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Community Composting: A Practical Guide for Local Management of Biowaste

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Abstract

The members of the professional association Fertile Auro (FeA), have over ten years of experience in fostering decentralized management models for organic waste, with an environmental and social approach based in the concept of circular economy.

They have designed and implemented tens of plans for the local management of organic matter, monitored thousands of domestic and community composters in different territories, gathered and analyzed data and samples from many experiences, both at national and international level... and even designed the first model of a modular community composter. Because of such experience, they found necessary to draft and suggest a reference guide for the implementation of community composting, allowing to foster the model's good practices, and develop the state, community or local regulation guaranteeing both the model's efficiency as well as the minimization of environmental risks and increasing social acceptance.

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The present Guide was developed after various technical meetings of information sharing and discussion about the community composting model for the management of bio-waste, which brought together representatives from the Catalonia Waste Agency (*Agència de Residus de Catalunya);* the Provincial Government of Pontevedra; IHOBE (Basque Government); the Department for Environment of the Provincial Government of Álava; NILSA - Navarre Waste Consortium; the County of Sakana, Navarre; GOIB - General Directorate of Environmental Education, Environmental Quality and Waste of the Balearic Government (*Conselleria Medi Ambient, Agricultura i Pesca - Direcció General d'Educació Ambiental, Qualitat Ambiental i Residus de la Comunitat Autònoma de les Illes Balears*); COR - Valencia Region Waste Management Consortium (*Consorci per la Gestió de Residus, Comunitat Valenciana*) and MITECO (Spanish Energy Transition Ministry).

Such meetings took place in Barcelona (Catalonia), on 16 May 2018, at the headquarters of *Agència de Residus de Catalunya*; and in Pontevedra (Galicia), on 5 and 6 November 2018, at the headquarters of *Plan Revitaliza* from the Provincial Government of Pontevedra.

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1. Introduction

The turn of the Century brought with it a conceptual change on the models for urban waste management, resulting on the gradual implementation, over the past few years, of the circular economy in our society's productive cycle, and where waste, previously considered directly as refuse, is now becoming to be seen as a resource.

Although such approach varies in intensity from one country and society to another, it is undeniable that societal worry about the immediate surroundings is becoming increasingly relevant, mainly since the consequences of climate change are more conspicuous and have direct and indirect adverse effects worldwide. Nevertheless, such concern runs against the serious lack of environmental education and training spread among the population, who have minimal knowledge and interest in issues related to the waste that we generate, and ignore the real environmental, economic and social consequences entailed in the most traditional waste management models. The result is a dichotomy between, on the one hand, the regulations and strategic plans set by the main international organisms to boost the circular economy in terms of waste and, on the other hand, the stagnation of some States, societies (and certain industrial sectors) not moving forward towards such model change.

In this context and closely to the citizens, the European Union has clearly set next steps for all its members, in order to progress towards an overall improvement regarding urban waste management, whose hierarchy is to be respected. First measures should include minimization and prevention, leaving as last options the energy recovery and landfilling of waste. However, one of the main axis around which this strategy is developed, is the establishment of the differentiated management for the organic domestic waste, as well as for other also organic streams from the nature generated in the municipalities (garden and park waste and remains from fresh product markets), collectively referred to as bio-waste.

Thus, the EU has set[1] the obligation of managing separately such bio-waste by following very precise delays and goals: 31 December 2023. The Spanish State, for its part, has recently displayed to the public the transposition of this requirement to the Law 22/2011 on waste and polluted soils (*Ley 22/2011, de residuos y suelos contaminados*). The current situation within the different regions is however completely uneven. Catalonia mainly, but also Basque Country and Navarre, stand out for including the selective collection and treatment of bio-waste as part of their urban waste management model, though without having reached the whole population yet. In the remaining regions, at best, the selective collection has only started in some cities, but without specific treatment facilities so far. Against this backdrop, landfills are currently the destination of 57.8% of all the urban waste generated in Spain, while composting of selectively collected bio-waste does not exceed 0.8% (Eurostat and MAPAMA).

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[1] Circular Economy Package (approved in April 2018).

As we face the important challenge of the differentiated management of bio-waste, which is essential to reach real recycling rates of the generated urban waste, serious difficulties are found:

- Scale of treatment: the existing management models are based on the concepts of economy of scale and centralisation of the treatment, which condition the design of new models adapted to the prevention and differentiated management of bio-waste. It should be considered that there are many European regions that lack any kind of waste treatment facilities, even for the residual waste fraction.
- Lack of specific facilities: the design of existing facilities, mainly based on mechanic-biological treatments, lacks the needed flexibility to ease their adaptation to the biological treatments of bio-waste in appropriate conditions guaranteeing the completion of the transformation process of organic matter. It creates the need of designing and building new facilities adapted to the quantities and typologies of bio-waste. The minimum time needed for such facilities to be operational is, in average, two years. The other inputs needed so that these facilities work optimally, must also be taken into account.
- Cheaper management costs (collection and treatment) against other options: a very common problem in many territories is that, of all the real activity costs of alternatives placed on the bottom of the international waste management hierarchy, some are unallocated. Mainly those arising from its environmental impact. Therefore, they end up looking cheaper options than those fostering minimization and recycling of bio-waste.
- Economic crisis: the current socioeconomic background and the significant reduction of the European funds allocated to development, represent a loss of investment capacity of the local administrations.

It is in this context that small-scale **decentralised composting** has made its way. First through very precise pilot experiments, but in the last ten years the implementation of this model has become, in some areas, the efficient alternative to the decentralised collection and management of bio-waste. This is because this biological process adapts easily to different operational scales, as long as the basic parameters guaranteeing the action of microorganisms, in optimal conditions and with minimum affections, are respected.

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In the specific case of **community (or collective) composting** understood as the composting carried out by different generators (mainly families) in the same shared and nearby area—, a number of positive effects and synergies are found, unlike in other scales of treatment.

Such aspects cannot be easily evaluated in quantitative terms, but qualitatively they are particularly transcendent in the surroundings:

- Increase of the public environmental awareness.
- Transparency in the management and the costs, which fosters participation.
- Creation of job positions directly related to circular economy, that may also be focused on boosting the integration into the labour market of people at risk of social exclusion.
- Improved management of the other selectively collected fractions in terms of quantity and quality, which means a reduction of the residual waste fraction.
- Improved legal and agronomic quality of the final product: compost.
- Possibility of being a real and feasible alternative (or complement) to the models of centralised bio-waste management including collection and transport, most notably in rural and semi-urban areas.

This only happens, though, when the composting process is properly followed, from the design and dimensioning of the community composting sites, as well as the characteristics of the used materials, to the training of staff in charge.

However, different models for community composting at this scale have spread in recent years, but they were only conceived as a reproduction of experiences from other places, without an analysis of the real needs of each case, a technical criterion or social perspective when making decisions. In those cases, such mistakes and bad practices have provoked negative environmental affections, scarce involvement of citizens, increase of economic costs, etc. They cannot be considered as representative examples of the model's reality, but they should serve as a warning of the consequences that an inappropriate approach to the management of bio-waste through community composting may involve.

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This aspect is the one that would worry local governments the most when authorising and fostering the implementation of this model, but the technicians **lack specific legislation and regulations on this scale of management,** as well as information about successful experiences or models and examples of best practices. In every country where community composting has spread, it happened the same.

So far, the most common practice when trying to regularise, has been taking as reference the regulation applied to the industrial facilities for waste treatment, and apply it to the community composting sites. At best, it means that the model becomes unaffordable due to the economic costs and administrative paperwork to be undertaken. But, meanwhile, the environmental, economic and social benefits of the community composting initiatives developed under appropriate criteria, have become patent and proved. Therefore, the approach on this issue should not be based on the adoption of a restricting regulation, but of one ensuring that, when implementing the model, it is done with all technical guarantees to assure the fulfilling of the conditions needed to be successful, because it would be adapted to the different circumstances and needs from each locality.

It is hence needed to provide a specific regulation state-wide, as already being done in different European countries, as well as in the United States and in Canada. To that end, it is advisable to share in advance experiences and knowledge between those territories that already consider community or collective composting as an alternative to the models of selective collection and centralised treatment of bio-waste. In this way it will be possible to determine which are the real keys that allow a model to work correctly, mainly at the practical level, and thus create a regulation gathering them under a technical criterion based on the knowledge of the biological process at this scale.

> "That whole approach is the basis for this Community Composting Guide, containing all data, knowledge, interests and difficulties gathered by the drafting team along their professional careers."

That whole approach is the basis for this Community Composting Guide, containing all data, knowledge, interests and difficulties gathered by the drafting team during their professional careers. In parallel to its drafting, a discussion forum[2] has been created, with technicians from the different Spanish administrations where this model is being implemented as an alternative for the differentiated management of bio-waste generated in their urban areas.

[2] Started at a meeting that took place on 16 May 2018 in the premises of the *Agència de Residus de Catalunya* in Barcelona, to which technicians from Catalonia, Basque Country, Navarre, Pontevedra, Valencia and the Balearic Islands were invited.

2. Scope and Objectives of the Guide

This Practical Guide to the implementation of community composting is framed within the global policies and strategies on circular economy for the local management of bio-waste and the promotion of recycling.

It intends to serve as a **reference to guide technicians, companies, users, public administrations and further stakeholders, on the community composting practices and on the operation of the dedicated areas.** Furthermore, **the document includes a proposal for classification of the community composting sites** and the follow-up requirements that they should meet according to their degree of vulnerability. Both the Guide and the provided classification were defined by considering all the cases currently implemented in Spain, as well as other international examples, and by taking into account the experiences shared by the technicians in charge of their implementation and operation.

In the light of the above, the **main objective** pursued by this Guide is to be a tool for the planning of the community composting practices and description of the best operational and follow-up techniques, so it could be use as a reference for future implementations of community composting.

"…the **main objective** pursued by this Guide is to be a tool for the **planning of the community composting practices and description of the best operational and follow-up techniques…**"

With the aim of fulfilling the main objective and leading to the creation of a useful, didactic and concise document, including also all aspects to be taken into account before getting started in community composting, following specific objectives have been set:

- Identify and assess the technical and social feasibility of the current community composting practices.
- Identify existing regulations at regional, national and international level.
- Define the most appropriate operational practices that facilitate the successful development of new community composting sites and the improvement of existing ones.
- Develop a realistic classification of types of community composting sites according to the included technical, environmental and social parameters.
- Establish the requirements for the process follow-up and control, that will be specific and adapted to the needs of each type of site.
- Define the social challenges of the implementation of community composting.
- Share the results obtained in previous experiences.

3. Glossary

One of the most common difficulties in this context and at this scale of composting process, lies in the definition of the specific terms related to the model. The definitions of the most frequently used terms are shown below, together with an informative image.

3.1. General glossary related to decentralised composting

Individual or home composting Treatment of bio-waste generated by individual persons or families, done by application of the composting process in their own house, terrace, garden, vegetable gardens, etc. It implies particular usage of the resulting compost.	
Community (or collective) composting Usage of the composting-at-source technique so that bio-waste generated by several individuals, families or generators is jointly treated in a single module, within a common area purpose-set.	
Restricted in situ modular composting for large or singular generators Usage of the composting-at-source technique so that bio-waste generated by one single entity or activity is jointly treated through composting, in an area or site placed within the land owned by the generator.	
Municipal/communal composting Usage of the composting technique to treat organic waste generated in a place, town, neighbourhood, municipality, etc.	
Supramunicipal composting Usage of the composting technique, in a single facility with limited capacity and simple technology, to treat bio-waste generated in several close municipalities, in a district or county, etc.	

Technical unit of community composting Set of facilities or equipment needed to develop the whole community composting process, including all its phases, as well as the storing of structuring material.	
Information/awareness campaigns Communication and dissemination actions and activities targeted to local citizenship. Their goal is to expose the key and operational aspects of the new bio-waste management model, as well as to solve doubts and receive suggestions and ideas from the public to increase its efficiency.	

3.2. Glossary related to composting sites

Module Cell or unit where the bio-waste is deposited through the upper part and, once filled, extracted through the side or front part to continue its maturation process in another module or area. The combination of several modules creates a community composting site. When one module is appointed to receive the waste input by the users, it is called **input module**.	
Community composting sites Place where the shared composting modules are located, in which several families or generators treat their self-generated bio-waste. Access to them can be free or restricted to users. A community composting site can include one or more Technical Units of Community Composting.	
Community site for home composting Common areas where each family has its own composter, exclusively for their bio-waste treatment.	
In situ modular composting sites for large generators Area, within the facilities of a unique singular generator, where the composting modules for the treatment of bio-waste generated by the establishment, are located.	

Independent rod composter Type of commercial composter made of recycled plastic, whose parts are joined together with rods. At the community composting scale, each of them is considered as one Module.	
Hut composter Type of community composter made of wood and generally consisting of four modules: two for input and two for maturation. They usually have an annexed storing space for bulking material.	
Modular slatted composter Type of community composter made of wood-plastic slats, that can be removed to ease operational tasks and, mainly, transfers. The modules can be joined together, sharing walls, to create composting sites of different treatment capacities.	
Priority areas of interest Areas where certain activities are developed, which may have a larger impact, positive or negative, on the citizens' awareness and consciousness (busy transit points, educative and health centres, hospitals…).	

3.3. Glossary related to the operation

Bulking/complementary material Woody or ligneous material of plant origin that, mixed with bio-waste in suitable proportions, allows air circulation throughout the mix, prevents compacting, provides carbon and regulates moisture. It is essential to provide it at adequate proportions in order to guarantee the right conditions for the composting process.	
Master composter Technical person responsible for the follow-up of the composting process and the maintenance of each composting point or site. It also usually works in dynamising and informing participants.	

Turning

Periodic mixing of material done with the aim of regaining the matrix porosity and ensuring thus aeration of the material, homogenisation of bio-waste and the structuring material, and optimisation of the moisture level of the mixture.

Watering

Homogeneous water input to the whole volume of the materials mixture being processed, so as to increase moisture level up to optimal values ensuring the degradative biological activity of the microorganisms responsible for the composting process.
After watering the material is usually turned to assure that the supplied water is distributed as homogeneous as possible.

Transfer

Relocation of the material being processed, from one module to another, once the first one has been filled with the inputs of the participants.

Sampling

Extraction of a minimum representative quantity of material, from different points, for their subsequent analysis and/or evaluation.

Traceability

Series of procedures guaranteeing the follow-up of the compost production process at each of its stages, on the one hand, and the applied maintenance activities, on the other hand. In the case of community composting, it is necessary that the operational protocol of the composting site include some guidelines to carry out a correct identification of all the materials during the different phases of the process, as well as to check that the established process conditions and time are respected.

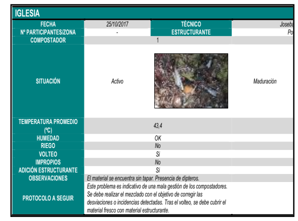
Batch Set of bio-waste provided for composting and physically detached from the rest. It is supposed to have similar conditions all around and, during the process, it is treated within the same period and delay of time and under same conditions. Depending on the model of composting sites and of operational type, the mixing of sub-batches can occur during and/or after the process, in order to eventually create a final batch consisting of several batches from the same site, area, or even from the same municipality.	
Sanitation Minimisation of the presence of pathogen microorganisms and viable seeds due to the effect of the process conditions (mainly temperature and time), down to required levels for a safe use of compost.	
Follow-up visits Periodic examinations of the community composting sites so as to monitor, follow-up and register them. They are done by the responsible technicians of the site, with the aim of checking the composting process status and the registration of the monitoring parameters.	
Maintenance visits Periodic examinations of the community composting sites by the responsible technicians, to perform the varied operational tasks, such as: turning, watering, input of structuring material, etc. with the aim of ensuring proper process conditions and enabling the correction of deviations if necessary.	
Audits Inspection or verification of the location of a community composting site, done by an external auditor, with the aim of checking the fulfilment of the stated regulatory requirements, both regarding the design of the model and its operational protocol.	

Transparency

Availability by the administration, the participants and further stakeholders, of all registries and data arising from the management of the community composting site.

Database

Compilation of all registered data arising from the management of the community composting site, following a common format.



IGLESIA			
FECHA	25/10/2017	TÉCNICO	Joseba
Nº PARTICIPANTES/ZONA	-	ESTRUCTURANTE	Po
COMPOSTADOR	1		
SITUACIÓN	Activo		Maduración
TEMPERATURA PROMEDIO (ºC)	43,4		
HUMEDAD	OK		
RIEGO	No		
VOLTEO	Sí		
IMPROPIOS	No		
ADICIÓN ESTRUCTURANTE	Sí		
OBSERVACIONES	El material se encuentra sin tapar. Presencia de dípteros.		
PROTOCOLO A SEGUIR	Este problema es indicativo de una mala gestión de los compostadores. Se debe realizar el mezclado con el objetivo de corregir las desviaciones o incidencias detectadas. Tras el volteo, se debe cubrir el material fresco con material estructurante.		

GHG emissions (greenhouse gases)

Gases that may be produced due to inappropriate conditions of the composting process and that have a potential impact on climate change (N_2O and CH_4). They are formulated in CO_2-equivalent units. CO_2 produced during the process is not taken into consideration because it comes from biogenic sources.

3.4. Other definitions of interest

Bio-waste
Biodegradable garden and park waste, food and kitchen waste from households, offices, restaurants, wholesale, canteens, caterers and retail premises, and comparable waste from food processing plants (according to Waste Framework Directive amending by Directive (EU) 2018/851).

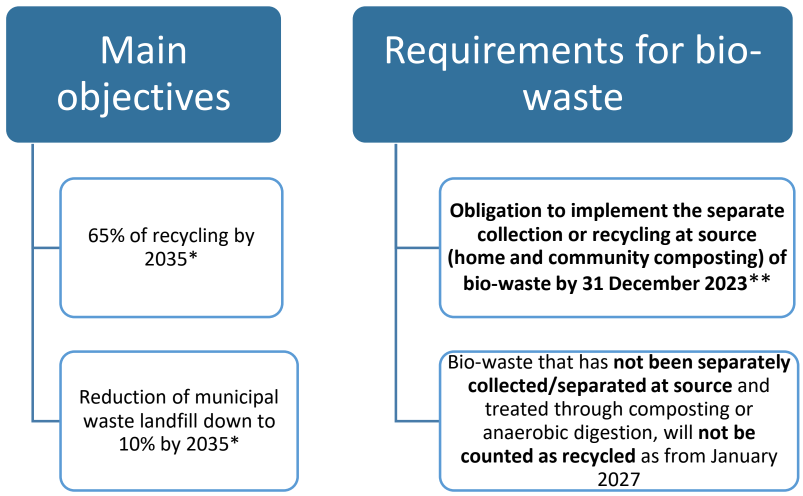
Waste management
Set of operations aimed at addressing waste to the most appropriate destination according to its characteristics, in order to prevent damages or risks to human health and the environment. It involves the collection, transport, recovery (including sorting), and disposal of waste, including the supervision of such operations and the after-care of disposal sites, and including actions taken as a dealer or broker (according to Waste Framework Directive as amendment by Directive (EU) 2018/851)..

Risk
Probability or possibility that while handling, releasing to the environment and being exposed to materials or waste, they provoke negative effects on human health, on the rest of living organisms, on the water, air and soil, on ecosystems and on assets and properties owned by particulars.

4. Regulatory framework

4.1. Bio-waste in the new EU strategy

As mentioned before, one of the main pillars of the EU strategy and objectives on waste management is the correct and efficient selective management of bio-waste, in order to achieve the proper functioning of the system and to meet the set goals:
<u>EU Circular Economy Package (approved in April 2018):</u>



**The objectives of recycling and limiting waste landfilling can only be achieved by a proper differentiated management of bio-waste.*
***Modification of the 'TEEP' requirements (article 10) to limit and monitor those cases that may be considered exception. It is proved that the management of bio-waste can be feasible in every territory and context (broadly speaking).*

4.2. Consideration of community composting in legislation

4.2.1. Waste Framework Directive

The **Waste Framework Directive** (of 30 May 2018) adds some key elements related to community and individual/home composting:

- It introduces the obligation of separating and recycling (treating) bio-waste at source by 31 December 2023.
- It equates composting with selective collection in terms of enforceability of managing bio-waste selectively.
- Composting is considered a (*in situ*) waste recycling activity (so it is confirmed that the idea of framing it as a bio-waste prevention practice should be ignored). Additionally, it means that the tonnes managed through home and community

composting must be included in the waste recycling concept in relation to the achievement of objectives.

- Member States must take measures to foster and encourage home and community composting.
- Recycling processes through composting must ensure a high level of environmental protection and result in output which meets relevant high-quality standards. Such conditions must be also ensured for home composting practices.

Article 22
Bio-waste
1. Member States shall ensure that, by 31 December 2023 and subject to Article 10(2) and (3), bio-waste is either separated and recycled at source, or is collected selectively and is not mixed with other types of waste.
Member States may allow waste with similar biodegradability and compostability properties which complies with relevant European standards or any equivalent national standards for packaging recoverable through composting and biodegradation, to be collected together with bio-waste.

2. Member States shall take measures in accordance with Articles 4 and 13, to:
(a) encourage the recycling, including composting and digestion, of bio-waste in a way that fulfils a high level of environment protection and results in output which meets relevant high-quality standards;
(b) encourage home composting; and
(c) promote the use of materials produced from bio-waste.

3. By 31 December 2018, the Commission shall request the European standardisation organisations to develop European standards for bio-waste entering organic recycling processes, for compost and for digestate, based on best available practices.'.

4.3. Analysis of existing international legislation in terms of community composting

Existing legislation considers, on a more frequent basis, below parameters or requirements as basic:

- Maximum capacity of the facility.
- Type of waste accepted.
- Parameters requested for sanitation.
- Allowed usage-users of compost.

Following table details the content of the analysed pieces of legislation in a summary and comparative form:

	Spain				USA	France	United Kingdom
PARAMETERS	Valencian Region *Orden 18/2018 15 mayo 2018*	Basque Country *Orden 10 abril 2018*	Navarre *Expediente 0003-0102-2017-000638*	Balearic Islands *Ley de residuos y suelos contaminados*	San Diego - California	*JORF n°0095*	*Composting Exemption T23 wales & England 2010*
Definition of community composting	YES	YES	YES	YES	NO	YES	
Previous engagement campaign	Request from authorized users. - Statement of commitment.	Needed training and qualification					
Prevention/Management	Prevention	Prevention	Community prevention	Recycling			
Administrative conditions	Environmental statement or notification of harmless activity	Previous notice of activity	Municipal authorisation	Municipal authorisation			Exemption register, free of charge and online
Determination of sites	By promoters, validation by local authority Requirements: minimum space, security and plagues.						
Access to the community composting site	Authorised users					Established by the master composter	

	Spain				USA	France	United Kingdom
PARAMETERS	Valencian Region *Orden 18/2018 15 mayo 2018*				Basque Country *Orden 10 abril 2018*	Navarre *Expediente 0003-0102-2017-000638*	Balearic Islands *Ley de residuos y suelos contaminados*
Land ownership	☒Public ☒Private			☒Public ☒Private	☒ Public ☐ Private		
Role of the public authorities	Initial validation, inspection and monitoring	Monitoring, data tracking					
Distance to inhabited areas	Respect land regulation, previous consultation if private land	Local regulations, easements		15 m from inhabited areas	1 m from private areas		250 m
Maximum capacity	20 m^3 (it also includes compost) 10 m^3 (bulking material)	10 m^3 (bulking material not considered)		20 m^3 + 10 m^3 of storage for bulking material	76 m^3 in 70 m^2 *Not specified what includes*	1 t input per week	60 t in process 80 t if local use of compost Limits per material: 10 t kitchen and market waste
Allowed materials (users/administration)	☒ Household[3] ☒ Garden/park ☐Wastes from agriculture ☒Others[4]	☒ Household[3] ☒ Garden/park ☐Wastes from agriculture ☐Others	☒ Household[3] ☐ Garden/park ☐Wastes from agriculture ☐Others	☒ Household[3] ☒ Garden/park ☒Wastes from agriculture ☐Others	☒ Household[3] ☒ Garden/park ☐ Wastes from agriculture ☐ Others	☒ Household[3] ☒ Garden/park ☐Wastes from agriculture ☐Others	☒Household[3] ☒ Garden/park ☒Wastes from agriculture ☐Others

[3] EWC 200108: biodegradable kitchen and canteen waste; EWC 200201: biodegradable garden and park waste.
[4] EWC 200101: Kitchen paper (not being dirty with detergent or other hazardous and non-biodegradable substances).

	Spain				USA	France	United Kingdom
PARAMETERS	Valencian Region *Orden 18/2018 15 mayo 2018*				Basque Country *Orden 10 abril 2018*	Navarre *Expediente 0003-0102-2017-000638*	Balearic Islands *Ley de residuos y suelos contaminados*
Operator	1 person (manager)	1 person (technical manager)		1 person (manager)		1 master composter per area/manager	
Users training	Specific training course	-				-	
Operators training	In case he/she performs analysis	Enough technical solvency				Trained	
Follow-up parameters	☒ Temperature ☒Turning frequency In case of malfunctioning - moisture - dry/humid proportion	☒ Temperature ☐Turning frequency Permanence				☒ Temperature ☐ Turning frequency	
Auditory system	-	-	-	-	-	-	-
Required maintenance (visits/turning frequency, etc.)		Report incidents to the city council Monitor waste typology				Avoid cross-contamination	
Recording/monitoring system (traceability)	Operations book (handbook)	Chronological record of all activities, required parameters and pathogens.					
Parameters requested for sanitation	Temperatures above **55 °C** during at least **14** consecutive **days**.	Temperatures above **55 °C** during at least **14** consecutive **days**.				- 55 °C / 14 days - 60 °C / 7 days - 65 °C / 3 days	

	Spain				USA	France	United Kingdom
PARAMETERS	Valencian Region *Orden 18/2018 15 mayo 2018*				Basque Country *Orden 10 abril 2018*	Navarre *Expediente 0003-0102-2017-000638*	Balearic Islands *Ley de residuos y suelos contaminados*
Frequency of compost analysis	Initially: first batch. If OK: yearly analysis.	Representative sample per batch (no sub-batches)					
Responsible for analysis	City council, manager may perform some	Facility holder					
Required compost analysis	RD 506/2013 and its update Pathogens	Pathogens (no heavy metals)		• Sanitation • Physico-chemical characteristics • Biological parameters • Foreign materials			
Compost use	☒Users ☒Parks and gardens ☐ Agricult./comerc.	☒Users ☒Parks and gardens ☐ Agricult./comerc. Excluding food-chain related uses, unless the requirements established in the regulations are fulfiled		☒Users		☒Users ☒Parks and gardens ☒ Agricult/comerc.	
Compost not fulfilling the required analysis results or sanitation	Treated as waste by the city council	Treated as waste					

	Spain				USA	France	United Kingdom
PARAMETERS	Valencian Region *Orden 18/2018 15 mayo 2018*				Basque Country *Orden 10 abril 2018*	Navarre *Expediente 0003-0102-2017-000638*	Balearic Islands *Ley de residuos y suelos contaminados*
Storage of finished compost		In site (or outside under the responsibility of the owner and containerized and/or packaged. Do not alter compost characteristics.				It can be sent to an authorized establishment.	Compost 12 months It is limited the storage of waste before its treatment.
Report information	Annually to General Management: • Number of sites, • Number of participants, • Quantity of bio-waste treated, • Quantity of compost and use, • Control dates.	City councils registration of facilities/sites: a) Individual or legal entity, public or private, b) Identity person acting as technical manager. c) Identity of users. d) Location of the facilities/sites. e) Capacity of the facilities. Autonomous Community may request information for statistics.		Annual data of the authorized facilities/sites to the competent body for waste management of the Government of the Balearic Islands.			

	Spain				USA	France	United Kingdom
PARAMETERS	Valencian Region *Orden 18/2018 15 mayo 2018*				Basque Country *Orden 10 abril 2018*	Navarre *Expediente 0003-0102-2017-000638*	Balearic Islands *Ley de residuos y suelos contaminados*
Others	Local ordinances to regulate the use-access, greater analytical periodicity	Initiatives of educational centers: - Comply with process and compost conditions. - Internal use of compost excluding food chain.					Exception by animal by-products (APBR) Rule 16 for category 3 kitchen waste in facilities that meet: (a) the treated material is only applied to the ground in those facilities/sites; (b) ruminant animals neither pigs are not kept in the facilities; and (c) if poultry is kept in the facility, the material is composted in a secure container that prevents poultry from having access to it during decomposition.

5. Composting process at community level

One of the main advantages of applying composting to the treatment of organic waste is its scalability. In other words, the same process can be used to convert the quantity of organic materials generated in a domestic unit, as well as for the hundreds of thousand tonnes yearly generated in a large city. However, even if the biological process is the same one, its kinetics, evolution and the relevance of the physico-chemical parameters, vary significantly depending on the applied scale.

The scale considered as community composting corresponds to modular units (or modules) with a volume of approximately one cubic meter. At such scale, certain parameters of the process are more sensitive to the surrounding conditions, so particular attention must be paid when managing community composting sites.

5.1. Process parameters most influenced by the scale of operation

Within composting, there are two categories of parameters depending on the phase:

i) **initial parameters**, conditioning how the process starts and the efficiency of first weeks;
ii) **parameters of the process evolution**, determining the optimal conditions for the development of the degradative biological activity, avoiding negative environmental affections.

In both categories there are parameters that must be carefully handled so as to guarantee the right evolution of the process. Each of these parameters is detailed below, together with specifications at community level.

5.1.1. Initial parameters

Physical structure or matrix The correct porosity of the materials mixture must be ensured to allow the air to go through the inside of the mass from the first moment.	
Particle size This parameter affects both the bulking material and the organic material to be composted. It affects the capacity of retaining the heat produced in the biological process, moisture control and carbon availability. A particle size over 40 mm limits the starting of the process.	

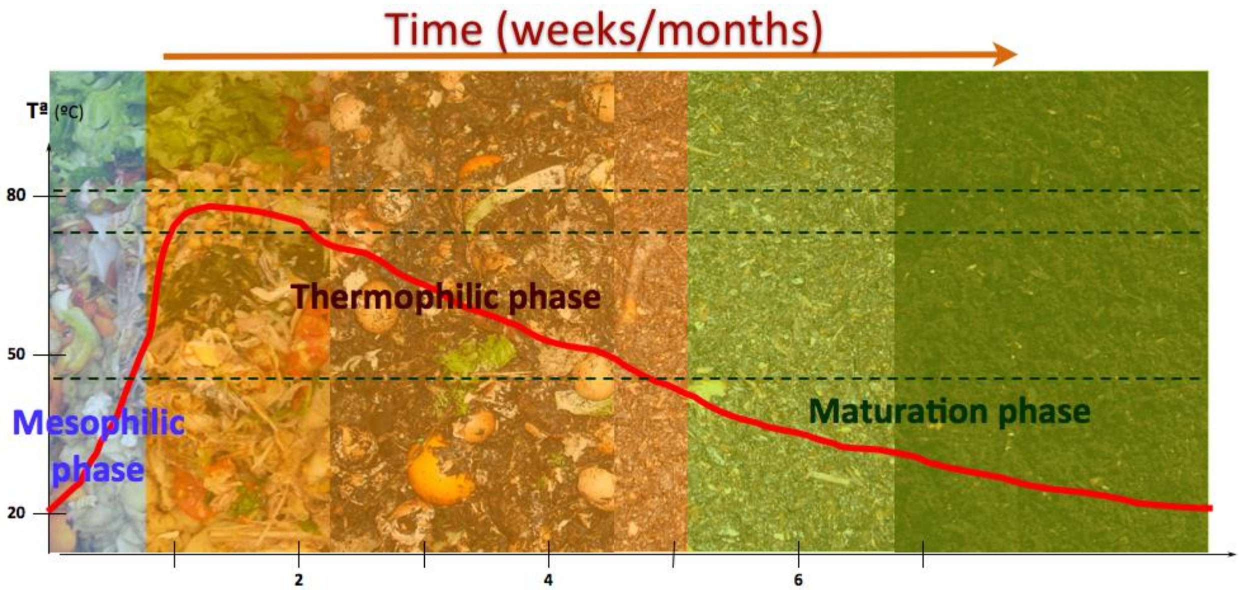
Moisture It affects optimization of the biological process efficiency as well as avoidance of negative environmental affections. During the initial phase, when inputs happen, it is essential to maintain this parameter levels around50-60% in order to avoid leaching and ease the beginning of the microorganisms activity.	
Surface/volume ratio Preservation of the heat generated from the beginning of the degradative process allows the temperature to increase gradually, until it reaches thermophilic conditions. A high surface/volume ratio eases the loss of convection heat and of material moisture. It is very important that the input frequency of fresh organic materials is consistent with the volume of the composting module and, also, that the disposition of those materials in the inside of the module during the first days has a low surface/volume ratio.	
Biodegradable carbon/nitrogen ratio Depending on the characteristics of bio-waste deposited in the composting modules, it may be necessary to consider a correction of the biodegradable carbon and nitrogen ratio, even if the porosity and moisture are adjusted because of the initial input of structuring or complementary material.	

5.1.2. Process parameters Initial parameters

Moisture The process volume, the materials of some composters and the exposition to the environmental conditions, are the main factors allowing a deviation from the optimal values of this parameter during the process time. It is essential to regularly monitor and correct it as soon as it deviates from the interval of optimal values.	
Porosity According to the aerobic conditions of the process, the passing of air through the inside of the material must be ensured at all times. In passive ventilation systems, as most of the community composting systems are, this requires avoiding material compactions, mainly of the material in the lower layers of the composter. The combination of an appropriate particle size, frequency and turning intensity, as well as considering transfers in the operational protocol of the composting modules, is basic to take care of this parameter.	
Surface/volume ratio Again, the scale of the process determines the possibility of this parameter to maintain the temperature within thermophilic values. As the process advances, the volume reduction of the organic materials mixture will increase the surface/volume ratio which, during times with lower ambient temperatures, higher air relative moisture or process maturation stages, will lead to a premature heat loss of the material.	
Temperature Since this parameter defines the process phases, it must be monitored in a relative continuous way during the whole process time. Adjustment and maintenance of the other named parameters, as well as a correct follow-up of the process protocol, will allow reaching thermophilic temperature values and maintain them during enough time to ensure sanitation of the material.	

5.2. Phases of the process at community level

The composting process is divided into three consecutive phases (mesophilic, thermophilic and maturation). These phases are mainly defined according to the temperature evolution of materials in decomposition:



I. Mesophilic Phase: from ambient temperature until 45 °C. The temperature increase through a longer or shorter period of time depends on how much the initial parameters of the process are adjusted to their optimal values, always based on the needs of the organic materials to be composted, according to their characteristics.

II. Thermophilic phase: from a temperature above 45 °C, this phase of the process is considered as started. The upper limit should be 70 °C, temperature from which there is an important limitation in variety of microorganisms intervening in the degradation of organic matter, limiting therefore the efficiency of the biological process.

III. Maturation phase: it is a phase of slow cooling with an exceptionally high quantity and diversity of microorganisms in charge of it. Duration of this phase will depend on the degree of maturity and stability intended for the resulting compost.

When adapting the composting process to community level, this process phases depend on the **design of the composting site** (mainly on the number of modules) and, in turn, such design defines the **working or operational protocol**.

6. Design of community composting sites

6.1. Common elements of community composting sites

First aspect to be taken into account in the design of the sites is their location. In this regard, points of easy access and close to the citizens are to be considered. Composting sites are proposed as management models replacing or complementing the selective collection of bio-waste, so they must be located following similar considerations to those applied to the containers for the organic fraction.

It is equally important their correct dimensioning, in order that the ratio of bio-waste input is in accordance with the volume of available composting modules. It will be thus possible to ensure having a treated mass of material that will enable reaching appropriate process conditions (temperature, porosity, moisture...). Dimensioning depends not only on the number of participants, but also on other parameters that directly influence it: model of composter used, type of structuring/complementary material, operational protocol set and even environmental conditions.

All sites intended to be used for the development of a community composting activity must have a series of common elements, whose number and distribution will depend on the capacity of treatment and management model of each site:

- Composting modules.
- Storing space for bulking material.
- Water intake point.
- Lightning.
- Tools.

> "Dimensioning depends not only on the number of participants, but also on other parameters that directly influence it: model of composter used, type of structuring/complementary material, set operational protocol and even environmental conditions."

There are further aspects of the sites that should also be taken into consideration, although they depend on the participation and citizen awareness strategy of the community composting model. They are accessory elements:

- Perimeter fence.
- Posters.
- System for access management.
- Place for input of green waste (trimmings, grass...).
- Closeness to selective collection containers to facilitate the deposit of other fractions, such as plastic bags.

6.2. Design according to the operational model

The key operation in the design of the site is the number of material transfers that are expected to happen during the process (see details in chapter 8).

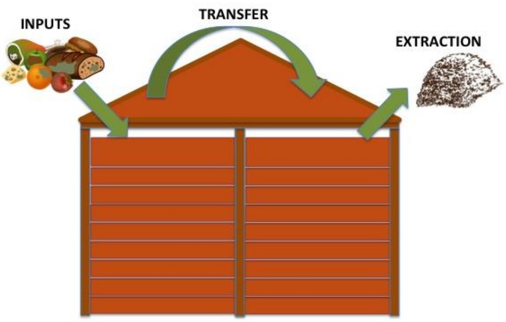
6.2.1. Sites where no transfers are performed

This system, without transfers, is usually linked to the use of independent rod composters. They belong to static composting systems at small scale, where the input of waste to be composted is provided through the upper part, and the extraction of stabilised material made through the lower part. Each composter acts thus as an independent space where the whole process takes place: both the fermentation and the maturation phases (see point 5.2.).

Despite not being a correct model of community management—as shown in later sections—, in this kind of sites, once the composter is filled with the inputs of the participants, it is closed down and kept without new inputs so that the maturation phase happens while a second composter is being filled. In order to ensure that this maturation phase is completed, it is essential to perform maintenance actions in the material of the closed composter, which do not always happen.

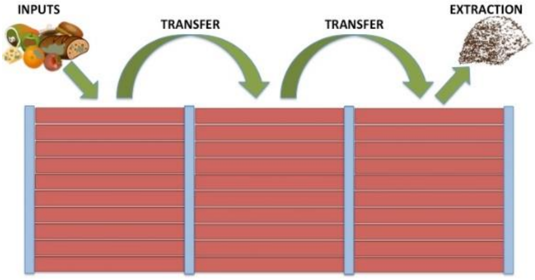
6.2.2. Sites where one transfer is performed

The operational model of this dynamic composting system is based on the fact that inputs of organic waste are provided in a first module. Once filled, all of its content is transferred to a second module, so that first one remains empty, being able to get new inputs.



6.2.3. Sites where two transfers are performed

This system is identical to the one before, the only difference being that, once the first module is refilled, the material deposited in the second module is transferred to the third module. Afterwards, the material that has filled the first module is transferred to the second one, so that first one is empty again and can continue getting inputs.

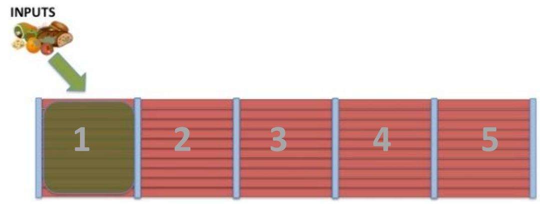


Systems involving two transfers have proved to be the most efficient, as they allocate the different phases of the process to independent spaces, so the required specific parameters for each phase can be met and monitored individually.

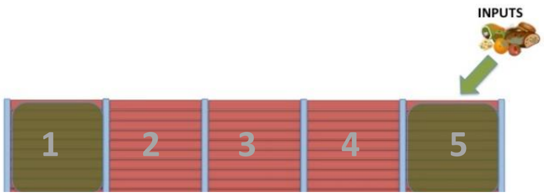
- **Module 1.** The filling stage of the first composter (chosen as ”input module”) corresponds to the mesophilic phase and beginning of the thermophilic phase of the process.
- **Module 2.** Once all the material provided to the first composter has been transferred to the second one, a reactivation of the process usually happens, thanks to the homogenisation of the mixture, recuperation of porosity and correction of moisture. Therefore, this second composter is still in the thermophilic phase of the project. This upturn of biological activity, and consequently of temperature, is essential to assure the sanitation of potential pathogens, as well as the inactivation of viable seeds. The residence period in the second composter, and the conditions of the process, should be enough for the material to reach the minimum degree of maturity required to get the end-of-waste status.
- **Module 3.** If the site has a third module, the maturation phase could be extended in there, in order to reach a higher stability of resulting compost.

			
Phase	Module 1	Module 2	Module 3
Mesophilic	✓	✗	✗
Thermophilic	✓	✓	✗
Maturation	✗	✓	✓

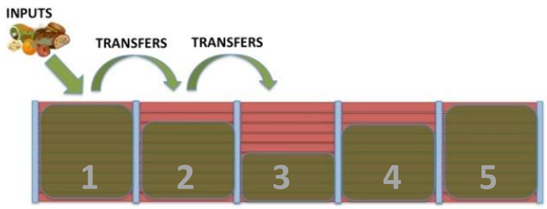
Depending on these two transfers, the number of modules per site can vary, but most often there are three, five, six or ten composting modules per site. The quantity of modules affects directly the process efficiency, but it also exponentially affects the treatment capacity of the composting site, since a proper combination of input and maturation modules can increase the residence periods and the efficiency of the process. The scheme shown in the next page presents the protocol for input and combined transfers that should be done when operating a site with five or ten modules (5 + 5).



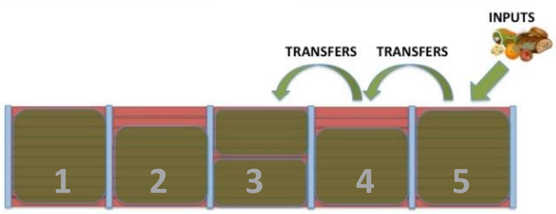
Start of inputs in module 1.



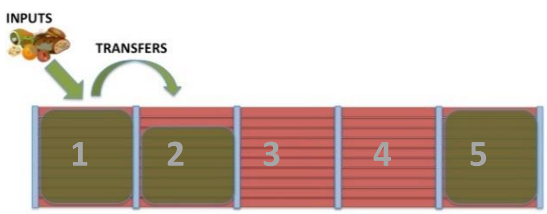
Once module 1 is filled, it closes and module 5 becomes the new input module.



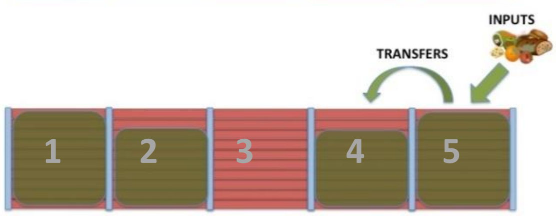
Closedown of module 5 once filled, transfer of material in module 1 to module 2, and module 1 becomes the input module again.



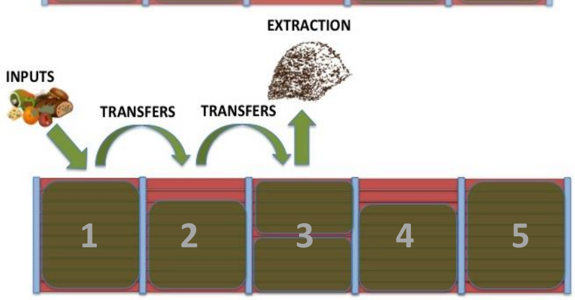
New closedown of module 1 once filled, transfer of material in module 5 to module 4, and module 5 becomes the input module again.



New closedown of module 5 once filled, material transfer from module 2 to 3 and from 1 to 2. Module 1 becomes input module again



New closedown of module 1 once filled, material transfer from module 4 to 3 and from 5 to 4. New inputs in module 5.



Compost extraction from module 3. Closedown of module 5 once filled, material transfer from module 2 to 3 and from 1 to 2. Module 1 becomes input module again.

7. Waste materials accepted for community composting

7.1. EWC codes treated in community composting

In most cases, the community composting sites are exclusively focused in the treatment of the so-called "bio-waste", waste of an organic nature generated in the surroundings. But the EWC codes included in this category have a wide variety of different characteristics, which are the most important for composting. Such variations are due to the seasonality, local gastronomy, weather conditions, etc. and condition the composition of the organic waste in terms of moisture, consistency, granulometry and oxidisable carbon/nitrogen ratio, among others.

EWC code	Description
20	**Municipal wastes (household waste and similar commercial, industrial and institutional wastes).**
2001	Separately collected fractions
200108	Biodegradable kitchen and canteen waste.
200138	Wood other than that mentioned in code 200137 (Wood containing dangerous substances).
2002	Garden and park wastes (including cemetery waste).
200201	Biodegradable waste.
2003	Other municipal wastes.
200302	Waste from markets.
Note: These EWC codes, associated to large generators, may be treated in a decentralised way at this scale of process (community composting, captive composting for large generators or municipal/community composting) under specific conditions/authorisations.	

7.2. Organic materials usually considered as unfit for composting

One of the most recurrent questions regarding the type of organic materials that can be provided to a composter, is about **meat and fish**, as they are waste referents with high content in proteins; these doubts are sometimes extended to any kind of cooked food. A large number of manuals on home composting have been published, suggesting non-experienced users not to use such waste in composting, which has been extrapolated as an almost total ban or a practice to be avoided by all means. However, **these materials allow ensuring temperatures for sanitation and pathogens removal at this scale**, so their presence in community composting is needed to develop the process in good conditions and improve the agronomic quality of the final product.

The reasons behind this position against composting of meat, fish and even cooked products, are based on the risks of unpleasant odours during the process and of attraction of animals, and even on the fact that they would increase conductivity of the resulting compost, impeding it to be applied to the soil. This type of affections is directly linked to inappropriate process conditions, mainly excess moisture and lack of porosity in the materials mixture. Likewise, these affections share one same factor, a lower than needed proportion of bulking or complementary material.

> "The presence of protein waste (meat and fish) is the only way of ensuring that the process reaches the necessary temperature to guarantee the sanitation of potential pathogens and the removal of viable weed seeds."

It must be remembered that the three functions of this material are: (i) providing structure or porosity, (ii) detecting excess moisture in the organic waste by bringing the value of this parameter within optimal limits for the process, and (iii) providing carbon to balance its ratio with the nitrogen available for the microorganisms. Hence, the inputs of protein organic waste involve direct effects in these same aspects of the composting process:

i) Proteins are organic molecules of easy biological degradation by microorganisms. This means that, since they count on an easily degradable feeding source, there will be a higher aerobic biological activity and, as a consequence, also a **higher demand of oxygen**. If such a demand cannot be met (scarce porosity of the materials mixture), the available oxygen level will be reduced even down to limiting concentrations, which would provoke anaerobic processes. In such conditions, when anaerobic microorganisms prevail in the degradation of organic matter, certain types of gas compounds will be produced, causing bad odours. That would be the first reason why it is necessary to think that protein waste must be always composted with an appropriate proportion of structuring material providing porosity to the mixture and a turning regime that ensures the maintenance of such porosity.

ii) The higher rate of biological activity provoked by the presence of protein materials in the waste mixture to be composted causes, at the beginning of the process, a strong hydrolysis of the organic matter affected by the degradative action of microorganisms. This hydrolysis provokes the breakdown of the organic macromolecules and the release of the water molecules held in their structures and/or of the water production in the biochemical reactions of degradation of the organic matter. One consequence is the production of **a significant water release in the phase with highest biological activity** of microorganisms, when starting the thermophilic phase of the process. Such water is called "metabolic water". If there is not a correct proportion of structuring or complementary material to get this specific excess moisture, water will saturate the micropores of the materials mixture, reducing or occupying thus completely the free space for the air. When this happens, and since this process demands high quantities of oxygen at that time, the process enters quickly in anaerobic conditions and produces gases causing bad odours. Furthermore, if such excess water is not reduced, the process material will be gradually cooled, so there are increased possibilities of animals entering and of the development of insect larvae in such habitat. That is the second reason why, when composting waste with high protein content, it must be guaranteed having a proper structuring material, with low moisture level, to supply to the organic materials mixture in due proportion.

iii) Proteins are organic molecules composed by amino acids, which in turn have a significant presence of nitrogen in its composition. Therefore, when supplying waste rich in protein to a composter, there is an input of nitrogen to the process, which affects the oxidisable carbon and nitrogen ratio (C/N ratio), one of the initial parameters of the composting process (see corresponding section). This input of nitrogen means that the value of **the C/N ratio will be reduced**, potentially down to values lower than the optimal balance between both elements. In terms of the biological process, such excess nitrogen tends, during the degradation reactions of the proteins, to be converted into ammonia (NH_3), a volatile compound. Thereupon, if the C/N ratio is not correct at the beginning of the process, composting of waste rich in protein will involve the volatilisation of NH_3, the compound causing bad odours and one of the factors of attraction of animals. A low C/N ratio due to the excessive input of protein materials is corrected with a carbon input to the initial mixture, and the main carbon source in the mixtures of organic waste to be composted comes from the structuring of complementary material. This is the third reason why it is necessary to have an appropriate quantity of structuring material to compost waste with high protein contents, as it allows correcting the initial C/N ratio of the mixture and avoiding or minimising the volatilisation of NH_3.

Therefore, the main effects caused by the presence of meat and fish remains in the mixture of materials to be composted, are perfectly manageable if there is an appropriate proportion of structuring or complementary material whose characteristics are correct (particle size, moisture, degradability, etc.). Obviously, this does not exclude the need of complying with the operational and management guidelines established both for the community composting site and to guarantee the efficiency of the degradative process.

Under the proper conditions, **the presence of protein waste** or, in other words, the input of all the domestic organic waste to composting (in this case community composting), **is the only way of ensuring that the process reaches the necessary temperature to guarantee the sanitation of potential pathogens and the removal of viable weed seeds**. If the process evolves in a more efficient way, it will reach maturity before and the resulting compost will have a higher humification level, which is an indication of agronomic quality of the product.

The other problem that is usually associated to the presence of protein materials, as well as to the input of remains of cooked food, is a higher **conductivity** of the resulting compost. Although it is true that there is some correlation between these factors, there are other factors closely linked to the compost conductivity, such as: rainfall patterns, types of soil, origin of the watering water, the operational and process control protocol, the input to compost of green waste from vegetables grown with a higher salt load, etc., and even the degree of maturity of compost has also influence. In this sense, it should also be remembered that in urban environments, the most serious problem in the maintenance of the park and garden soils is related to their salinity (conductivity), which comes from the salts provided due to the use of regenerated water when watering.

7.3. Use of compostable bags in community composting

Another of the usual factors in these models is related to how the bio-waste is gathered in the households and how the users transport them to the community composting site. The considered options are very varied, depending largely on the previous experience of the town and/or local administration in selective collection of bio-waste and in the use of compostable bags, and we cannot say that there is an only optimal approach for this factor. The main objective of the community composting model addressed in this document is that it could become a real alternative or complement to the selective collection of bio-waste. In that context, the public participation is intended to be maximised, within the correct dimensioning of each community composting area, in order to gather the biggest quantity of the organic fraction, so an option for this fraction must be looked for, in terms of storage in the households and transport to the area with highest participation. Among the four most common options, the aspects presented hereinafter must be taken into account:

- <u>Participants do not use any kind of bag.</u> Bio-waste is stored at home in a 10-15 litres bin, which is transported to the community composting site and emptied directly in the input composter. As described in point 6.1. of the present document, the community composting sites must count with a water intake point, that may be useful to clean the bin in which bio-waste in transported by those participants not using bags. It is an option that must be promoted and allowed in all models, as it avoids the bags consumption (both plastic and compostable) and their subsequent management.
    - Disadvantages: it obliges the user to go back home in order to leave the bin, so the action of carrying the organic fraction to the composter should be specific, not linked to any moment when they must leave home for whichever reason.
- <u>Participants use polyethylene bags.</u> It is a common model, as it does not involve any substantial change in the habits of the citizen in most of the towns or cities. In these cases, it is essential that the composting site is close to the containers for selective collection of light packaging (point 6.1.) and that the training to users includes the indication of emptying the content of the bag, not throwing it closed inside the composter, and leaving the bag in the closest selective collection container of light packaging.
    - Disadvantages: each input means, in general, that a plastic bag is consumed and deposited as waste in the container of light packaging.

- <u>Participants use compostable bags.</u> In this case, only the compostable bags certified according to UNE-EN 13432 are considered appropriate. They must be used combined with aerated bins, as the jointly usage of both elements allow that, during the time when bio-waste stays at home, a mass reduction happens due to the combination of water evaporation and the beginning of the degradative process, avoiding odours problems. (Puyuelo *et al.*, 2013). The use of a closed bin allows neither ventilation nor aeration of bio-waste, which ends up causing problems of leachate accumulations, damaging of the compostable bag and bad odours. Although these bags are degraded during the composting process, they are designed to do it in intense process conditions, similar to those produced at an industrial treatment plant where, additionally, during the pre-treatment phase, the bags are opened and/or broken mechanically to mix their content with the bulking material, so they fragment and become exposed to the degradative activity of microorganisms. At the scale of community composting, it would be even more necessary that they were not only opened but also fragmented so as to become subject to be composted with bio-waste. That would assign a new task to the master composter, as the citizen will hardly tear the bag after emptying its content in the bin. If they are thrown intact, they will accumulate in the composter, as their degradation will be slower than that of the bio-waste, so their handling will be hindered. Therefore, if used, users should ideally throw them to the bin of the composting site after having emptied them in the input composter.

    - Disadvantages: although environmentally they have a lower impact than polyethylene bags, they must be properly managed taking advantage of their biodegradability. It means that they need to be grinded or fragmented before introducing them for composting, so they are usually managed as trimming remains.
    - There are specific compostable bags for the household composting scale, designed to be more easily degradable. In our experience, that makes them more likely to break when bio-waste is stored at home for several days, regardless of whether or not they are used combined with the aerated bin. This usually provokes that participants with less environmental awareness have a negative opinion about it, and could be the reason of them quitting the model if they are not given the choice of using other types of bag to carry their bio-waste to the community composting site.

8. Operational protocol of community composting sites

Some aspects for the management of a community composting model must be previously clarified:

⇒ **Training** both the participants and the responsible persons of the community composting sites, is one of the key factors for the success of the system. It must be linked to initial and subsequent campaigns so as to match composting with the requirements suggested for each type of community composting site. All the stakeholders involved in this initiative must clearly know which actions should be taken for the separation and input of bio-waste and the reasons behind them.

⇒ It is essential that the *master composters* or people in charge of maintenance and follow-up of the composting sites perform **technical visits** with appropriate frequency and, also, that they have enough practical and theoretical knowledge to detect and diagnose potential problems when applying the necessary preventive and/or corrective measures.

8.1. Factors affecting the composting process

Effectiveness of the treatment of organic waste through composting depends largely on the capacity of controlling the process. In the specific case of the community composting scale, success of the system, from the point of view of the "functioning" of composters or composting modules, depends mainly on following factors:

Factor	Considerations
Dimensioning	Factor closely linked to the number of participants, the type of composter and the characteristics of the domestic organic waste and other provided materials. A poor forecast of the treatment capacity involves the non-optimisation of the process conditions, eases the arising of problems and precludes reaching the pre-set objectives.
Load height	The fill level and, consequently, the composter load height, together with the physical characteristics of the process material (particle size and porosity), establish the needs in terms of turning, water intake, bulking material, etc.

Operation of the site	It is essential to adapt the operational protocol of the site and the frequency of technical and maintenance visits to the space and technical characteristics of each community composting site.
Process conditions	In order that the biological degradation of the organic matter is properly developed, appropriate conditions in terms of certain parameters are required: porosity, moisture, pH, oxidisable C/N ratio, particle size, etc. The working protocol is key to keep optimal process conditions adapted, at all times, to the corresponding phase in which the material being composted is.

8.2. Action plan

The tasks to be performed by the persons appointed as *master composters* during the maintenance and follow-up visits of the community composting sites are described hereinafter. It should be considered that, at least, **one follow-up visit and two maintenance visits per week** must be done, in order to check that the process is properly developed and to act in case of detecting an incidence.

"...at least, **one follow-up visit and two maintenance visits per week** must be done, in order to check that the process is properly developed..."
"...it is **absolutely necessary to qualify and train the responsible persons**, the *master composters*, so that they can properly perform the tasks..."

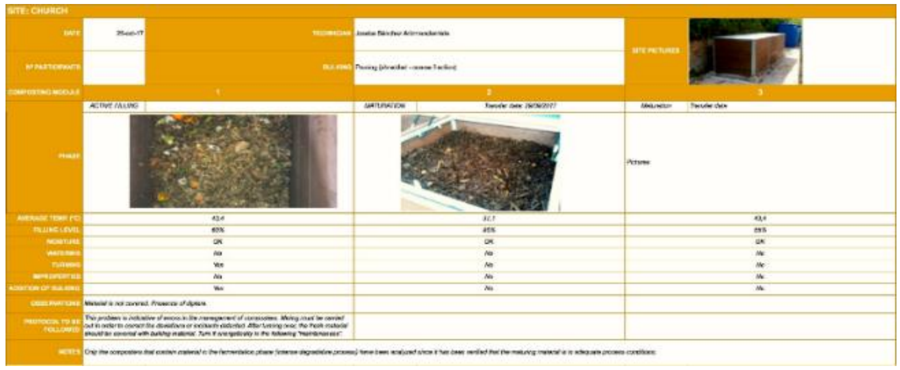
When establishing the visits calendar, as well as the frequency of the maintenance and follow-up visits, the responsible persons must adapt to the reality of each town, and even modify the initial forecast, as the habits of the users of the composting sites may be very different.

Anyway, it is **absolutely necessary to qualify and train the responsible persons**, the *master composters*, so that they can properly perform the tasks described below.

8.2.1. Follow-up tasks

Temperature	It is the parameter that most directly shows the status of the biological activity of the process. It is measured with a temperature probe (thermocouple or Pt100) and must be tested in at least 3 different points of the mass: in the centre of the composter (theoretically, the most active place, or the place with the highest temperature), in the transition area (theoretically it is not such an active place, lower temperatures) and, lastly, next to the composter walls (theoretically the coldest place). A good method to measure it is to test the temperatures diagonally. This information must be collected in all the modules of the site, regardless of the phase they are going through. Before measuring the temperature in the site's composters, the ambient temperature must be registered.

Moisture	In order that the composting process stays active, it is essential the presence of an adequate moisture level. Excess moisture will cause a radical decrease in the activity of aerobic microorganisms and will cause odour problems. Low values limit, or even prevent, biological activity and the process stops. This parameter should be quantitatively analysed in a laboratory from a representative sample, so in the field, the used methods are qualitative, in order to calculate moisture level and to know whether watering is necessary or not. The easiest method is the so-called "fist test".
Porosity or degree of compaction	The composting matrix needs to have a minimum porosity to ensure the proper air circulation throughout the whole mass. The material compaction is directly related to its moisture and to the proportion of bulking material, as well as its particle size. Proper porosity is reached by means of an adequate proportion between bio-waste and bulking material, a homogeneous initial mixture and periodic turnings. Special attention should be paid to the material that remains in the bottom of the composting module, as the compaction effects are enhanced there. The degree of compaction can be only measured quantitatively in a laboratory, so in the field it is visually estimated in qualitative terms during turnings.
Fill level	The distance between the surface of the process material inside the composting module and the upper limit of the composter is measured with the help of a tape measure. The difference between this value and the total load height of the module is the fill level at each moment.
Odour	While getting close to the composting site, it must be checked if anything can be smelled, and what type of odour it is. Likewise when material turnings happen. If it is an odour revealing anaerobic processes, the corresponding measures must be taken to correct such situation. When checking the odour, and its potential incidences, it is very important to consider the wind direction.
Incidences	Each time that an incidence is detected in the composting site, it must be noted and reported to whom it may concern. Furthermore, the necessary corrective measures must be taken, which shall also be registered.

<table>
<tr>
<td>Monitoring sheet</td>
<td>During or right after each visit, a follow-up sheet must be filled. It will contain all the information collected and measured according to the working protocol. In those sheets, each input of structuring material, closedown of composters, etc. must also be recorded.


It is important to take pictures of those aspects considered relevant: process incidences, status of the material, defects in the composting site, etc.
In chapter 10 about traceability, and annex 1, this task is detailed.</td>
</tr>
<tr>
<td>Collection of bulking material</td>
<td>The drawers must be kept full with bulking material, whose good state and quality must also be ensured. It is therefore necessary to count on logistics to distribute the bulking material to each composting site. Good bulking material fulfils following conditions:
It comes directly from the trimming of branches and trees, without any kind of previous treatment.
Remains are woody materials, not herbaceous.
Trimming remains are clean and are not mixed with other kinds of remains.</td>
</tr>
<tr>
<td>Registration</td>
<td>Once the visits of the day are finished, all data in the follow-up sheet have to be recorded in a registration system. This system must ensure traceability of all the bio-waste batches being processed in the visited community composting sites.</td>
</tr>
<tr>
<td>Sample collection</td>
<td>When it is established that a compost batch or sub-batch must be analysed, a representative sample of the material must be collected by following the set protocol.</td>
</tr>
</table>

8.2.2. Maintenance tasks

Turnings	The process material must be turned periodically in the composter. Material in the fermentation phase requires more intense and frequent turnings, while maturing material should be turned less often. In this operation, it is recommended the use of a long aerator, with a spiral-shaped end. Main objectives of the turnings are: • Regaining the matrix porosity and ensuring thus aeration of the material. • Homogenisation of the bio-waste and bulking material mixture, by breaking lumps or clods of compacted material that there may be. • Homogenisation of the moisture level of all the material.
Watering	Whenever the material loses moisture, the mixture must be watered so as to get rewetted. Watering must be done smoothly while the mixture is being turned, so that moisture is homogenised through the whole volume of the material being processed in the composter.
Input of bulking/ complementary material	In order to avoid excessive compaction or episodes of excessive moisture, an input of bulking material must be done. It must be done during the turnings so that the mixture is homogeneous over the whole composter volume.
Emptying of bins	If the community composting site counts on bins to throw the plastic bags where users transport their bio-waste, the materials thrown there must be emptied in each visit.

9. The master composter figure

Whichever system and technology are implemented for the management of organic waste at community scale, periodic visits need to be performed by someone trained on operating the composting site and with practical knowledge allowing them to diagnose the process status, guarantee its efficiency and act appropriately to avoid potential incidences and affections in the surroundings. Such figure is usually known as "master composter" and is an essential element for the success of this treatment model.

The need for staff in the development of the community composting model opens the door to local job creation, mainly in isolated rural areas, where the development of new job positions is not the only advantage; thanks to this diversification of the rural economy, the population is encouraged to take root there.

> "The community composting model opens the door to local job creation, mainly in isolated rural areas."
> "It can also be addressed to groups at risk of social exclusion."

Because of the type of activity to be developed, it can also be addressed to enterprises and groups fostering the integration of people with some kind of risk of social exclusion. The combination of both factors—local employment and social integration—is also a strength of the community composting model with regard to how the population of the area supports it.

9.1. The tasks of the master composter

Their **main tasks** are classified under two categories: technical and social.

I. <u>TECHNICAL</u> (described in detail in chapter 8)

   A. **Follow-up visits.** These are the tasks that the master composter must perform in all their visits:
      a. Measure the temperature of <u>all</u> the site's modules where material is being processed.
      b. Check the moisture status of the material being processed in those same modules.
      c. Check the compaction level (or porosity) of the process material.
      d. Measure the fill level in the input modules.
      e. Check if odours pointing bad process and/or management conditions can be smelled in the community composting site.
      f. Check the status of the site to detect possible incidences and take measures to solve them.

B. **Maintenance visits.** They should not be as frequent as the follow-up visits, since they are connected to specific management and operational tasks of the composters, so as to guarantee the efficiency of the process. The main tasks of these visits are following:
    a. Material turnings in the composting modules. It is thus ensured the porosity and homogenisation of the materials and their process conditions.
    b. Watering of the process material with scarce moisture level so as to guarantee the efficiency of the process.
    c. Transfers of all the material from one module to the adjacent. During this operation, it must be guaranteed that all the transferred material is supplied with the same conditions regarding moisture, homogeneity and porosity.
    d. Additional input of bulking or complementary material.
    e. Sieving of the material deemed to have completed the process.

II. SOCIAL: The master composter is the visible figure of the management model towards the users and the reference person to whom they shall express their doubts, concerns, suggestions, complaints, etc. Such communication can be face-to-face, but other communication systems should be also implemented, such as via telephone, e-mail, users support office, social networks, etc. One of the most important duties of the master composter is showing a proactive attitude to attend those people, dynamise the participation in the area and encourage the incorporation of new users.

9.2. Training of the master composter

In order to properly develop these tasks, it is very important that the master composters receive **specific training**, both theoretical and practical, on the fields of activity where their tasks are framed. As an example, below are listed the training modules that were designed for the training plan of master composters within the *Plan Revitaliza*[5] of the Provincial Government of Pontevedra (Spain):

- Waste, environment, specific regulations and environmental education.
- Municipal Solid Waste collection/treatment.
- Composting: Science, technology, implementation and applications.
- Design, strategy and functioning of the local plan of waste management.
- Operational practices of community composters.

[5] More information can be found in the following link: https://revitaliza.depo.gal/inicio

Additionally, and transversally to these training modules, they are trained on specific aspects related to the development of capacities for social communication, since they must perform their activity in direct contact with the citizens.

A regularly discussed issue regarding the figure of the master composter is whether it should be performed by local residents on a voluntary basis, by a professional hired by the administration or by promoters of the community composting model.

The examples in which local volunteers are used, like in the Flemish region, are essentially based on retired people managing community composting sites with voluntary inputs, not designed as an alternative model to the selective collection of the organic fraction in the town. Therefore, those sites do not need to ensure the optimal treatment efficiency at all times. Furthermore, Flanders has adopted the VFG[6] composting model, so the biological process is less intense than in other models where all kinds of organic waste with domestic origin are included, and its operational requirements are simpler.

This guide suggests models of community composting sites substituting those of selective collection and transportation of bio-waste, and in its approach, the technical, environmental and economic efficiency compels to: manage all kinds of bio-waste, ensure the highest efficiency of the composting sites so as to reach the dimensioned treatment capacity and guarantee the lack of environmental affections. Under such approach, and especially during the first years after its implementation, it is essential to count on staff specifically trained to manage the sites (as described) by fulfilling the tasks described in this guide. Later on, when the model consolidates among the population, it will be possible to suggest training some neighbours wishing to carry on voluntary tasks of follow-up and/or maintenance of the community composting sites, which will allow a reduction of the working load of the professional master composters in such town.

[6] VFG = Vegetables, Fruits and Gardening

10. Traceability of the community composting sites

10.1. Proposed methodology

In every composting process, it is important to have the possibility of following-up and registering the different supplied materials, monitored parameters and carried-on activities, with the aim of ensuring the fulfilment of the requirements of minimum temperature and time set by some existing regulations (see point 4.3.).

To do this, the operational protocol of the community composting sites needs to include the guidelines to perform a correct identification, measurement and registration of all the elements involved in the development and management of the process, and foresee the format in which registers will be done.

Monitoring units are batches and sub-batches (described in section 3). The registration of the batches must be included into an operational book, advisably in digital format (data can be taken on paper and afterwards transcribe them, or directly on a computer or tablet), or through a specific smartphone app, so that all the information gathered by the master composter during the visit is included into the registry at the same time. It is recommended to store all information in the cloud.

Preferably, all composting sites belonging to the same promoter should follow the same traceability protocol and the same method for the registration of data, gathering thus all the information in a single platform, accessible to all managers, promoters or associated control entities.

10.2. Elements or parameters requiring traceability at each management stage

A) Start-up of the community composting site

- Location (geo-referenced).
- Date and time of the facility.
- Type and number of composters, code of each module installed in the site.
- Characteristics and equipment of the site (water point, container for foreign materials, aerator, place or box for the bulking material, fencing, etc.).
- Operational/transfers protocol.
- Number and type of users (must be updated).
- Type of first inputs (by users, by point operator, etc.).
- Type of follow-up and periodicity protocol.
- Technical responsible assigned to the site.

B) Follow-up visits

- General data:
    - Code of the community composting site.
    - Date, hour, technician/s doing the visit.
    - Duration of the visit.
    - Ambient temperature.
    - Environmental conditions.

- Parameters to be checked in each module:
    - Identification of the corresponding code to each batch or sub-batch.
    - Status: active, inactive, phase.
    - Temperature.
    - Moisture.
    - Degree of compaction.
    - Fill level.
    - Pictures.
    - Incidences: odours, type of foreign materials, flies, rodents, leachates, etc.
- Others:
    - Type of bulking material and filling of the drawers or collecting area.

See more details about the protocol for the follow-up visits and how to collect the listed data in section 8.2.

> It allows for the verification of the correct development of the process, the fulfilment of sanitation parameters and the registration of the incidences that must be solved.

C) Maintenance visits

- General data:
    - Code of the community composting site.
    - Date, hour, technician/s doing the visit.
    - Duration of the visit.
    - Environmental conditions.

- Maintenance tasks performed in each module:
    - Identification of the corresponding code to each batch or sub-batch.
    - Turning.
    - Watering, stating if possible the supplied quantity.
    - Input of bulking/complementary material, type and quantity.
    - Transfer, destination module and fill level after the transfer.
    - Detected incidences and correction protocol.
    - Pictures.

See more details about the protocol for the maintenance visits and how to collect the listed data in section 8.2.

> It allows for the verification of the fulfilment of the operational protocol and, when applicable, the registration of the detected incidences.

D) Compost: extraction, application and analysis

- Extraction:
    - General data:
        - Code of the site.
        - Identification of the corresponding code to each batch or sub-batch.
        - Date, hour, technician/s doing the visit.
        - Duration of the visit.
    - Sieving tasks: yes/no, estimation or weight of the rejected material and destination.
    - Estimated volume or weight of the rejected and useful compost.
    - Characteristics: appearance, colour, odour, foreign materials, etc.
    - Pictures.

- Destination and application of compost:
    - Collection point: inside/outside the process area, identification of the batches or sub-batches there.
    - Type of collection: bulk, bagged, others.
    - Users: Name and type of users, withdrawal date.
    - Type of application: urban-periurban horticulture, gardening, agriculture.

- Analysis:
    - Taking of representative samples from the batch in order to make the established analysis: date, responsible, number of samples, weight or volume, assigned code, destination laboratory for the sample.
    - Laboratory report and results for each sample.

> It allows for the verification of the compost quality and characteristics and enables knowing the distribution and applications of compost. Based on the compost quantities, it would be possible to estimate the material inputs.

10.3. Methods to estimate or calculate the quantity of treated material

As already mentioned, it is particularly interesting to be able of calculating, as reliably and approximate as possible, the quantities of organic matter managed via community composting, since they will count when estimating the fulfilment of the recycling goals set by the EU. Despite the wide debate on the most effective method and the fact that work is being done to improve the methodology, some estimation or calculation formulas are hereunder proposed:

- Measure the direct weight of the supplied materials (from each input) with a scale and estimate the volume of added structuring material.
- Estimate or measure the quantities of compost. If the returns associated to the modules model/operating type are known, the quantities of material inputted into the process can be estimated.
- By having the quantities of the collected remainder fraction and its specific and representative composition, the difference with the new quantities collected after having implemented community composting can be established. Such difference should match with the treated organic matter.
- Others.

11. The final product

Compost is a product legally described as: "*sanitised and stabilised product obtained through aerobic and thermophilic biological decomposition under controlled conditions, of authorized biodegradable organic materials and always selectively collected*". This definition encompasses all the considerations established in different regulations and laws at European level.

The main objective of using this compost is to be a tool to encourage participation and awareness of local citizens in the field of organic waste management and care of the environment. For this it is necessary that compost it is used in agriculture and gardening in the closest possible environment to its place of production. In this way, the correct management of organic matter becomes more visible and patent for citizens. In any case, within the community composting implementation strategy, the local distribution of the compost does not intend to be the object of an economic activity, so its sale or commercialization is not considered.

The following table shows the requirements that should be considered for the compost generated in this model:

GENERAL COMMUNITY (OR COLLECTIVE) COMPOSTING MODEL
The uses and analytical parameters considered will depend on the form of presentation of the product and current legislation at each moment: <u>(a) Bags of less than 1 kg:</u> If it is packed in bags of less than 1 kg, its distribution and application are often exempt from fulfilling the national fertilisers regulation, so it is possible that no analysis would be required, provided that it is used to "*grow, in inhabited homes or premises, ornamental or flowering plants (domestic gardening and indoor plants)".* That must be specified in the label. It is a highly suitable choice for environmental education campaigns and the promotion of use of compost. <u>(b) Bags of more than 1 kg or bulk:</u> Its traceability must be ensured until its final usage. Each distributed lot should be linked, physically or virtually, to the accompaniment documentation. Such documentation shall contain the information required in the regulations in force according to its application: 1. As fertiliser: Fertiliser Registration Number. Batch and analysis number according to national regulations. In such case, there will be no usage restrictions, but it cannot be object of private economical activities. 2. As substrate: Traceability and annual analysis according to national regulations. Use as Substrate or growing media: Growing of plants in milieus others than the soil *in situ.* As microbiological parameters, those described in the use as fertiliser are considered sufficient.

11.1. Characteristics of compost

From the organoleptic point of view, it should have a dark brown colouring, a homogeneous and loose appearance, and be exempt of materials of non-organic origin, such as glass, plastic, metal, etc. Additionally, its characteristics must be stable over time so as not to generate either unpleasant odours, nor other problems associated to its extraction from composters with a low degree of stabilisation and/or maturity. Under normal using conditions, it will be innocuous for plants, animals and people.
Every typology of compost must be accompanied, physically or virtually, by documentation for its identification showing, at least, the number of batch, producer and origin, as well as information about its composition, potential applications and how to contact the maker.

The documentation of each batch must include temperature records to ensure that the composted material has been subjected to an intense thermophilic phase of at least a period of 14 days at 55°C. This requirement is associated with compliance with the requirements of the regulations of Animal By-Products (ABPs) that people do not consume.

11.2. Storing and distribution

The final compost must be stored, bagged or bulk, in a dry place protected from the sun, wind and rain. Access to compost shall be restricted to avoid potential contaminations caused by human actions, presence of animals and propagation of seeds of adventitious vegetables.

11.3. Recommendations of operation and use

In horticulture, fruit culture and urban and domestic gardening, it shall be applied as:

- **fertilizer** on surface or buried under the first centimetres of the soil, in a dose of between 0 and 5 kg of compost per square meter, depending on the crop and the edaphoclimatic conditions. On continuous surfaces of more than 5,000 m^2 doses higher than 250 kg of nitrogen per hectare should not be applied.
- **substrate** or cultivation medium in containers, planters, pots, terraces, flowerbeds and crops in non-natural growing media. Reference applications and doses are developed in the table attached.

Plantations	Ratio compost: other
Plants at large	Volumetric mixtures 1:1 (compost:another material). Example: Peat, sand, soil, etc.
Plants sensitive to salinity	Volumetric mixtures 1:3 (compost: another material). Ex. Peat, sand, soil, etc.
Tree basins autumn/spring	Depending on the crown size: 3 $L \cdot m^{-2}$

Plantations	Ratio compost: other
Urban and sport turfs (gravelling, growth medium)	Volumetric mixture 1:1 (compost:sand)
Not recommended in seedbeds and in types very sensitive to salinity.	

Anyway, due to the great variety of potential applications of compost from bio-waste, as well as the different crop types and conditions that there can be in urban and periurban environments, it is recommended to practise prior to its use. In order to do so, there are **simple evaluation techniques**[7] for compost, with which the most appropriate dose can be determined.
Once determined the dose and conditions of use of compost, there are several options: sharing of compost among the users from the community composting site, use of the compost for municipal needs, compost party, etc.

In any case it is highly recommended that the conditions of use of the product include logical and basic hygiene practices after handling, such as: washing hands after using compost, not eating or smoking while handling, etc …

[7] Link to the video tutorial for simple evaluation trials of a bio-waste compost.

12. Most usual incidences

Incidences are usually due to poor operation of the community composting sites, that may be caused by users and by people in charge of maintenance and management without proper technical training.

"When these incidences are detected, the master composter must implement appropriate corrective measures to solve them."

When these incidences are detected, the master composter must implement appropriate corrective measures to solve them. Nevertheless, as general criterion, it is advisable to follow below indications:

⇒ "When the incidence is not serious, the composter can keep on being used, but in the case of detecting a serious incidence (as could be the appearance of rodents), the procedure shall be closing the composter and opening a new one".

⇒ In the event of serious incidences or many minor incidences, users enrolled in the site will be informed so as to remind them of the working method and, if appropriate, a meeting with all users would be called to review the happened incidences and give them technical training again, if necessary".

12.1. Wrong dimensioning

The quantity of bio-waste supplied to composters is not coherent with the real treatment capacity of the composting sites and/or the established working protocol, so it is difficult to achieve appropriate process conditions ensuring the initially foreseen performance of the site.

12.2. Scarce moisture during the process

The wrong moisture management during the composting process develops into inhibition of the process. That is to say, if waterings are not carried out and the only moisture input comes from the initial water content of bio-waste, then the reached moisture levels will limit the biological activity of microorganisms and, as a consequence, and due to the inefficiency of the process, input modules will fill faster than foreseen in the dimensioning, and it will not be able to complete the minimum needed time for the process to achieve the desired maturity of the material.

12.3. Presence of diptera

Another usual incidence is the appearance of the so-called "common fruit fly" or "vinegar fly" (*Drosophila melanogaster*), often found in these systems in specific process conditions. Those insects are attracted by the presence of fermenting organic remains, and the abundant appearance of such diptera is one of the most common causes why users give up on their participation. However, it is under no circumstances either a dangerous organism, nor involves any negative environmental or health affection.

Its presence is only a sign denoting poor management of the composters. Likewise, another usual incidence is the appearance and proliferation of other diptera, the housefly (*Musca domestica*), that evidences also the inappropriate management of the composters. This happens because these insects are attracted by the fermenting material (which they live off) and, if the composting process is developing inadequately, those diptera deposit their eggs on the organic material being processed and the subsequent larvae develop without problem as they find food and shelter. In any case, it must be pointed out that their presence does not affect under any circumstances the quality of the final product.

12.4. Presence of rodents

Lastly, the appearance of rodents is a direct consequence of the poor management of the composting site. In those sites where rodents have access to the inner material of the composters, they are attracted by fresh remains and, if the composting process is inactive or its biological activity is really low, such animals find a shelter with food.

If, additionally, the management of the community composting site does not include a suitable turning frequency and protocol, mainly for the material in maturation in the closed composters, they could end up serving a shelter for rodents.

12.5. Appearance of leachates and bad odours

Overall, an inappropriate mixture of bio-waste and structuring material, caused by a wrong proportion of materials or by the lack of homogeneity, develops into excess moisture and/or compaction of the mixture, which often generates conditions of anaerobiosis and, as a ripple effect, the creation of gas compounds causing bad odours and leachates.

12.6. Presence of foreign materials

Sometimes, in some community composting sites, inorganic foreign materials are continuously deposited, mixed with bio-waste. Even if this fact is not a big problem in terms of the good development of the composting process, it can develop into some incidences such as the appearance of bad odours, the attraction of insects, etc. It is thus essential that the operators responsible for the maintenance of the sites withdraw immediately those foreign materials when detected.

If the incidence is repeated, it must be determined whether it is caused by a communication failure to the site's users or it is a deliberate practice of a particular user.

13. Classification proposal for the community composting sites

Community composting sites are not based on a single model. Wherever they have spread and become a successful alternative to the management of bio-waste, it has been thanks to the adaptation of their design and/or operational protocol to the circumstances of each place. But such adaptations have had common characteristics. Characteristics that guarantee the possibility of achieving the needed process conditions for the biological process to be consider efficient and without environmental affections, and also, for the resulting product to fulfil the legal requirements for compost. Among this diversity of models, there are however a wide variety of parameters which, if inappropriately treated or handled, involve a higher vulnerability of these community composting sites to malfunctioning due to inadequate operation or to adverse environmental circumstances.

> "…it is needed to present an evaluation and classification system for the composting sites that allows for the identification, once in the project phase, of its vulnerability level, in order to determine the degree of control and monitoring to be required by the competent administration."

Because of this situation, it is needed to present an evaluation and classification system for the composting sites that allows for the identification, once in the project phase, of its vulnerability level, in order to determine the degree of control and monitoring to be required by the competent administration. In turn, this classification can also serve as a guide to choose the model with most guarantees when designing an initiative, or to select the elements that can involve design improvements for the already existing and operating experiences.

In order to list a variety of site types encompassing all the models that currently work properly, without being a large enumeration of variants of models, it is suggested to classify them based in only three types. Every model whose design parameters fit in one of the three types of sites, should work without any problems, but those classified as Type 3 are more vulnerable to suffer problems or affections than those of Type 1. Based on such approach, sites of Type 3 will have higher monitoring and follow-up requirements than those of Type 1.

> "Six classification parameters have been established, which must be completely fulfilled so that the site can be considered as included within this typology: Type 1, Type 2 or Type 3."

Six classification parameters have been established, which must be completely fulfilled so that the site can be considered as included within this typology: Type 1, Type 2 or Type 3 (Table 1). If some of the set requirements are not fulfilled, the site loses category gradually (from 1 to 2, from 2 to 3) and is subject to increased follow-up and monitoring. In the case of not fulfilling, at least, the requirements for Type 3, it should not be considered as an acceptable or suitable community composting model, and in no case it could be considered as an alternative or complementary option to the selective collection of bio-waste.

Table 1.- Classification of the community composting sites and specifications to fulfil.

PARAMETER	CLASSIFICATION CHARACTERISTICS		
	SITE TYPE 1	SITE TYPE 2	SITE TYPE 3
Operators profile (MC[1])	Professional with specific technical training	Municipal operators or equivalent	Volunteers with specific technical training
Availability of bulking material	Particle >5 mm <15 mm / Vol. mixture 1:1	Particle >15 mm / Vol. mixture 1:1	Particle >25 mm / Vol. mixture 1:1
Availability of water[2]	Point in the CC site[3]	Point in the CC site[3]	Point in the CC site[3]
No. of transfers per batch	2	1	1
No. of MCs per working team attending to the site	2 MCs	1 MCs	1 MCs
No. of input modules[4] /MCs team/day	≤ 17 modules visited by MC per day	≤ 24 modules visited by MC per day	≤ 30 modules visited by MC per day

[1] MC = master composter
[2] It relates to the availability of a water intake in the community composting site or to the accreditation of a moveable water point fulfilling the needed guarantees for the task of watering the process material (cleaning machinery or similar).
[3] CC site = Community Composting site
4 Input module = Those modules of the community composting site that are appointed to receive the bio-waste input by the users.

Once the site has been classified, the requirements to be demanded are set (Table 2). All types have common requirements to be respected and specific requirements that vary depending on whether it is Type 1, 2 or 3. Based on such requirements, apart from providing working guarantees to the three types of sites, the selection or implementation of composting sites of Type 3 (or 2) can also be discouraged in order to try that, over time, it is more feasible to devote efforts and resources to design and plan from the beginning sites of Type 1. Another option is that existing initiatives adapt or evolve to sites of Type 1.

Table 2.- Requisitos exigibles a las zonas de compostaje comunitario según su clasificación.

PARAMETER	REQUIREMENTS DEMANDED DEPENDING ON THE CLASSIFICATION		
	SITE TYPE 1	SITE TYPE 2	SITE TYPE 3
Common			
Participation campaign	Yes		
Traceability / transparency	Yes		
Required analytical parameters (minimum)	Heavy metals, *E. coli*, *Salmonella*		
Usage of compost	If it fulfils the parameters, it should not have restrictions. It is not considered as commercialization.		
Sanitation (Temperature / time)	It should fulfil, at least, the 55 °C / 14 days		
Distance to households	According to the agreement between the promoter administration and the residents		
Specific			
Minimum frequency of MC visits to each module	1 every 2 weeks	2 per week	>3 per week
Frequency of analysis (1)	First batch + 1 annually	First batch + 1 every six months	First batch + 1 every four months
External audits	Biannual	Annual	Semi-annual
Maximum capacity per site	10 m^3 (2)	10 m^3	6 m^3
Minimum process time	3 months	4 months	6 months

(1) *For Type 2 and Type 3 sites, if the analysis of all parameters is successful during a whole year, the frequency of analysis for the following year will be such of the immediately above category (Type 3 for Type 2 sites or Type 2 for Type 1 sites). From that moment, in the case that an analysis is unfavorable for any parameter, the frequency of analysis must return to the one corresponding with their classification.*
(2) *In particular and justified cases, they can be considered sites of higher capacity, like it could be the case of locations where a lighter increase of the capacity treatment of the community composting site is needed to assume the treatment of all the bio-waste generated by the inhabitants.*

This context lacks the models that may be described as "educational" (schools, educational centres, etc.) or "demonstrative" (some cases whose intention is to show people what community composting is). None of these models are considered as a real alternative to the management of bio-waste, so they will not be required to fulfil the exhaustive parameters and controls, but they may fit or be based in a specific type or category according to their design characteristics.

14. Restricted *in situ* modular composting

Throughout this Guide, we have referred generically to a community composting model where there are areas in which a common bio-waste contribution is made, which is located on unrestricted public land and where the final compost can be either distributed among the participants, or used by the local administration for municipal gardening or other tasks. It is the most common model in community composting applied to the treatment of bio-waste generated in urbanized areas. In this model, the resources allocated tend to come from the public administration: land, elements of the composting area, materials, conditioning and personnel (or at least their training).

But when adapting community composting to the circumstances, characteristics and possibilities of a locality it is necessary to take into account that, in addition to the common elements defined in chapter 6 of this document, it can be given a second type of decentralized composting model that we believe should be treated differently.

This second case or application model is what would be referred to as "restricted *in situ* modular composting". It is an individual model, located on restricted access floor and with own use of the produced compost[8]. Private residential areas could be included in this model that would install and manage their own community composting site and keep the compost for their own use. It would be the equivalent (on a larger scale) to household composting. It would also be the general case of large generators or singular generators[9] that, in their own land, have one or several individual and fully used composting sites, adequately sized, for the treatment of organic waste generated in their activity and for the subsequent use of the compost produced there. Contrary to what happens with the so-called "educational" or "demonstrative" models, discussed in the previous chapter, this model is presented as a real alternative to the local management of bio-waste, where it would not be necessary to outsource collection or transportation to a treatment center.

Obviously, within a single municipality or population nucleus, this model can coexist with the generic community composting model, in a strategy of decentralizing the treatment of bio-waste, adapting it to the specific circumstances of each locality to maximize its efficiency, but without forgetting that these restricted modular *in situ* composting sites must always guarantee their efficiency and correct management and operation, following the guidelines described in this Guide.

Therefore, although this restricted model is usually driven by private entities or private groups and located in particular spaces, it should be designed to ensure that it offers an adequate treatment according to the quantities and types of waste to be composted, as well as including the process factors and management explained in previous sections of this Guide, including the need to have a trained technical person for the management and monitoring of these composting facilities.

[8] See definition of "*In situ* modular composting sites for large generators " in the glossary of Chapter 2

[9] Such as hotels, restaurants, training centers, work centers, residences, hostels, etc.

In any case, and considering them only at a technical level, the requirements of control and administrative supervision of the final product, the compost, could be different to those required for community composting, but in any case must comply with the corresponding legal regulation. The following table shows the minimum requirements that should be considered for this model.

RESTRICTED *IN SITU* MODULAR COMPOSTING MODEL
It is recommended, at least, an annual analysis of the resulting compost, taking as reference all the common analytical parameters required in the substrates (RD 865/2010) and fertilisers (RD 506/2013) Spanish regulations: • heavy metals, • pathogens (*Escherichia coli* and *Salmonella*), • organic matter, • pH, • conductivity.

15. References

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16. Example of Monitoring Sheet

SITE____________________

DATE		TECHNICIAN: Name and Surname	SITE PICTURES
Nº PARTICIPANTS		BULKING: Type and origin of the bulking material	
COMPOSTING MODULE	1	2	3
PHASE	*Active (filling)*	*Active* / *Transfer data*	*Maturation* / *Transfer data*
	Pictures	*Pictures*	*Pictures*
AVERAGE TEMP. (ºC)	*67,1*	*53,4*	*43,4*
FILLING LEVEL	*35%*	*80%*	*55%*
MOISTURE	*Excess*	*OK*	*OK*
WATERING	*No*	*No*	*No*
TURNING	*Yes*	*Yes*	*No*
IMPROPERTIES	*No*	*No*	*No*
ADDITION OF BULKING	*Yes*	*No*	*No*
OBSERVATIONS	*Material is not covered. Presence of diptera. Excess of moisture*		
PROTOCOL TO BE FOLLOWED	*This problem is indicative of errors in the management of composters. Mixing must be carried out in order to correct the deviations or incidents detected. After turning over, the fresh material should be covered with bulking material. Turn it energetically in the following "maintenances".*		
NOTES	*Only the composters that contain material in the fermentation phase (intense degradative process) have been analyzed since it has been verified that the maturing material is in adequate process conditions.*		

17. Example of community composting

17.1. Leintz-Gatzaga (Gipuzkoa, Basque Country)

RESPONSIBLE FOR THE INSTALLATION	*LEINTZ-GATZAGA CITY COUNCIL*
TYPE OF FACILITY/SITE	MUNICIPAL 
COMPOSTING SITE MODEL	*HUT COMPOSTER*
No OF COMPOSTING SITES	*1*
TOTAL NUMBER OF COMPOSTING MODULES/CELLS	*8*
TOTAL SITE VOLUME (m^3)	*10*
No TECHNICAL STAFF RESPONSIBLE	*1*
No MAINTENANCE OPERATORS	*1*
No USERS (inhabitants)	*215*
No USERS (large generators)	*4*
BIO-WASTE MANAGED ($t \cdot month^{-1}$)	*2,4*
WORKLOAD	*4 hours/week*
OBSERVATIONS	*The composting sites manage all of the bio-waste generated in the urban nucleus of Leintz-Gatzaga, a small rural municipality located in the south-western part of Gipuzkoa (Basque Country), bordering the province of Álava. It has an extension of 14.72 km^2 with a density of 17.07 $inhab \cdot km^{-2}$. It has a small urban area where 70% of the population resides. The rest of the population lives scattered in some 35 hamlets ("baserris") distributed by the municipal term.*

17.2. Itsasondo (Gipuzkoa, Basque Country)

RESPONSIBLE FOR THE INSTALLATION	*ITSASONDO CITY COUNCIL*
TYPE OF FACILITY/SITE	MUNICIPAL 
COMPOSTING SITE MODEL	*MODULAR COMPOSTER*
No OF COMPOSTING SITES	*8*
TOTAL NUMBER OF COMPOSTING MODULES/CELLS	*36*
TOTAL SITE VOLUME (m^3)	*36*
No TECHNICAL STAFF RESPONSIBLE	*1*
No MAINTENANCE OPERATORS	*2*
No USERS (inhabitants)	*675*
No USERS (large generators)	*13*
BIO-WASTE MANAGED ($t{\cdot}month^{-1}$)	*6*
WORKLOAD	*6 hours/week*
OBSERVATIONS	*The composting sites manage all the bio-waste generated in Itsasondo, a Guipuzcoan municipality located 18 km from Tolosa and 38 km from Donostia (in Basque Country), with an area of 8.94 km^2. It is a small semi-rural municipality that has an urban area in which 85% of the population lives and in which 100% of the large generators are located.*

17.3. Island of Zuhatza (Álava, Basque Country)

RESPONSIBLE FOR THE INSTALLATION	ÁLAVA PROVINCIAL COUNCIL
TYPE OF FACILITY/SITE	PRIVATE (LARGE GENERATOR) 
COMPOSTING SITE MODEL	*MODULAR COMPOSTER*
No OF COMPOSTING SITES	*1*
TOTAL NUMBER OF COMPOSTING MODULES/CELLS	*24*
TOTAL SITE VOLUME (m^3)	*24*
No TECHNICAL STAFF RESPONSIBLE	*2*
No MAINTENANCE OPERATORS	*6*
No USERS (inhabitants)	*21.000 stays*
No USERS (large generators)	
BIO-WASTE MANAGED ($t{\cdot}month^{-1}$)	*8,5*
WORKLOAD	*8 hours/week*
OBSERVATIONS	*The composting area serves the youth hostel located on the island of Zuhatza (Álava), an island of 500,000 m² located in the reservoir of Ullíbarri-Gamboa, 15 km from Vitoria-Gasteiz (Basque Country). This shelter is open during the months between June and October, in which there are around 21,000 overnight stays.*

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Association Fertile Auro (FeA)
Non-profit Professional Association Fertile Auro, 2019
Fertile Auro (FeA) has over ten years of experience in fostering decentralised management models for organic waste, with an environmental and social approach based in the concept of circular economy.

Zero Waste Europe is the European network of communities, local leaders, businesses, experts, and change agents working towards the same vision: phasing out waste from our society. We empower communities to redesign their relationship with resources, to adopt smarter life styles and sustainable consumption patterns and think circular.

Non-profit Professional Association Fertile Auro, 2019
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