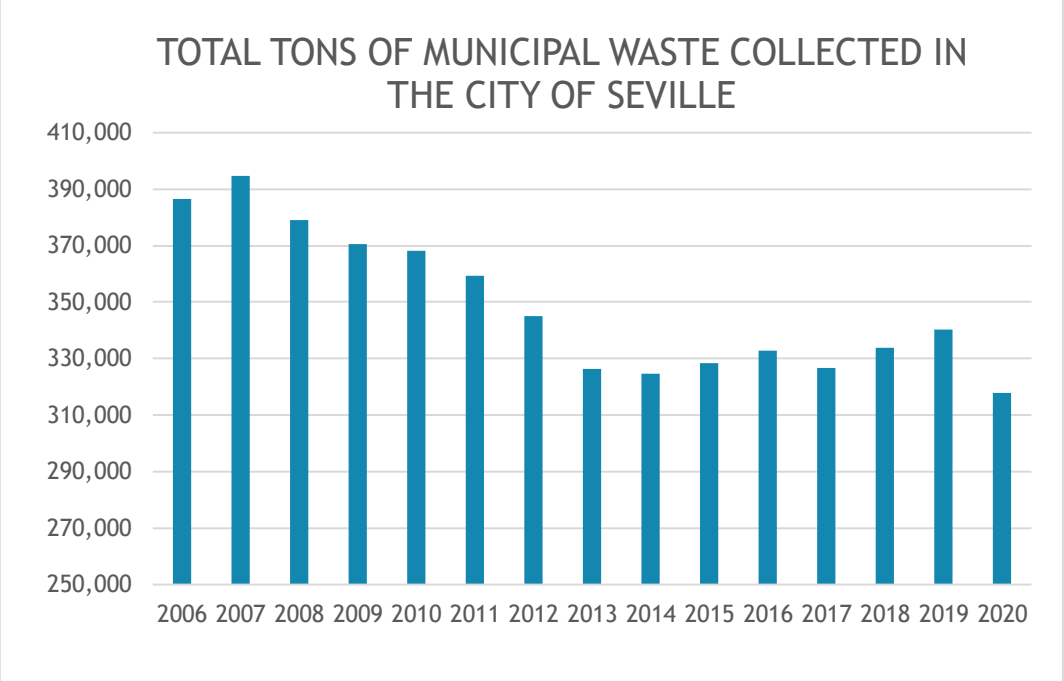


*Figure 6. Quantities (tons) of waste collected in Seville from 2006 to 2020. Data from LIPASAM annual management reports.*

The following table shows, by fraction and weight, the waste collected in from 2015 to 2020:

*Table 23. Table 23. Waste fraction and quantities (kg) collected in Seville from 2015 to 2020. Data from LIPASAM annual management reports.*

| Waste (Kg) | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|
| Used Cooked oil | 593,026 | 327,634 | 67,923 | 63,508 | 108,511 | 32,900 |
| Glass not packaging | 60,220 | 66,020 | 74,580 | 72,640 | 74,440 | 66,680 |
| Light Packaging | 5,845,700 | 6,147,900 | 6,455,320 | 7,400,260 | 8,301,320 | 8,799,560 |
| Construction and Demolition wastte | 19,301,180 | 20,939,670 | 19,864,700 | 19,398,103 | 22,342,337 | 18,453,676 |
| Fluorescents | 6,180 | 5,329 | 5,313 | 6,848 | 7,990 | 5,860 |
| Metals | 233,091 | 309,100 | 316,920 | 317,560 | 347,540 | 365,330 |
| Biowaste | | | 537,680 | 1,562,860 | 1,776,260 | 1,693,900 |
| Paper and Board | 8,046,073 | 8,622,475 | 9,131,885 | 11,372,263 | 12,635,490 | 13,140,883 |
| Batteries | 38,675 | 39,388 | 35,885 | 37,552 | 43,712 | 37,028 |
| X-rays / Photographic material | 999 | 1,474 | 1,276 | 2,837 | 5,303 | 3,566 |
| Other WEEEs | 320,872 | 336,670 | 341,377 | 354,213 | 488,379 | 544,912 |
| Hazardous Waste | 99,021 | 108,603 | 110,153 | 102,883 | 137,764 | 131,296 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Prune and gardening waste | 203,040 | 233,560 | 166,040 | 233,720 | 445,720 | 529,480 |
| Textils | 1,538,888 | 1,728,095 | 1,529,952 | 1,551,395 | 1,225,820 | 1,916,868 |
| Toner | 7,591 | 6,462 | 8,873 | 12,611 | 14,381 | 12,375 |
| Glass | 7,838,328 | 8,410,820 | 8,593,324 | 9,552,328 | 10,358,743 | 10,547,464 |
| Wood | 3,154,040 | 3,584,828 | 3,160,010 | 3,249,123 | 3,433,479 | 3,377,325 |
| Bulky waste | 95,930 | 145,170 | 296,250 | 40,380 | 22,780 | 20,480 |
| Fibrocement | | 1,775 | 3,895 | 2,884 | 3,831 | 2,530 |
| Tires | | | 11,600 | 8,240 | 8,980 | 8,520 |
| Coffe Capsules | | | | | 10,094 | 11,840 |
| CD/DVD | | | | | 4,020 | 2,440 |
| Rest+Biowaste mixed | 264,789,492 | 267,101,428 | 257,492,780 | 258,563,050 | 259,012,987 | 235,413,224 |
| Inerts | 16,218,720 | 14,748,890 | 18,414,720 | 19,787,780 | 19,532,080 | 22,704,880 |
| TOTAL | **328,391,066** | **332,865,291** | **326,620,456** | **333,693,038** | **340,341,961** | **317,823,016** |

With these figures, the selective collection indicator (waste collected selectively compared to total waste collected) stood at 18.8% in 2020, representing a rise of 3.4% compared to 2019.

Despite the pandemic and activity restrictions, especially in the HORECA channel, the quantities in the majority of the fractions selectively collected in the city have increased. The only fraction that has suffered a slight decrease has been the biowaste fraction (-4.6% compared to 2019).

The historical series of this indicator is shown in the next graph.

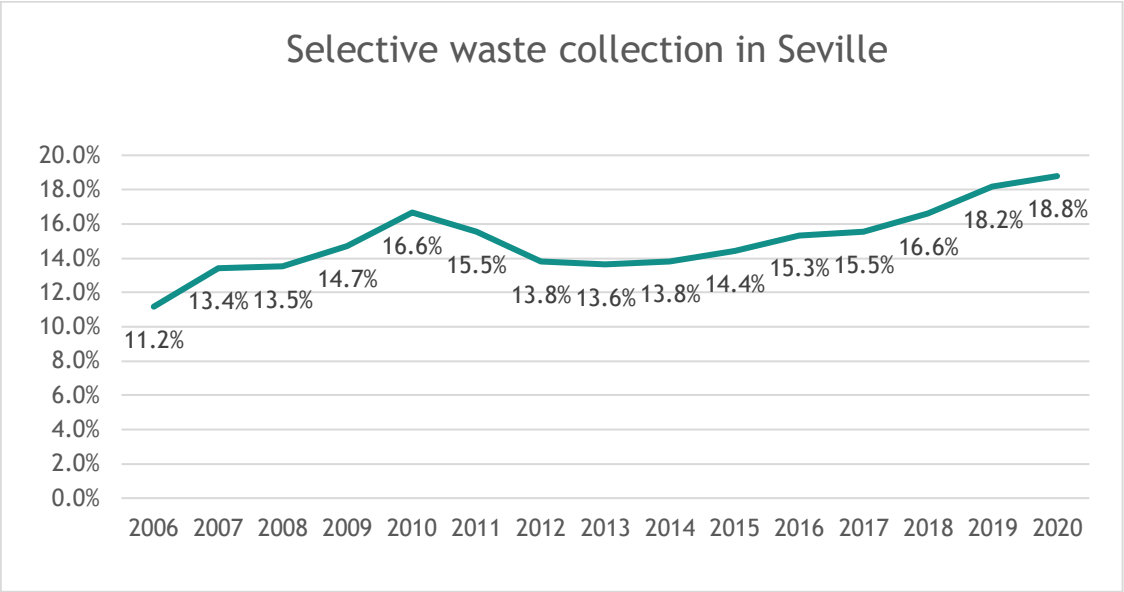


*Figure 7. Evolution of the selective waste collection in Seville. Data from LIPASAM annual management reports.*

Regarding the selective collection of light packaging (yellow container), glass containers (green and door-to-door collection) and paper-cardboard (blue and door-to-door collection), an increase can be seen in the total amount collected from 2020 compared to 2019.

*Table 24. Evolution of quantities (kg) of main waste fractions selectively collected from 2006 to 2020. Data from LIPASAM annual management reports.*

| | Kg of waste fractions collected selectively | | | | |
|---|---|---|---|---|---|
| **Year** | **Light Packaging** | **Paper and Board** | **Glass** | **Biowaste** | **TOTAL** |
| **2006** | 5,574,500 | 14,738,182 | 6,044,946 | 0 | 26,357,628 |
| **2007** | 6,184,820 | 15,619,165 | 6,435,095 | 0 | 28,239,080 |
| **2008** | 7,020,580 | 16,376,389 | 7,267,151 | 0 | 30,664,120 |
| **2009** | 7,397,900 | 15,308,915 | 7,522,490 | 0 | 30,229,305 |
| **2010** | 7,788,860 | 14,109,046 | 7,482,775 | 0 | 29,380,681 |
| **2011** | 7,220,420 | 12,669,787 | 7,389,440 | 0 | 27,279,647 |
| **2012** | 7,793,825 | 10,933,370 | 7,723,740 | 0 | 26,450,935 |
| **2013** | 7,249,120 | 7,372,049 | 7,671,330 | 0 | 22,292,499 |
| **2014** | 6,494,800 | 7,092,829 | 7,769,765 | 0 | 21,357,394 |
| **2015** | 5,845,700 | 8,046,073 | 7,838,328 | 0 | 21,730,101 |
| **2016** | 6,147,900 | 8,622,475 | 8,410,820 | 0 | 23,181,195 |
| **2017** | 6,455,320 | 9,131,885 | 8,593,324 | 537,680 | 24,718,209 |
| **2018** | 7,400,260 | 11,372,263 | 9,552,328 | 1,562,860 | 29,887,711 |
| **2019** | 8,301,320 | 12,635,490 | 10,358,743 | 1,776,260 | 33,071,813 |
| **2020** | 8,799,560 | 13,140,883 | 10,547,464 | 1,693,900 | 34,181,807 |

| | | | | | |
|---|---|---|---|---|---|
| % | 6.00% | 4.00% | 1.80% | -4.60% | 3.40% |

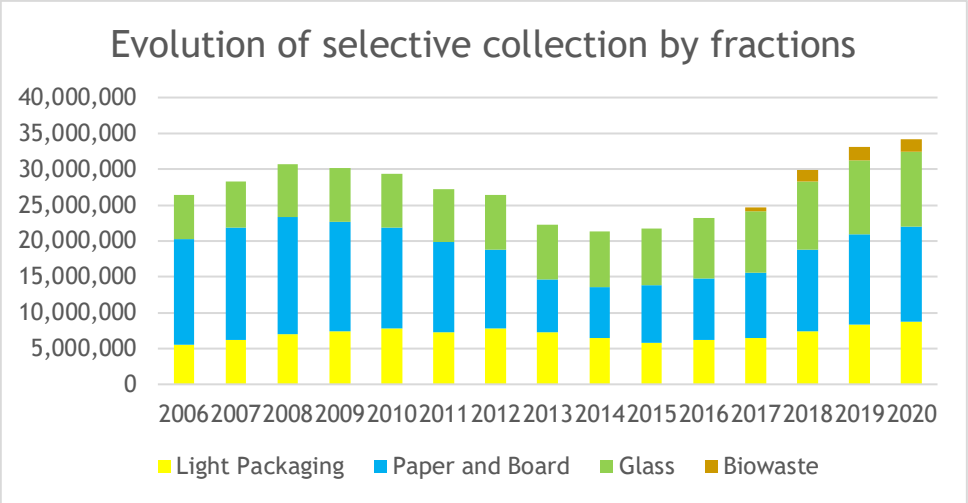


*Figure 8. Graph of the evolution of the main waste fractions selectively collected from 2006 to 2020. Data from LIPASAM annual management reports.*

The following shows, in a particularized way, the data for biowaste collected, according to different and significative milestones of implementation of the system:

*Table 25. Biowaste collected in Seville from 2017 to 2020. Milestones of biowaste collection implementation. Source: LIPASAM internal data.*

| Kg | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|
| **Biowaste** | **537,680** | **1,562,860** | **1,776,260** | **1,693,900** |
| **Milestones.** | July 2017 installation of containers 18 municipal markets. End of 2017 containers in 4 large hotels. | In June 2018, a pilot selective collection system was established in the some ares of the city center. In December 2018, the first side loading container route was placed in Sevilla Este. | In March 2019, installation of the second side loading containers route in Bellavista - Bermejales. | November 2020, installation of the third Macarena-Norte side loading container route. |

Below, in a broken down manner, the amounts collected for each of the routes currently implemented are shown:

*Table 26. Breakdown of biowaste collection in Seville per year and route. Source: LIPASAM internal data.*

| Route 301 (Large Generators) | 2017 (since July) | 2018 | 2019 | 2020 |
|---|---|---|---|---|
| kg collected | 537,680 | 1,562,860 | 1,487,620 | 1,402,522 |
| Nº collections | 147 | 335 | 296 | 287 |
| Frecuency | 1 collection per 1.2 days | 1 collection cada 1.1 days | 1 collection per 1.2 days | 1 collection cada 1.2 days |
| kg / collection | 3,658 | 4,665 | 5,025 | 4,886 |
| Kg per day | 2,922 | 4,282 | 4,076 | 3,832 |

| Route 302 (Sevilla Este) | | | 2019 (Since January) | 2020 |
|---|---|---|---|---|
| kg collected | | | 149,300 | 108,600 |
| Nº collections | | | 57 | 31 |
| Frecuency | | | 1 collection per 5.9 days | 1 collection per 11.8 days |
| kg / collection | | | 2,619 | 3,503 |
| Kg per day | | | 447 | 297 |

| Route 303 (Bellavista Bermejales) | | | 2019 (Since March) | 2020 |
|---|---|---|---|---|
| kg collected | | | 139,340 | 174,578 |
| Nº collections | | | 41 | 37 |
| Frecuency | | | 1 collection per 6.8 days | 1 collection per 9.9 days |
| kg / collection | | | 3,398 | 4,718 |
| Kg per day | | | 499 | 477 |

| Route 301 (Macarena - Norte) | | | | 2020 (Since November) |
|---|---|---|---|---|
| kg collected | | | | 8,200 |
| Nº collections | | | | 4 |
| Frecuency | | | | 1 collection per 12.5 days |
| kg / collection | | | | 2,050 |
| Kg per day | | | | 164 |

As can be seen in the figures, the COVID-19 pandemic has had a negative effect on the segregation at source of biowaste, due to being an issue to be analyzed for future implementations.

### 4.2.2. Waste composition

In this section, the composition of the waste deposited in the containers of organic waste mixed with rest (gray container) and biowaste (brown container) is analyzed.

Regarding the gray container, the latest available samples (2018) provided by the company Abonos Orgánica de Sevilla, S.A. (ABORGASE), waste treatment concessionaire of the Mancomunidad de Los Alcores, are the following:

*Table 27. Waste composition (in weight) of grey container (rest + organic waste). Source: ABORGASE internal Data.*

| 2018 | |
|---|---|
| **Waste Fraction** | **%** |
| Biowaste | 47.12 |
| Paper and Board | 15.71 |
| Plastics | 14.33 |
| Glass | 4.96 |
| Construction and Demolition wastte | 3.28 |
| Metals | 2.99 |
| Wood | 2.91 |
| Bricks | 1.14 |
| Batteries | 0.01 |
| Textil | 2.29 |
| Tires | 0.32 |
| Celluloses | 4.64 |
| WEEE | 0.2 |
| Others | 0.1 |
| Total | 100 |

From the above data, it is extracted that the amount of biodegradable organic matter (biowaste) present in the grey container is more than 110,000 tons per year. Moreover, there are a significant presence of others waste fractions, which have containers on the public street, such as:

- Glass, being collect mixed around 11,500 tons per year.
- Light packaging, being collect mixed around 34,000 tons per year.
- Paper and board, being collect mixed around 37,000 tons per year.

During the years 2017 - 2019, various characterizations of the biowaste fraction have been carried out, where a distinction has been made between biowaste produced by large generators and small generators. For both producers, the 56% residue collected was strictly

biowaste. If we include paper and cardboard and other celluloses, the percentage of biodegradable waste would be around 75%.

*Table 28. Biowaste composition (in weight) collected in Seville. Source: LIPASAM internal data.*

| | ***Large generators*** | ***Small Generators*** |
|---|---|---|
| Biowaste | **56.62%** | **56.38%** |
| Paper and board | 13.33% | 8.54% |
| Celluloses | 5.41% | 10.24% |
| ***Total Biodegradable waste*** | **75.36%** | **75.16%** |
| Lightpackaging | 8.20% | 3.83% |
| Glass | 6.80% | 5.79% |
| Rest | 9.63% | 16.15% |
| ***Total*** | 100.00% | 100.90% |

### 4.2.3. Treatment given to waste.

The treatment carried out for the mixed waste, lightpackaging, glass and paper an board fractions is described below. To see biowaste treatment, see section 4.2.4.

The treatment of the waste collected in the grey (mixed waste) and yellow (lightpackaging) containers is carried out in the same location.

The city of Seville belongs to the Mancomunidad de los Alcores for the waste treatmen, whose center is located in the Montemarta -Cónica farm, in the municipality of Alcalá de Guadaíra, the current concessionaire being the company Abonos Orgánica de Sevilla, SA (ABORGASE).

The treatment center consists of two differentiated units: one for mixed waste and another for lightpackaging. In addition, it has a support landill for rejections.

**Mixed waste (organic fraction + rest fraction)**

The design capacity of the mixed waste treatment plant is 450,000 tons/year, and it is made up of 6 treatment lines of 15 tons/hour. Each line consists of:

- A 12 m long trommel per line, equipped with bag opening blades and a 110 mm mesh sieve.
- 35 mm mesh size sieves for the organic fraction.
- Conveyor belts at the exit of the trommel, for each line.
- Belt for collecting and transporting the “sunken trommel” (organic matter to fermentation).
- Electromagnet for the separation of ferrous metals.

The manual separation of high-density polyethylene (HDPE), polyethylene terephthalate (PET), brick, paper and cardboard and ferrous materials is carried out. The amount of recovered materials is around 9,100 tons/year.

The organic matter is then directed to the fermentation zones, primary refining (equipped with a 35 mm mesh trommel), maturing park outdoors (about five months after primary refining and one after secondary) and secondary refining (equipped with trommel of 10 mm mesh size and densimetric table).

Some 30,000 tons of biostabilized material are produced annually, of which it can be interpolated that around 15,000 tons come from waste generated in the city of Seville.

The percentage of waste deposited in the landfill in relation to entering the treatment plant is approximately, and depending on the material entering the plant, higher than 76.00%.

*Image 2. Images from Monte Marta Cónica Treatment Plant (Mixed waste treatment and landfilling). Source: Aborgase web page: https://www.aborgase.com/*

The treatment center also consists of a leachate treatment plant through forced evaporation and a plant for degassing the landfill and generating electrical energy using internal combustion biogas engines (10.41 MW), capturing about 75 million $Nm^3$ annually. , which represents an electricity generation of 70,000 MWh/year.

**Lightpackaging**

The lightpackaging treatment plant has a capacity of 9,700 t / y (a line of 5 t / h). It is an automated plant in which an average of 5,700 t / y of HDPE, LDPE, PET, mixed, aluminum, steel and brick materials are separated. In the first place, a manual sorting is carried out in the cabin where bulky, HDPE, etc. are eliminated, and the ferrous ones are eliminated by means of an electromagnet. The trommel is divided into two zones of different mesh size, the first of 70 mm and the second of 250 mm. The first sink constitutes the fine rejection that goes to the landfill and the second 250 mm one leads to the ballistic separator. In the ballistic, the planar

and rolling fraction are separated; the latter goes to the optical separator where materials are recovered. The fraction that continues through the trommel is mainly film, which is also recovered. The rejects of the planar and rolling fractions are joined and destined for landfilling.

**Glass and Paper and board.**

The management of paper, cardboard and glass waste is carried out through authorized managers in particular:

- For glass: Recuperadora Andaluza de Vidrio (RAVSA S.A.), located in the municipality of Alcalá de Guadaira, near Seville. In this treatment plant, the glass is conditioned, classified and crushed, producing calcine as the final product, which is transported and sold to packaging companies.
- For paper and cardboard: S.Solís Recovery and recycling, located in the municipality of Alcalá de Guadaira, near Seville. In these facilities, the material is preconditioned, to be later transported to the paper and cardboard recycling plant.

### 4.2.4. Biowaste treatment in Seville.

The selectively collected biowaste is sent to Cónica Montemarta plant for his treatmet as compost.

At the Montemarta-Cónica facilities, once the access control and weighing scale have passed, the selective organic matter is unloaded in the reception hall, in its specific storage area, which is delimited, concreted and with leachate redirection . It is stored in it for a short period, until a sufficient quantity is obtained for processing.

*Image 3. View of Monte Marta Cónica Treatment Plant. Source: Aborgase web page: https://www.aborgase.com/*

During storage time and throughout the entire process, water and moisture losses are constant.

The waste is transported by means of a grapple crane to the hopper of the 110 mm trommel.

In the tromel, the improper ones larger than 110 mm are separated. The fines from the tromel go through a conveyor belt to the fermentation hall, where they are deposited in an independent plot, separated from any other waste.

Once the first stages of fermentation and self-heating have been reached for a minimum of 15 days, in which due to high temperatures (70ºC) pathogens, weed seeds and insect larvae are eliminated, it is turned over to oxygenate and is introduced into the second screen, or tromel with a diameter of 35 mm, whose sunken is transported or transferred to the maturation zone.

The stay in maturation is about 6 months, during which the high temperatures are lost, it is turned to improve the oxidation conditions, and the composting process is completed, intervening throughout this process, sequences of microorganisms and decomposing fungi whose end result is the stability of the compost.

Once this maturation period has passed, the compost will be passed through a 15 mm sieve and a densimetric table, which will leave the final compost free of impurities such as stones, or glass-ceramic remains.

This final compost will also be subjected to various analyses, prior to its dispatch, including the maturity test and all the parameters necessary for its classification as an organic amendment useful for the improvement of the soils of the cultivation fields and its enrichment in nutrients for the vegetables.


*Image 4. View of exclusive area for compost maduration which becomes from biowaste collection. Source: Aborgase web page: https://www.aborgase.com/*

In particular the analyses carried out are (information obtained from internal interviews):

**INTERNAL CONTROLS**

The analyses carried out for the quality analysis of the compost in the laboratory are: Temperature, pH, Humidity, Ash and Organic Matter by calcination, percentages of Inert and degree of Maturation.

**EXTERNAL CONTROLS (BY ACCREDITED LABORATORY)**

- Humic determinations (%): Fulvic acids, Humic acids and Total humic extract.
- Main nutrient elements: N (%), K (% K2O).
- Granulometry: <25 mm (%), Impurities> 2 mm (%).
- Other characteristics: Conductivity (dS / cm, 25ºC), Humidity (%), pH.
- Organic richness: Total organic matter (%), C / N ratio.
- Heavy Metals (mg / kg): Cd, Cr, Cr VI, Hg, Ni, Pb, Cu, Zn.
- E. Coli (NMP / g in 25 g).

From the tons of biowaste selectively collected in 2020, 212 tons of compost were produced. The main clients were small farmers, and the application of this compost was the restoration of soils and the improvement of degraded soils mainly.

In general, the acceptance by farmers of compost from selectively collected biowaste has been good, although this production is still very incipient.

### 4.2.5. Biowaste codigestion experience.

Biomethanization or anaerobic digestion is a biological process that, in the absence of oxygen and throughout several stages involving a heterogeneous population of microorganisms, allows the most degradable fraction of organic matter to be transformed into biogas, a mixture of gases mainly formed by methane and carbon dioxide and by other gases to a lesser extent (water vapor, CO, N2, H2, H2S,…) (MITERD, 2021)

Biogas is a gas composed mainly of methane (CH4) and carbon dioxide (CO2), in variable proportions depending on the composition of the organic matter from which it was generated. The main sources of biogas are livestock and agro-industrial waste, sludge from urban wastewater treatment plants (WWTP) and the biodegradable organic fraction of household waste (biowaste).

Anaerobic digestion is one of the most widely used techniques for the stabilization and reduction of the sludge generated in a Wastewater Treatment Plant (WWTP). This technology allows treating sludge, minimizing the volume of this waste, and producing biogas useful for generating energy in a cogeneration facility, which means into a reduction in the facility's operating costs. In this context, for several decades, the wastewater treatment plants of the city of Seville have biogas production systems based on an anaerobic digestion process of their sludge. (López Villa, 2018).

Codigestion is used to express the joint anaerobic digestion of two or more feedstocks of different origin. The main advantage lies in taking advantage of the synergy of the mixtures, compensating for the deficiencies of each of the feedstock separately. The fact is that, taking advantage of the existing volume, the sludge digester of a WWTP offers the possibility of incorporating other substrates that compensate the balance of nutrients and humidity and increase, in a very important way, the biogas production performance of this process. .

Additional advantages of the process are obtaining a valuable sludge that can be used as an organic amendment following current legislation and the unification of the management of various waste by sharing treatment facilities, reducing investment and operating costs. The codigestion process is a solution for waste with a high organic load that, at the same time, causes an improvement in the production of biogas from WWTPs. It is a procedure for the recovery of non-hazardous and difficult-to-manage waste, which can facilitate proper compliance with environmental regulations (López Villa, 2018).

In recent years, EMASESA, the company that manages the water cycle in the city of Seville, has opted for the co-digestion, together with its sewage sludge, of other industrial effluents with significant biodegradable organic matter content, to increase the production of renewable biogas.

EMASESA over the years has carried out full-scale pilot tests with different substrates (information obtained during internal interviews):

- Of industrial origin: Dairy fats, flavored waters, fats from the manufacture of biodiesel, with high glycerine content, waters from the manufacture of sauces, leachate from landfills, sugar waters and fatty waters, among others.

*Image 5. Co-digestion Pilot Plant overview, feed tank and gas flow meter from EMASESA.*

- Municipal waste, particularly with pruning waste and bitter orange. In 2020, EMASESA in order to advance in its line of work of transforming and optimizing wastewater treatment plants, carried out a pilot project together with the Ecological Transition area of the Seville City Council and with the involvement of the municipal service of Parks and Gardens that Its purpose is to evaluate the viability of generating clean energy from bitter oranges from the public road (City Council of Seville, 2021). The pilot project was

carried out with 35 tons of bitter orange and approximately 1,500 kWh were generated. Likewise, bitter orange was valued in two ways:

- On the one hand, the juice was extracted so that it could enter the anaerobic digestion process.
- The rest was composted in a small composting plant

Given these previous experiences, it is considered of special interest to carry out a pilot test with biowaste collected in the city of Seville at the Emasesa facilities in order to evaluate the production of biogas.

The management of biowaste through EMASESA would have another added advantage. Currently, biowaste is transported to the Montemarta-Cónica treatment plant, located about 37 km away, so its management in the EMASESA plants (closest) would mean savings in terms of traveling fewer kilometers, less fuel consumption and lower CO2 emissions.

## 4.3. Current status of compliance with municipal waste targets.

After analyzing the information described in previous sections, the situation in Seville is summarized below in terms of the main objectives to be faced in the matter of municipal waste.

At this point, it is worth highlighting the difficulties of local administrations in capturing some of the data necessary to carry out statistical monitoring and compliance with objectives in their field; in particular, those referring to commercial waste management through private companies outside the municipal services.

*Table 29. Status of Seville regards to the compliance with municipal waste targets.*

| Items | Milestones | Comments | Situation of Seville 2020 |
|---|---|---|---|
| Selective collection of paper, metals, plastic, glass and biowaste. | Biowaste ystem implemented before 2021 | Separate collection systems must be adapted to this separate collection. | In Seville, the selective collection of biowaste has started in an incipient way. The rest of the fractions are consolidated. |
| Paper, metals, glass, plastic, biowaste or other fractions destined for preparation for reuse and recycling | At least 55% by weight before 2025 | Households and commercial waste | Around 22% |
| Selective collection of Biowaste | 20% before 2016 and 40% in 2020 | For composting or anaerobic digestion | Around 2% of the theoricall quantities generated. |

| | | | |
|---|---|---|---|
| Biodegradable Waste Landfilling | less than 35% biodegradable generated in 1995 | The maximum quantity that should be deposited would be around 38,500 tons / year of biodegradable (for this calculation the paper and cardboard fraction has been omitted). | 61.44% |
| Landfilling of the rejection of recovery and composting plants | Less than 10% for 2030 | | 68,26% |

## 4.4. Payment of waste fees.

Derived from the provision of the municipal solid waste management service that is generated (or that may be generated), the households and commercial establishments, surfaces and/or facilities of any kind in which they are directly exercised or indirectly economic activities of all kinds, business, professional and artistic, as well as the provision of services by public administrations or other entities that do not act on a business basis, are required to pay a fee to the Seville City Council, regulated by the Municipal tax ordinance regulating the municipal waste collection and sanitary waste

The amount of the fee meets different parameters or circumstances depending on the nature of the activity, surface area, rates for the provision of sanitation services (wastewater treatment), etc. The waste fee in Seville is calculated differently depending on the waste generator.

- For households, the rate has a fixed component for the provision of the Service and a variable component, based on the cost of providing the sanitation service for the water consumed in the home (wastewater treatment) multiplied by a coefficient (52.34%). The fee is paid on a quarterly basis.
- For commercial establishments, etc. the fee is constituted by a fixed amount, depending on the surface of the establishment and a coefficient depending on the economic activity carried out.

As an example, a typical household in the city of Seville, consisting of 3 people and a standard water consumption of 4 $m^3$ per person and month, the annual amount of the waste fee is € 97.57.

One of the economic instruments that can contribute greatly to the achievement of the European waste recovery and recycling targets is the payment for generation. The payment system for generation (PAYT, Pay As You Throw) has proven to be the most efficient in terms of better separation of waste at source, because in a certain way, waste is clearly linked to the generator in the first place and a certain feeling of "belonging" and responsibility is generated.

This system, at the European level, is implemented in several municipalities and cities, although the degree of maturity is highly variable, even between regions of the same country.

In Spain, up to now, PAYT systems have had little implementation despite the fact that there have been initiatives aimed at promoting this type of system. These initiatives include the National Urban Waste Plan 2000 – 2006 (Plan Nacional de Residuos Urbanos 2000 – 2006), which established various measures aimed at promoting PAYT systems, such as:

- *Pilot experiences for the quantitative application of the "PAYT" principle.*
- *Implementation of progressive taxing systems, to be put into practice by local entities, based on the quantitative application of the "PAYT" principle.*
- *Application of economic instruments that incorporate in their amount all the real costs originated by the correct waste management.*

Likewise, the Plan included other measures that, although not directly related to the establishment of rates for payment per generation, could facilitate the technical implementation of the systems necessary for the implementation of the necessary collection systems.

- *Incorporation of mandatory criteria into building and urban planning regulations in new actions that include spaces and facilities for the containerization and selective collection of urban waste, both in private homes and in common areas.*

Some examples of the implementation of this system can be found, mainly in small municipalities such as Argentona, Torrelles de Llobregat, Miravet and Rasquera (Catalonia).

A large part of the municipalities, both at the Spanish and European level, that have implemented this type of systems, part of a door-to-door collection scheme, in which the citizen (or household) is identified or is easily identifiable. The traceability of the origin of the waste is diluted, and is more complex, in those cities that have opted for a collection scheme through common contribution points, such as large capacity containers on public streets, which is the case of Seville.

For the progressive implementation of this system in Seville (and related cities), at least three previous steps would be required:

- A first one consisting of separating the municipal waste collection and management fee from other fees or concepts that were associated (in the case of Seville, the fee, as mentioned above, is associated with the cost of wastewater treatment, although in separate concepts) and the definition of the rate based on the amount of waste generated and not on other parameters (surface area, number of inhabitants of the home, activity, etc.).
- The second step would be to develop a formula / way that allows knowing the traceability of the waste deposited in the containers. For this second, the incorporation and operation of access control systems is especially interesting, such as those that

are installed on a pilot basis, in Seville, in the containers destined for biowaste collection.

- Analyze and implement the legal instrument that allows to benefite and / or penalize citizens for their behavior in terms of segregation at source of waste.

# 4.5. Awareness and Communication

## 4.5.1. Awareness at a general level Seville.

Awareness, communication, information and training are a key element in the proper collection of waste. The real performance of the recycling or material recovery treatment processes is clearly diminished if the waste streams entering these processes do not have a minimum level of quality, that is, if the fractions that enter the different types of treatment plants they have a high content of inappropriate materials, thus generating greater amounts of rejections. Hence the importance of separation at source.

In essence, it is about joining forces in three lines to take advantage of their synergies: the awareness and sensitization of the citizenship and the stimulation of proactive environmental behaviors, the adequate collection logistics and the waste treatment technologies.

For all these reasons, awareness, communication and training actions, both general and specific, have been gradually increased at the local level. Some of these actions have been carried out in coordination with the systems of extended responsibility of the producer for financing the adequate management of the waste derived from the products that they put on the market when they reach the end of their useful life (Non-financial report of LIPASAM, 2020).

Because of the pandemic situation, during 2020, LIPASAM only had been able to do physical communication actions in schools during January – March 2020. Schools are one of the main targets where LIPASAM are focused on. The educational activities have had a total of 15,011 participants.. The participation programs developed are shown:

- *Recycling in your District:* 4,868 participants. Informative talks to participants in Municipal District Workshops.
- *Recycling in Seville with LIPASAM*: 1,273 participants. School visits LIPASAM Environmental Education Center.
- *Recycling in the Classrooms:* 1,071 participants. Educational Actions in School Centers.
- Other Environmental Education actions: 5,216 participants. Sevillalandia, Simof, etc.

The activities had as general objectives:

- Favor the improvement of the quality of life of the population.

- Raise awareness of the importance of the contribution of citizens to the recycling process and to the sustainability of the city.
- Promote environmental education, in the matter of waste and street cleaning, in the educational field and in all citizens in general, to promote responsible behaviours in order to achieve a cleaner, healthier and more sustainable city.

Specifically, some of the objectives on waste management were:

- Explain aspects related to the use of containers.
- Reinforce concepts on recycling and separate collections.
- Publicize the functions that comply with the clean points and the types of waste that should be deposited in them.

To support the communication actions carried out by the company on an ongoing basis, as well as the aforementioned actions, LIPASAM has designed and implemented a new communication strategy that transfers to citizens a new mental framework where LIPASAM is not responsible for the bad attitudes of many citizens who do not take care of Seville, and raises a new debate on the cleanliness of the city, which swings not on the axis "clean-dirty" as up to now, but on the axis "citizens who do not comply- Green / healthy / sustainable Seville".

The development of communication actions during 2020 has been marked by Covid-19 pandemic. During these period five campaigns were carried out, for whose dissemination practically all the local media have been used, that is, print and digital press, radio stations, local television station and media of outdoor advertising, such as MUPIS, urban transport buses and bus shelters.

The campaigns focused on those aspects of urban hygiene directly related to the situation of the pandemic, as well as with the new concept of caring for the city, and those aspects of citizen collaboration with the greatest impact on the state of cleanliness and performance of services. The campaigns were also disseminated through the internet and social networks, by publishing them on the Lipasam website, through the profiles @Ayto_Sevilla and @RetoLipasam, and by carrying out digital marketing actions to optimize the positioning of the information.

Apart from this, during 2020 different specific information campaigns have been developed on the occasion of the implementation of new services or infrastructures or to request citizen collaboration in the use of existing waste collection systems and equipment. Some examples:

- Communication Campaign for the implementation of a separate biowaste collection in the neighbourhoods of the EDUSI Seville Project's area of action.
- Communication campaign regards to the works carried out to improve the pneumatic waste collection system in the Pino-Montano neighbourhood.
- Communication campaign on the correct use of containers (labelling of messages on the pavement next to the container locations).

With this, during 2020 a 449,222.39 € have been invested in the development of campaigns and informational and public awareness actions.

## 4.5.2. Biowaste Awareness and Communication.

Current biowaste campaigns have always focused on the collection stage, without paying attention to previous or subsequent stages (reminders, prevention, self-composting, etc.). Campaigns related to biowaste have always been associated with the installation of the system in new neighbourhoods or in the facilities of large generators (Hospitals, Hotels, etc.).

For large generators, the methodology that has been followed has been the previous visit to the establishment and meetings with the management staff. Subsequently, training sessions are held for employees in small groups. This training is carried out by direct LIPASAM staff.

For citizens, the methodology of the communication action follow the next schemes:

*Table 30. Biowaste communication campaings methodology.*

| Action | Timing | Coverage (example of 1 collection route). |
|---|---|---|
| **Previous information to the Municipal District and neighboring entities of the implantation area..** | This action is carried out prior to the installation of the containers (1 month approx.) | 1 collection route = 150 containers = around 50,000 – 60,000 inhabitants. |
| **Placement of informative posters in residential buildings.** | In parallel with the installation of containers (1 month approx.). | 2,500 residential buildings. |
| **Door-to-Door Information Action in commercial establishments in the implantation area** | In parallel with the installation of containers (1 month approx.). | 350 -370 comercial establishments. |
| **Information Points in the Street.** | In parallel with the installation of containers (1 month approx.). | 3,000 – 4,000 inhabitans |
| **Digital marketing campaign, on the internet and social networks** | 2-3 weeks. | - |

So far, 3 campaigns have been carried out with this methodology.


*Image 6. Examples of leaflets and others products given during communication campaings.*

# 4.6. Future scenarios of waste generation.

In general, it is a matter of coupling the curve of future generation of municipal waste to economic magnitudes (for instance, variation of GDP or ICP) or demographic ones (population growth rate).

It is obvious to say that the shape of the waste generation curve in recent years responds to a large extent to the economic cycle, roughly identifying the boom years and the crisis, and observing an increase in generation in 2015 for the first time since 2009.

This increase has continued during 2017 - 2019, and it has been interrupted in 2020 during the pandemic caused by COVID-19.

Given the availability of a wide historical series on the generation of the different types of waste in the city, the maximum amounts of waste of each type generated in recent years are taken as a reference.

Following this criteria, organic fraction (biowaste collected mixed) and the rest fraction (grey container), would generate slightly less than 300,000 tons per year. If a presence of biowaste is considered in the range of 42% to 47% (47.12% in the last available characterization, not including paper / cardboard and wood), this means, around 120,000 t / a of biowaste, having to be the mid-term objective, to capture the maximum amount of this waste, in order to meet the European recycling targets.

*Table 31. Maximum waste generation scenario in coming years by type of waste (in tons).*

| Type of waste | Maximum generation scenario in coming years (tons) |
|---|---|
| Rest fraction (mixed waste) | 175,000 |
| Biowaste | 120,000 |
| Glass | 8,000 |
| Paper and Board | 15,000 |
| Light-packaging | 15,000 |
| Pruning waste (only collected by “Clean Points”). | 300 |

## 4.7. Environmental aspects of selective collection. Biowaste.

According to the 2009 ISWA (International Solid Waste Association) “White Book”, waste management activities have great potential to contribute to the mitigation of climate change, estimating that the implementation of $CO_2$ reduction measures in their activities would achieve the 18% of the emission reduction target at European level.

In cities, the collection of a new fraction contributes to the degradation of the urban area in terms of land (occupation of space by containers and other equipment) emission of odors and noise immission, although these are outweighed by environmental benefits local and global scale such as the sustainable management of resources, green land protection due to less landfilling, and climate change mitigation due to the recycling and minimization of virgin materials extraction (MAGRAMA, 2013):

- **Waste as a resource**: The separate collection and treatment of biowaste is a way to give value to this material as a resource and close the cycle of organic matter, although

the prevention of Biowaste should be a priority. On the other hand, the waste management models that have implemented a good separate collection of Biowaste have also increased the levels of collection and quality of the rest of the fractions collected separately, enhancing the overall results of material recycling.

- **Prevention of climate change**: The main source of emissions in the waste sector are landfills, in which methane gas is produced as a result of the anaerobic decomposition of untreated organic waste fraction , so its treatment through composting represents a reduction of greenhouse gases. On the other hand, the slow degradation of organic carbon supplied to the soil through the application of compost supposes a sequestration of this carbon in the soil, which, together with its positive effects on the production of biomass, helps to prevent greenhouse gas emissions.
- **Soil protection:** The use of compost derived from biowaste collected separately can stabilize or improve the organic matter content of the soil and promote its biological activity. The application of compost to soils modifies its physical, chemical and biological properties in the long term, which means into positive environmental effects such as less erosion, better water retention and better soil structure.
- **Conservation of natural resources:** Part of the mineral fertilizers needed in agriculture can be replaced by compost, which would contribute to the conservation of non-renewable resources, such as phosphate, and to the reduction of nitrate leaching in water.

The previously announced advantages highlight the improvement in the local and regional environment that the separate collection of biowaste in the city of Seville entails. Likewise, this initiative is included within the Action Plan for Climate and Sustainable Energy (PACES) of Seville, dependent on the 2030 Agenda and the Seville Climate Emergency Plan, framed in the Sustainable Development Goals agreed by the Nations United.

To conclude, as example, taking into account the GHG mitigation coefficient for diffuse sectors, established by the Road Map of the diffuse sectors to 2020, for the selective collection of biowaste, whose final destination is composting (174 kg CO2 / year) in 2020, were mitigated due to the selective collection of 1,776 tons of biowaste, 309 tons of CO2 equivalents.

# 5. Conclusions and action plan.

This section should be understood as the roadmap draft to implement the selective collection of biowaste in the city. Obviously, the integrated strategy must be complemented with measures aimed at preventing the generation of this type of waste, while defining the treatments that are considered most appropriate.

# 5.1. Conclusions and general action lines.

After the data provided in previous sections on waste management and the resulting situation, especially in relation to the fulfillment of currently established objectives and those foreseen in accordance with European and national regulations, the following considerations should be made.

By 2020, the amount of household and commercial waste destined for preparation for reuse and recycling for paper, metal, glass, plastic, biowaste or other recyclable fractions must, together, reach at least 50% in weight.

The **Error! Reference source not found.** stood at 18.8% in 2020 (with the aforementioned reservations about the non-availability of certain waste management data from the commercial sector). Therefore, 81.2% are collected non-selectively.

If attention is focused on the brown container, intended for the collection of biowaste, the amounts collected are still very incipient. Currently only around the 2% of the amount of theoretical biowaste generated in the city is captured, despite the fact that this fraction represents, according to the latest characterization of waste carried out in the city (Table 27), around 47%.

To achieve the fulfillment of the previous objective, and other stricter ones in the 2030 horizon, it is necessary to capture this material (in addition to the rest of the selective fractions), reinforcing the existing selective collections and implanting them in those areas where they basically do not exist. It is necessary to bet decisively on its selective collection. The city is diverse enough to analyze the feasibility of different collection system alternatives depending on the urban areas and generators in question, always trying to do it in the smartest and most optimized way possible.

For its treatment, future actions should be considered following the guidelines of the European hierarchy on waste management, maximizing the recovery of resources contained in waste and minimizing landfilling.

Taking into account the important limitations for the deposit of waste in landfills, the option of anaerobic digestion of biodegradable organic matter for the production of compost and biogas is more attractive than aerobic composting.

In this context, for several decades, the city's wastewater treatment plants have biogas production systems based on an anaerobic digestion of their sludge. Furthermore, in recent years, the city's water cycle management company (EMASESA) has opted for the co-digestion, together with its sewage sludge, of other industrial effluents with significant biodegradable organic matter content, to increase the renewable biogas production.

The fact that biowaste would managed through the city's wastewater treatment plants, in order to produce biogas (renewable energy), has another associated advantage. Currently, the biowaste collected is transported to the Montemarta-Cónica mechanical-biological treatment

plant, located about 37 km away, so its management in the closest wastewater treatment plants would mean savings in terms of driving fewer kilometers , lower fuel consumption and lower CO2 emissions.

In other hand, the selective collection of biowaste must promote a robust market for quality compost.

Given the uncertainty about the public's response to this new container, the city has opted for a container model with an electronic lock opening / closing, through a card that is distributed to citizens who voluntarily want to use it, and to those who they are presumed greater environmental awareness. With this, it is intended that the collected waste is of higher quality, that is, that the percentage of organic waste is higher and that of improper waste is lower.

Likewise, the implementation of the selective collection of biowaste must be implemented gradually, being fundamental not only the citizens, but also the commercial sector. In this, awareness campaigns and incentives for environmentally proactive behaviours of citizens must be key, including systems of payment for generation and bonus / penalty, so that a structural cultural-environmental change is achieved, and all this without forget the actions aimed at the prevention of their generation.

Finally, it is necessary to promote this type of collection in the City Center, due to its high population, tourist and commercial density, taking into account the difficulties that its configuration implies for the installation of containers and the collection operation.

Taking into account the previous conclusions, it is considered appropriate to develop the following general lines over the next few years, which have been grouped according to the stage within the waste management value chain in which they are applicable:

*Table 32. General lines to be developed in the field of biowaste management in the city of Seville.*

| Stage | General Lines |
|---|---|
| Prevention | ▪ Awareness campaigns on waste prevention and recycling.<br>▪ Promotion of self-composting and the use of food waste for domestic livestock.<br>▪ Inclusion of clauses in public purchases that promote the prevention of generation, recycling and reuse.<br>▪ Agreements with organizations, entities, and companies preferably based on the social economy, in order to avoid food waste.<br>▪ Carrying out a waste minimization study in local administration. |
| Collection | ▪ Promotion and implementation of selective collection in large generators.<br>▪ Promotion and implementation of selective collection for citizens. Continuation of tests of surface containers with access control by card.<br>▪ Continuous analysis and periodic adjustments of the collection systems and installed capacity.<br>▪ Study of bonus methods for environmentally proactive behaviors of citizens, in particular segregation at source and payment per generation. Implementation of the legal structure that supports the previous initiatives. |

| | |
|---|---|
| Treatment | ▪ Co-digestion pilot tests.<br>▪ Construction of a comprehensive waste treatment center, in order to increase the recovery capacity of organic matter contained in the waste. |
| Landfilling | ▪ Deposit in landfill of only those waste that have not been able to be recovered / recycled in previous stages. Less than 10% of the waste generated. |

## 5.2. Demoactions to be developed under the Cityloops project framework.

This report is part of the Cityloops project and pretends to be a diagnosis of the current situation of the flow of biowaste in the city of Seville.

Of the general lines of action described in the previous section, it has been considered appropriate to address several of them, which will be developed, on a pilot approach, in two demonstration actions, which will take place during the life of the project (see D3.3 Optimised Implementation Plan – Biowaste Sevilla).

Seville's CityLoops cluster consists of the Municipality of Seville, LIPASAM (Municipal Solid Waste Management Company), EMASESA (Municipal Wastewater Treatment Management Company) and IDENER (Private Research Company). Together it is committed with the CityLoops' approach to close the loops of biowaste in the city promoting a circular economy approach to the city's development.

**DEMO 1 – IMPLEMENTATION OF A BIOWASTE COLLECTION ROUTE IN A NEIGHBOURHOOD OF SEVILLE.**

A selective biowaste collection route will be demonstrated within CityLoops in a city neighbourhood by LIPASAM, the municipal waste management company of Seville.

This project aims to improve both the quantity and purity of the biowaste collected by the city. A set of biowaste collection containers will be installed, for exclusive access to neighbourhood citizens and commercial establishments, with an information and awareness raising campaign to accompany this. A software tool designed to optimise the logistics of biowaste collection is also being developed and will be tested in the demonstration neighbourhood.

Alongside the demonstration action a further (mainly digital) awareness raising campaign will be launched across the whole city aimed at encouraging people, mainly large generators such as Horeca channel, to reduce food waste.

If the demonstration action is successful, recommendations will be developed for upscaling across the city.

**DEMO 2 -BIOMETHANE PRODUCTION FROM BIOWASTE IN CO-DIGESTION WITH**

| SLUDGE |
|---|
| The methane production capacity of the biowaste collected from Demo Action 1, will be tested through a process of co-digestion with sewage sludge in a wastewater treatment plant (WWTP). This is being tested as an alternative to the current collection and transportation of biowaste for composting in a treatment plant more than 32 km far away of the city.<br><br>The aim of this action is to reduce the distance travelled by the biowaste (and consequent fuel consumption and $CO_2$ emissions), and increase the energy self-sufficiency of the WWTP, which is significantly closer to the city. Furthermore, following this action, feasibility studies will likely be carried out to evaluate the use of biowaste, as source of biogas to be used as fuel for the fleet of municipal vehicles, urban buses and heavy-duty vehicles for waste collection, among others. |

In order to launch these demonstration actions, a battery of actions and tools have to be carried out (too see more details consult the Optimized Implementation Plan for Biowaste Demoaction of Seville):

*Table 33. Description of preparation actions and tools to develop/delevoped in Seville.*

| TOOLS | DESCRIPTION | RESPONSIBLE |
|---|---|---|
| ***Preliminary diagnosis report*** | This report. The report analysing the current flow of biowaste in the city (in terms of quantity and quality – both separate biowaste collection and organic matter in mixed waste), together with an overview of current collection and treatment systems, the legal framework, and environmental and financial factors. | LIPASAM |
| ***OMSW flow optimisation tool*** | The software tool developed is based on Material Flow Analysis (MFA) to model different scenarios in terms of routes, as well as the location and expansion of containers. This should serve to improve the management of biowaste and efficiency of the routes implemented. | IDENER |
| **PLANNED ACTIONS FOR DEMO 1** | **DESCRIPTION** | **RESPONSIBLE** |
| ***Installation of 100 separate waste*** | 100 side-loading containers of 2,200 litre with electronic locks will be purchased and | LIPASAM |

| | | |
|---|---|---|
| ***collection containers in one neighbourhood*** | installed (with circularity criteria taken into account in their procurement) in a neighbourhood of Seville<br>The purchase of containers will include circular clauses in order to incorpore recycling materials during their manufacturing.<br>Citizens who want to participate in the system will be able to open the container with a card, in order to guarantee, in the long term, the purity of the waste fraction, which is essential for its subsequent valorisation. | |
| ***Neighbourhood communication campaign on the separated collection system.*** | Associated with the installation of containers in the neighbourhood yet to be selected, a communication campaign will be developed. Various actions will be carried out, focused on improving citizen engagement:<br>▪ Meetings with associations, etc.<br>▪ Physical Information points.<br>▪ Mailing of leaflets and installation of posters.<br>▪ Communication through LIPASAM social networks. | LIPASAM |
| ***Citywide communication campaign on reducing food waste*** | Taking into account the principle of prevention, it is considered necessary to carry out a pilot experience consisting of a communication campaign, aimed mainly at large generators (Canal Horeca) in order to reduce food waste. The actions to be developed within the campaign will be based, mainly on digital marketing. | LIPASAM |
| ***Testing of OMSW flow optimisation tool*** | The tool will be tested in real conditions of operation. Also it is expected that it will support the analysis of biowaste collection in order to improve the efficiency of the different routes deployed in Seville. Ultimately, the tool is intendeds to be used to increase the biowaste collection separately to the whole city, including | LIPASAM Supported by IDENER. |

| | | |
|---|---|---|
| | households and large generators | |
| ***Analysis of the results*** | If the demonstration action is successful, recommendations will be developed for upscaling across the city, being integrated in the Local Plan for Waste Management of Seville. | LIPASAM and IDENER |
| **PLANNED ACTIONS FOR DEMO 2** | **DESCRIPTION** | **RESPONSIBLE** |
| ***Physical characterisation of the biowaste collected.*** | Several physical characterisation, to determine the purity of the biowaste fraction collected will be done. | LIPASAM |
| ***Lab analysis of COD, BMP and others parameters*** | Several chemical characterisations for COD, BMP, etc. to determine the capacity of methane production will be done using samples of biowaste collected from the route of the Demo 1. | EMASESA |
| ***Pilot of energy generation from biowaste collected and sludge*** | Once these characterizations have been done, the dose of biowaste to introduce in the pilot plant can be calculated. The biowaste will be mixed with WWTP sludge before introducing it into the pilot digester. During the course of the test, the production of methane will be measured. The quality of the gas produced will also be analysed, in order to determine the amount of hydrogen sulphide, methane, CO2 and other gas concentrations. | EMASESA |
| ***Revision of the results obtained.*** | Data obtained will be used to define the methane production potential of the biowaste, in order to design the pre-treatment system or the process strategies for managing the anaerobic digestion of the WWTP. | EMASESA |
| ***Economic and environmental benchmarking analysis*** | Economic and environmental comparison between the base scenario (transport to treatment plant for composting) and the | EMASESA and LIPASAM |

| | | |
|---|---|---|
| | demo action will be done, as part of the analysis results of the demo action. | |

## 5.3. Evaluation

As part of the CityLoops project, and associated with the implementation of the demonstration actions to be carried out in the city of Seville an evaluation process will be carried out. The means of this process is to measure and monitor the progress of the city, committing in becoming more circular. The evaluation process is regulated by an Evaluation plan elaborated in CityLoops framework (D6.2 Evaluation Plan: Biowaste sector Sevilla).

The demonstration actions that are intended to be evaluated through this process are expected to contribute to the following outcomes:

- Advance in the fulfilment of the European, national and regional objectives, in the matter of selective collection, recycling and not disposal in landfill, marked by Directive 851/2018 and 850/2018.
- Strengthen the education, awareness and knowledge of citizens and other socio-economic agents related to the bases of the circular economy in relation to the improvement of biowaste management.
- Promote the inclusion of “circular” indicators and specifications in tender documents and contracts.
- Increase the amount of material that can be recovered / recycled , and therefore, reduce the amount of material that is deposited in landfills.
- Increase the local energy generation capacity from local biomass.
- Generate potential economic and energy savings by optimising collection logistics, making better use of the resources contained in the waste and increasing the self-sufficiency capacity of the anaerobic digestion facilities.
- Reduce the carbon footprint of waste collection activities.

The evaluation process will be carried out during the implementation of the demonstration actions (M18-M44) and will be supervised by the evaluation manager.

It will be produced an Interim Evaluation Report at M36, containing a detailed analysis of the data collected for the indicators selected in the present Evaluation Plan and a review of the success of the approach taken, and a Final Evaluation Report at M44.

The results obtained during the evaluation process will be shared with the group of local stakeholders in Seville.

*Table 34. Evaluation team for Seville.*

| EVALUATION TEAM |
|---|

| Role | Tasks | Organizations |
|---|---|---|
| Evaluation manager | ▪ Data collection.<br>▪ Monitoring and analysis. | Seville city council – César Gallardo Sóler. |
| Supporters | ▪ Data reporting.<br>▪ Analysis. | Demo manager wp3: LIPASAM – Pedro Cruces González.<br>Rest of the Seville Cityloops Cluster. |
| Local stakeholder group. | ▪ Analysis and data reporting.<br>▪ Results sharing | Treatment plant, waste and water managers (private and public), suppliers, public administration, universities, merchants associations, distribution, social organizations and citizens. |

The indicators to be monitored in Seville had been selected from the D.6.1 Evaluation framework and indicator developed by the Nordland Research Institute (NRI). The next table is showing the indicators that have been selected for monitoring, specifying scale it will be monitored and for each demonstration action/tool it will be considered (demonstration action and/or city scale).

*Table 35. Indicators selected to be monitored in Seville.*

| INDICATOR # | INDICATOR D.6.1 | INDICATOR NAME | SCOPE (DEMO/CITY) | DEMOACTION 1 | DEMOACTION 2 | DIAGNOSIS REPORT | IT - TOOL |
|---|---|---|---|---|---|---|---|
| 1 | 4 | CE-related knowledge building campaigns: Qualitative description | D | X | | | |
| 2 | 5 | CE-related knowledge building campaigns: Impact | D | X | | | |
| 3 | 6 | Circularity related stakeholder activities | D/C | X | | | |
| 4 | 11 | Communication measures on circular transformations and waste prevention | D | X | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5 | 18 | Cityloops indicators used in procurement tenders and contracts | D | X | | | |
| 6 | 32 | Reduced costs due to improved circularity | D | X | | X | X |
| 7 | 36 | Total energy demand | D | X | | | X |
| 8 | 38 | Local biomass for energy generation | D/C | | X | | |
| 9 | 52 | Quantity of material subjected to recycling | D/C | X | | X | |
| 10 | 53 | Quantity of material for anaerobic digestion | D/C | X | X | | |
| 11 | 54 | End of Life Collection Rate | D/C | X | | X | X |
| 12 | 56 | Quantity of material for composting | D/C | X | | X | |
| 13 | 58 | End of Life Processing Rate | D/C | X | X | X | X |
| 14 | 61 | Landfilling rate | C | | X | X | X |
| 15 | 62 | Landfilling rates per material fractions | C | X | X | X | X |
| 16 | 85 | GHG emissions per year | D/C | X | X | X | X |

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# CITYLOOPS

CityLoops is an EU-funded project focusing on construction and demolition waste (CDW), including soil, and organic waste (OW), where seven European cities are piloting solutions to be more circular.

Høje-Taastrup and Roskilde (Denmark), Mikkeli (Finland), Apeldoorn (the Netherlands), Bodø (Norway), Porto (Portugal) and Seville (Spain) are the seven cities implementing a series of demonstration actions on CDW and soil, and OW, and developing and testing over 30 new tools and processes.

Alongside these, a sector-wide circularity assessment and an urban circularity assessment are to be carried out in each of the cities. The former, to optimise the demonstration activities, whereas the latter to enable cities to effectively integrate circularity into planning and decision making. Another two key aspects of CityLoops are stakeholder engagement and circular procurement.

CityLoops started in October 2019 and will run until September 2023.

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