Sustainable Composting of Garden and Food Wastes in Higher Education Institution

Santos M. T., Freitas F., Lamego P., Trindade T.

Abstract— The preservation of resources and the promotion of sustainable economic growth must be achieved by replacing the concept of a linear economy with a circular one, based on decentralized recycling. Decantralised composting like domestic, and community is a biologic treatment for biowaste that can be applied in urban areas. Here, our main objective is to study the process of domestic composting of biowaste produced in food spaces and gardens on the Instituto Superior de Engenharia de Lisboa (ISEL) campus. Experimental data of pH, temperature, and solids (volatile, fixed, and total) was collected for 6 months in 9 composters (8 for food wastes and 1 for garden waste). Results are inline with previously published trends, showing that is possible to apply composting on the university campus.

Index Terms— Domestic composting; biowaste, fruits, vegetables, compost.

I. Introduction

Waste production has increased worldwide, mainly due to population growth, presenting environmental and economic challenges.

Municipal Solid Waste (MSW) represents around 10 % of total waste generated. However, MSW is one of the wastes with the greatest political relevance, due to its composition, complexity and diverse origins and being interconnected with consumption patterns. In Europe, the generation MSW increased between 2004 and 2022, having an annual production of 500 and 513 kg per capita, respectively. In the EU-28 the MSW production varies significantly, depending on several factors such as, consumption patterns, economic wealth, and waste management system. In 2022, MSW generation ranged from 301 kg per capita in Romania to 835 kg per capita in Austria. In Portugal, the MSW production varies from 445 to 513 kg per capita, in 2004 and 2022, respectively, which places Portugal inline with the European average in terms of waste production [1].

Nowadays, the MSW management hierarchy consist of different treatment/valorisation options, like recycling, biological processes (anaerobic digestion and composting), incineration and landfill.

Due to the European legislation, until 2030 Portugal has the challenge to improve the treatment of biowaste, to achieve recycling targets and reducing the amount of bio-waste sent to landfill. According to PERSU 2030, it is expected to collect around 1 million tons of biowaste in 2030, and the installed capacity to treat this waste from selective collection is clearly insufficient at national level. To achieve the established goals, there must be a significant increase in the selective collection of biowaste and recycling at source, as is the case with domestic and/or community composting, together with the prevention of waste production [2].

Composting is a biological process under aerobic conditions, consisting of the transformation of organic waste into compost, which can be applied as organic fertilizer [3]. When composting, it is important to consider several factors that affect the process: size of the waste, temperature, humidity, pH oxygen and C/N ratio [4]. Industrial composting allows biowaste to be treated [5] and has been applied as an alternative to diverting this waste to landfill, however it requires significant investments in terms of transport, operation, and maintenance [6], so the current focus is on the application of decentralized treatments such as community or domestic composting [7][8].

When carrying out domestic or community composting, some precautions must be taken into consideration, such as not placing waste from meat, fish, or prepared foods, as this may increase the appearance of pests, such as cockroaches, rats, and others. There are also some limitations when placing other foods, such as citrus fruits, which can cause a drop in pH, jeopardizing the degradation of organic matter, as mentioned in several composting guides or manuals produced by the Portuguese's Municipalities [9]-[11].

Although domestic composting has been the subject of several studies [7][12], it appears that the amount of biowaste treated is not very significant and that citizens sometimes abandon it because it is a slow process that may have some difficulties in controlling the operative parameters. Another difficulty encountered is ensuring the quality of the compost in domestic or community composting. Generally, the quality of the compost obtained from composting depends on the quality of the biowaste (presence of pollutants and nutrient content) and the operation of the composting process (stability and maturation of the compost). The compost can contain various contaminants, namely microplastics [13] and metals [14].

Higher education institutions have a determining role in the future of citizens, as they transmit knowledge, promote the spirit of initiative and cement decision-making capacity, being a suitable place to raise awareness and promote the challenges of domestic and/or community composting as a tool for a

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sustainable circular economy. Therefore, it is pertinent to develop studies on the issue of biowaste and composting. The present work issue is to study the process of domestic composting of biowaste produced in food spaces and gardens on the Portuguese university campus of Instituto Superior de Engenharia de Lisboa (ISEL).

II. MATERIALS AND METHODS

A. Wastes

Wastes for the composting assays were biowaste produced in food preparation sites and gardens of ISEL campus.

The food wastes were from four places: refectory (P building), student bar, residence, and ByChef restaurant (A building), whose locations on ISEL campus are shown in Fig. 1. The composters were the following designation: residence – F1, refectory - F2, student bar – F3, and ByChef restaurant – F4.

The gardens wastes were from ISEL gardens, mostly grass tree leaves and smalls trunks. The grass is usually cut once a month from November to December and twice a month in the remaining months. The garden composting was done in composter G1, which was placed near F1.

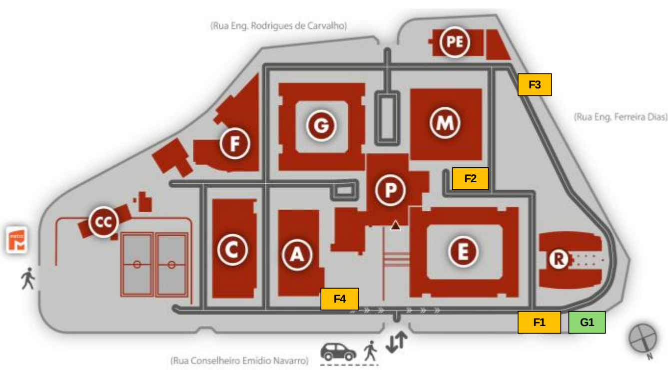

Fig. 1. Waste sources and composters localizations (yellow and green boxes) in ISEL campus.

B. Experimental composters

For the food waste composting it was necessary to assemble eight domestic plastic composters for food waste with about 320 L (Fig. 2). Seven composters were provided free of charge by the Lisbon city council and one of the composters was purchased. Two composters were placed in each location (Fig. 1), to ensure that when one of the composters was full, the waste was placed in the other composter.

a) Outside view b) Inside view

Fig. 2. Composters for food wastes: a) outside and b) inside.

For green waste, a larger capacity composter (1800 L) built with wooden pallets was necessary (Fig. 3).

a) Outside view b) Inside view

Fig. 3. Composter for garden wastes: a) outside and b) outside

The composters locations were chosen to avoid significant sun exposure and protection from precipitation.

C. Composting assays

Before the composting tests, several awareness-raising activities were carried out, which began with a survey that aimed to collect data on knowledge of waste separation, domestic composting and biowaste. The results of the survey were presented at another scientific event and are therefore not presented in the present work. Workshops, webinars were subsequently held, and a leaflet was drawn up as a composting manual, which was also placed near the composting sites. At these events, it was explained which waste should be placed and which should be avoided (e.g. cooked food, meat, or fish) in the composters, to avoid various pests.

Two composting assays, for food waste, were carried out for six months each, starting in January and September, respectively. The first assay consisted of monitoring the eight composters for food waste, coming from food preparation sites on the ISEL campus (refectory, student bar, residence, and ByChef restaurant).

Due to several factors, namely the operation of the institution per semester with academic interruptions in August and part of December, and other holidays, it was necessary to adapt the sample collections. In the case of the composters located in F4, monitoring had to be interrupted due to works on the facades of building A for several months, so data is scarce and is not presented in the present work.

In the composting assays, samples of the composter's contents were collected 1 to 2 times a week, to measure the pH, total and volatile solids.

A third composting trial was carried out for garden waste, starting in September, and lasting around six months.

D. Analytical procedures

For the individual characterization of waste (e.g. fruits, vegetables, tree leaves and grass) samples were prepared according to the quartile method, being previously crushed.

To measure the temperature inside the composters, 5 points were selected, four points along the sides and a central point. At these points the temperature was measured with a glass laboratory thermometer.

Also, temperature and humidity sensors were also placed, which allowed hourly readings.

To measure pH, the electrochemical method with selective electrode was applied. For each pH measure 1 g of waste was taken into a beaker with 10 mL of distilled water. The solution was stirred by a magnetic stirrer, for 30 min. Then, the data were recorded.

The total (TS), volatile (VS) and fixed (FS) solids were determining according to the Standard Methods 2540 [15]. Each measurement was performed in duplicate.

III. Results and discussion

A. Waste characterization

Several wastes were characterized individually, such as pine needles, plantain leaves and bark, grass, rubber tree leaves, cabbage, watermelon rind, banana peel, yellow plum, tomato, red apple, courgette. The individual waste characterization in terms of pH and solids contents are presented in Fig. 4 and Fig. 5, respectively.

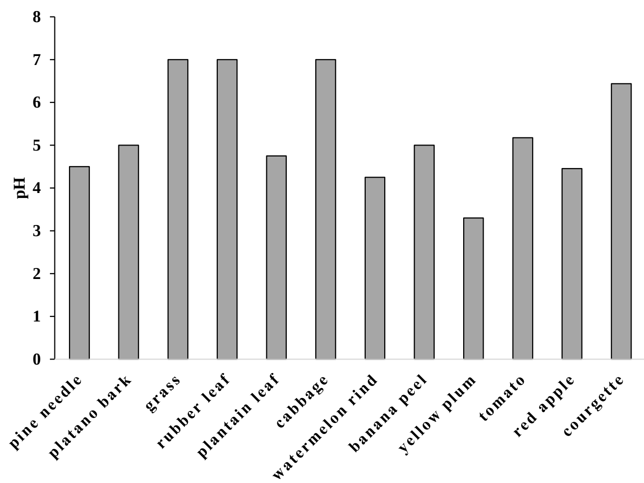

Fig. 4. pH data for the individual waste types.

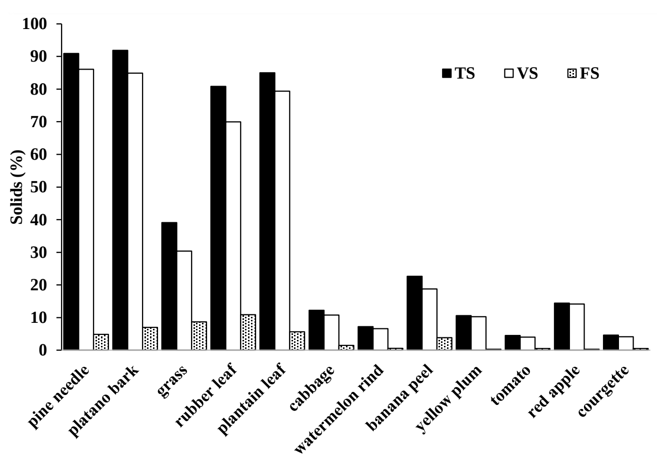

Fig. 5. Solid contents for the individual waste types.

The results reveal that the wastes pH range was from 3.3 (yellow plum) to 7.0 (cabbage, grass, and rubber tree leaves). According to [16] [17] [18] food waste from school lunches and from restaurants have a pH range of 5.4-5.6 and 3.8-6.5, respectively. Banana peels have a lower pH value (5.0) than that presented in [19] around 6.7.

In composting, the optimum range of pH values is 7-8 [16], so wastes with a lower pH should be mixed with others with a higher pH, to optimize the pH of the mixture.

The solids results reveal significant differences, with tree bark and leaves having higher solids contents, with TS values of 80 to 90 % and VS of 70 to 85 %. Fruit and vegetable wastes have lower TS values in the range of 4.5 to 20.6 %. The VS contents for fruits and vegetable were within the 4.1 to 18.8 % range. Similar results were report by [20] for TS with a range of 7.5 to 23 % for fruits and 3 to 11 % for vegetables and for VS with 5 to 12 % and 2 to 9 %, respectively.

Of all waste characterized in terms of solids, grass presents intermediate values, with around ST of 40 % and VS of 30 %.

Waste with a higher moisture content are affable to degradation, which helps the faster release of nutrients [19], which is beneficial to the composting process.

B. Composting Assays

During the food composting assays several contaminants were identified, and the composters near the refectory (F2) were those that presented the greatest diversity and largest quantity of contaminants, despite several awareness campaigns on how to do domestic composting for refectory employees. The following items were identified and removed as contaminants: plastic bags and nets, prepared foods (fish bones), knives, and potato peelers.

The composters F1, F2 and F3 have similar temperature profiles, so it was decided to only present the graph for composters F2 (Fig. 6) and F3 (Fig. 7). The temperature was measured in five points in each composter as mentioned in point II D. The composters F1 to F3 the temperature range was from 15.3 to 28 ºC for the five points.

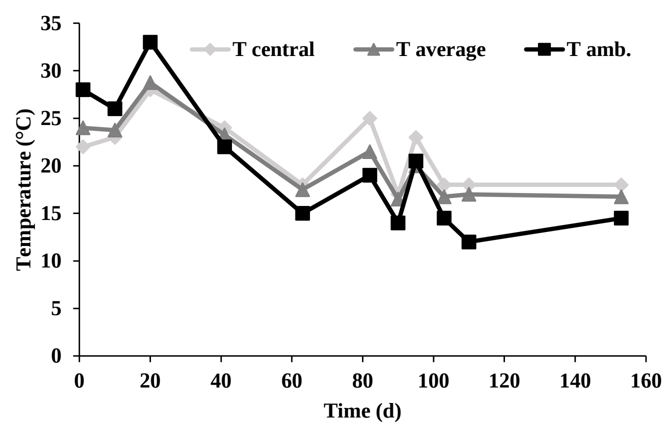

Fig. 6. Temperature evolution in composter F2.

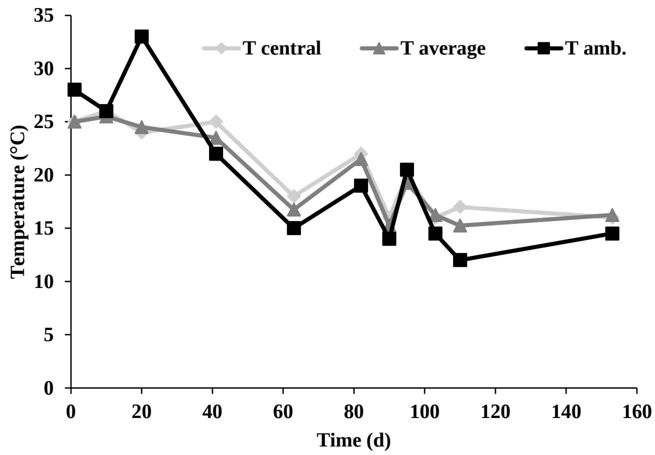

Fig. 7. Temperature evolution in composter F3.

The central point of the composters had the highest temperature when compared with the average temperature but with a difference of only about 2 ºC. The maximum temperature is lower than usual for the thermophilic phase of the composting process, probably due to the small amount of organic matter deposited in the composters. This is in accordance with the profile of the solids during the composting assays. According to [21] the composting assays with food and vegetable garden wastes, in 340 L composters had a temperature range between 10 to 70 ºC, and the thermophilic phase was reached with a temperature range of 50 to 70 ºC.

The pH determination for the three composters (F1 to F3) during the food composting assays is presented in Fig. 8.

The composters contents had a pH range from 5.0 to 9.8. During the assay, compost was removed twice and applied to the ISEL campus gardens.

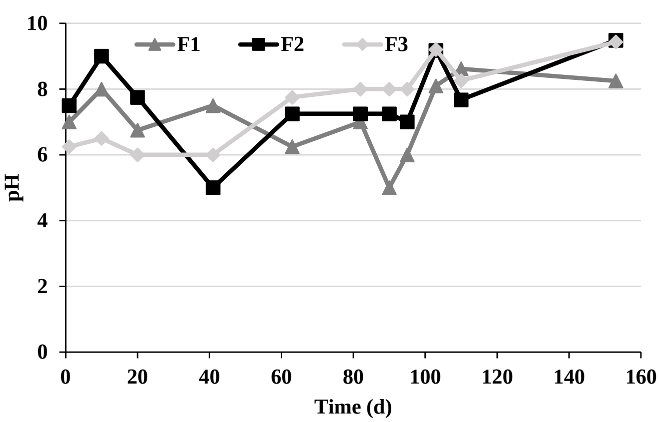

Fig. 8. pH evolution during the food composting assays, in composters F1 to F3.

The third assay was with the garden wastes, mainly grass, and tree leaves. The composter G1 presents a temperature range from 25 to 57 ºC for the middle point and from 20 to 30 ºC as an average temperature of the four points (Fig. 9).

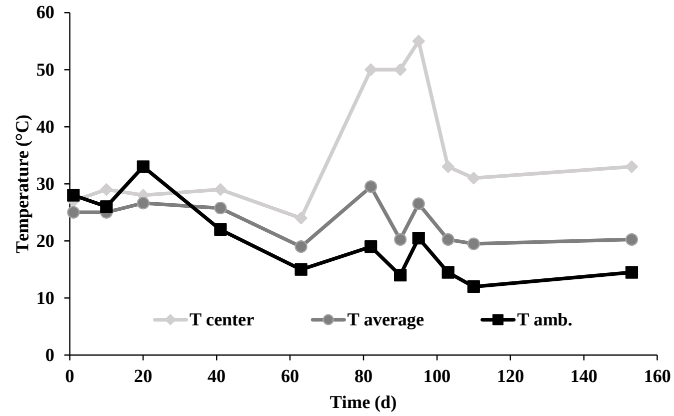

Fig. 9. Temperature evolution in composter G1.

In this assay the highest temperature was also the middle of the composter, but with significant difference (+ 27 ºC), probably due to the greater amount of organic matter that enhances exothermic reactions with heat release. Therefore, the thermophilic phase was reached as mentioned by [21].

As happened in the food wastes composting assays, contaminants were also found in these assays, mainly plastics.

IV. CONCLUSIONS

The experimental composting data revealed that is possible to carry out domestic composting in higher education institutions. Nevertheless, this process is highly dependent on participants procedure, and it is a relatively slow process (5 to 6 months). It is difficult to collect adequate food waste, without contaminants, and it is necessary to carry out frequent awareness campaigns to reach as many people as possible. In ISEL campus it was easier to compost garden waste because they are produced from only one source.

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