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Home Composting: a Review of Scientific Advances †

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† Presented at the 1st International Electronic Conference on Processes: Processes System Innovation, 17–31 May 2022; Available online: https://ecp2022.

Abstract: Composting has demonstrated to be a sustainable technology to treat organic wastes. The process is based on the microbial decomposition of organic matter under aerobic conditions to obtain compost: an organic amendment that can be safely used in agriculture and other applications. Among the composted wastes, the organic fraction of municipal waste is commonly used. In this sense, the interest in composting at home or community scale is exponentially growing in recent years, as it permits the self-management of waste and obtaining a product that can be used by the own producer. However, some questions about the quality of the obtained compost or the environmental impact of home composting are in an early stage of this development. In this review, the main points related to home composting are analyzed in detail according to the scientific current knowledge. Among them: i) the performance of the process, especially in the temperature reached and the fact that if home compost is sanitized, ii) the quality of home composting, especially in terms of maturity and stability, iii) the main environmental impacts of home composting, that is, gaseous emissions and iv) the main trends related to community composting, a step forward from home composting, to make this alternative attractive for municipal organic waste management. The main advantages and possible drawbacks of home composting are also highlighted.

Keywords: organic fraction of municipal waste; home composting; process performance; compost quality; environmental impact.

Citation: Lastname, F.; Lastname, F.; Lastname, F. Title. *Proceedings* **2022**, *69*, x. https://doi.org/10.3390/xxxxx

Academic Editor: Dariusz Dziki

Published: 20 May 2022

1. Introduction

Among municipal waste, food waste (FW) comprises the main fraction (45%) of total municipal solid waste in Europe [1]. This percentage can increase up to 55% in developing countries [2]. Some years ago, the final destination of FW was either the disposal in controlled/uncontrolled landfills or incineration with/without energy recovery.

FW treatment is usually performed by biological processes such as composting and anaerobic digestion, although new strategies are being developed to obtain added value bioproducts from organic waste [3]. Composting is based on the biological degradation of organic matter under aerobic conditions, being compost is the product of composting. The process is considered a sustainable and environmentally friendly alternative for treating FW and is used worldwide at commercial scale in industrial composting plants [4].

In contrast to these big facilities, an increasing number of initiatives using home or community composting have emerged in different parts of the world. Initially, these experiences were explained as hobbies and low scientific information could be obtained from them [5]. Today, we have scientifically-based information about home and community composting, in different aspects such as the performance of the process, the quality of home compost or the environmental impact and Life Cycle Assessment.

The objective of this communication is to present a general perspective of home composting, especially in those studies with scientific data, to provide updated information to the readers about the state-of-the-art of this technology.

2. Home composting

2.1. Process performance

Home composting performance is different from that of industrial full-scale composting. On one hand, it is difficult to maintain the thermophilic conditions that allow compost to be sanitized [6] or the presence of considerable stratification of temperature found in home composters [7]. The results obtained in the composters indicate that small-scale composting was viable, since thermophilic sanitization temperatures (55 °C) were maintained for three consecutive days. However, stability indicators showed a different organic matter biodegradation process along the compost bins height, with the bottom layer requiring a longer period to be stable than upper layers. The authors conclude that these phenomena can have importance when designing commercial home composting reactors. On the other hand, other works studied other important aspects of home composting performance, such as mass balances [8], which are very important for further studies related to Life Cycle Inventories and Life Cycle Assessment (LCA) [9].

Regarding the performance of the process, other aspects are considered in recent literature. Among them, the need of a bulking agent has a special relevance to provide porosity to the mixture to have a strict aerobic process and avoiding unpleasant odors and unwanted gaseous emissions in form of greenhouse gases, especially methane and nitrous oxide (Figure 1).

Figure 1. Detail of a home composter with a proper porosity adjustment.

In this sense, Castiglioni Guidoni et al. (2018) investigated how different ratios of bulking agent and food waste can affect the progress the composting process [10]. Results showed that the ratio of bulking agent has an important effect on the biodegradation of organic matter, nitrogen dynamics and the toxicity of the product. It is evident that this ratio must be carefully studied in home composting to reach an equilibrium between biodegradation and environmental impact [11]. About FW to be included in a home composting process, there is some discussion on the fact of including meat and, in general, food waste of animal origin. Storino et al. (2016) studied the comparison of home composting with and without the presence of meat in the initial mixture [11]. The authors concluded that meat has several positive effects on the process activity and an acceleration of the biodegradation of organic matter, without altering the main physicochemical characteristics (pH, salinity or phytotoxicity) and a low pathogen level with a proper handling of the home composters. However, no information of gaseous emissions expected from meat waste such as ammonia is provided. Other authors showed low gaseous emissions when composting leftovers of raw fruits and vegetables without animal wastes [12]. In the case of inoculation, home composting is a perfect system to use the obtained compost as a source of active microorganisms to maintain a semi-continuous process, although some authors point that the presence of the so-called "Effective Microorganisms" is positive in only particular aspects such as odor control and humification [13].

Finally, some authors comment that collection is a critical step to have a good home composting process. Thus, Puyuelo et al. (2013) performed the comparison of several methods to collect food waste before composting, showing that the use of perforated passively aerated bins jointly with compostable bags was superior to other conventional systems [14]. For instance, this system composed did not imply more gaseous emissions and it was suitable for preparing the organic waste for further composting. Besides, in terms of weight loss, temperature, respiration index and organic matter reduction, the best results were also achieved with the aerated system (Figure 2).

Figure 2. Collection of food waste using compostable bags and aerated bins.

2.2. Home compost quality

In reference to the quality of compost obtained from home systems, there is a consensus in the sense that this quality is similar, if not better, than that of industrial facilities. The absence of impurities in the initial mixture is the main reason of this high quality of home composting. Thus, Vázquez and Soto (2017) present a study including 880 experiences of home composting in rural areas, using household biowaste including meat and fish leftovers [15]. 90 home compost samples were analyzed showing excellent properties: a low C/N ratio (10–15), no physical contaminant materials (less than 0.3% in dry matter), low heavy metal content and high nutrient content (2.1% N, 0.6% P, 2.5% K, 0.7% Mg and 3.7% Ca, respectively). Other studies show similar results of home compost quality in terms of physicochemical characterization (pH, moisture, carbon, nitrogen and C/N ratio) [16,17]. Regarding the presence of pathogenic microorganisms, they were not detected, even when thermophilic temperatures are not fully reached [11].

Apart from these studies, literature is scarce in the comparison of home and industrial composting. A special interesting study is that of Barrena et al. (2014), where a large number of home and industrial composts were compared in terms of stability using respiration techniques [18]. The main conclusion is that home composting, when properly managed, can reach high levels of stability, similar to those of the full-scale composting.

If only physicochemical properties are compared, industrial and home composts are not significantly different.

2.3. Environmental impact

Regarding environmental impacts of home composting, they have been quite extensively studied in literature. On one hand, a main advantage of home composting is the absence of waste transport and lower energy requirements, whereas a possible disadvantage is the lack of gaseous emissions control as in full-scale facilities, which is practically unavoidable [19]. On the other hand, there is a need to compare home composting with industrial composting from the environmental point of view to have an experimentally-based comparison. The preliminary studies on this topic were presented by Colón et al. (2010) and Andersen et al. (2012) [9,20]. Both papers performed a very complete study on the environmental impacts, which were compiled in a LCA. The conclusions of both works are similar: home composting performed better than other waste management technologies in most of the impact categories. Both studies also agree in the fact that gaseous emissions are the main contributors to negative environmental impacts in different environmental categories, especially in the global warming potential.

Accordingly, further studies on the environmental impact have been focused on gaseous emissions during the home composting process [21]. For instance, Ermolaev et al. (2014) studied the greenhouse gases (GHG) emissions of several home composters treating FW and compared them with literature data from full-scale composting [22]. In this case, home composting emitted less methane than large-scale composts, but similar amounts of nitrous oxide. Other works have focused on this comparison, in rigorous studies with the same initial mixture, season and location, with more environmental categories studied. This is the case of Colón et al. (2012) [23]. In this study, four different full-scale facilities treating source-selected organic fraction of Municipal Solid Waste (OFMSW) were environmentally evaluated with a LCA, including composting technologies (in-vessel, turned piles and home composting) and anaerobic digestion plus composting. In this case, home composting was better in terms of environmental impact than the other composting technologies. In a previous work, Martínez-Blanco et al. (2010) directly compared by means of a complete LCA home and industrial composting [24]. In summary, the results were as expected: ammonia and GHG emissions (methane and nitrous oxide) released from home composting were considerably higher than those of industrial composting. However, this latter option involved within 2 and 53 times more needs of transport, energy, water and infrastructures.

3. Community composting

Although used extensively in many countries, especially in central Europe [25], and having an extraordinary development in recent years, community composting has received low attention in the world of research. Thus, there are starting experiences in universities, hospitals, municipal markets or just a group of households. However, the information found in scientific literature is very scarce.

Most of the studies on community composting are related to economic feasibility. From these studies, it is evident that many entities can use community composting. In this case, universities can play an important role as the first stakeholders to impulse this strategy that can be easily extrapolated to other organic waste producers, such as hotels, hospitals or schools. Community composting can have an important influence on two items: on one hand, it can treat a significant amount of organic waste and, on the other hand, it can be a stimulus to promote home composting among citizens [26]. In Figure 3, a recently developed program of community composting in Pontevedra (Spain) is presented.

Figure 3. Community composting in Pontevedra (Spain).

4. Conclusions

It can be concluded that home and community composting have a great potential to be a massively-implemented strategy in organic waste management when developing national and regional programs. One important reason for this expansion is the fact that home composting has passed from being a hobby to a scientifically-based technology. From the environmental and economic points of view, home and community composting appears to be superior to industrial composting in most of the environmental categories, which again makes this strategy attractive to be included in waste management programs.

Author Contributions: "Conceptualization, A.S.; methodology, R.B.; formal analysis, A.S.; investigation, R.B. and A.S.; writing—original draft preparation, A.S.; writing—review and editing, A.S.; funding acquisition, A.S.
All authors have read and agreed to the published version of the manuscript..
Funding: This research was funded by *Agència de Gestió d'Ajuts Universitaris* i de *Recerca of Generalitat de Catalunya*, grant number Pandèmies Project Ref. 2020PANDE00021.
Institutional Review Board Statement: Not applicable.
Informed Consent Statement: Not applicable.
Data Availability Statement: Not applicable.
Acknowledgments: Not applicable.
Conflicts of Interest: The authors declare no conflict of interest.

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