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BIOMASS REDUCTION OF ORGANIC MATERIALS IN A DOMESTIC COMPOSTING SYSTEM

REDUÇÃO DE BIOMASSA DE MATERIAIS ORGÂNICOS EM SISTEMA DE COMPOSTAGEM DOMÉSTICA

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ABSTRACT

The population growth of urban cities has led to an increase in the demand for food and, consequently, in greater quantities of solid organic waste destined for landfills and/or dumps. The objective of this work was to evaluate the effect of temperature on household organic waste in reducing biomass through the domestic composting process. The waste was collected with 5 families (F1, F2, F3, F4 and F5) located in a neighborhood of São Luis and deposited in compost containers made with plastic containers with a capacity of up to 15 kg of waste. A period of 95 days was adopted to finalize the process. The temperature parameter was performed with the aid of a chemical thermometer and the biomass loss was calculated taking into account the initial weight minus the final weight divided by the initial weight of the biomass, a result given in percentage. The temperatures reached by all composters were, on average, above 40° C in the thermophilic phase and 30° C in the mesophilic phase, the biomass reduction was over 50% in all composters, with emphasis on F1, which reached a percentage above 70%. Other factors such as the presence of ants spp., larvae of *Hermetia illucens* (L., 1758) (Diptera: Stratiomyidae), aeration and types of residues may also have affected the percentage of biomass loss. These data are important because they will serve as a planning basis for future work, with the possibility of using larger areas destined for composting and, consequently, higher volumes of organic solid waste will no longer be sent to landfills, dumps or in inappropriate places.

KEYWORDS: **Environment, Loss, Temperature, Waste.**

RESUMO

O crescimento populacional das cidades urbanas levou ao aumento pela demanda por alimentos e consequentemente em maiores quantidades de resíduos sólidos orgânicos destinados a aterros e/ou lixões. O objetivo deste trabalho foi avaliar o efeito da temperatura sobre os resíduos orgânicos domiciliares na redução de biomassa através do processo de compostagem doméstica. Os resíduos foram coletados juntamente à 5 famílias (F1, F2, F3, F4 e F5) localizadas em um bairro de São Luis e depositados em composteiras confeccionadas com recipientes de plástico com capacidade para até 15 kg de resíduos. Foi adotado período de 95 dias para finalização do processo. O parâmetro temperatura foi realizado com auxílio de um termômetro químico e a perda de biomassa foi calculada levando em consideração o peso inicial menos o peso final dividido pelo peso inicial da biomassa, resultado dado em porcentagem. As temperaturas atingidas por todas as composteiras foram, em média, acima de 40°C na fase termofílica e 30°C na fase mesofílica, a redução de biomassa foi superior a 50% em todas as composteiras com destaque para F1 que atingiu percentual acima de 70%. Outros fatores como a presença de formigas spp., larvas de *Hermetia illucens* (L., 1758) (Diptera: Stratiomyidae), aeração e tipos de resíduos podem também ter afetado no percentual de perda de biomassa. Esses dados são importantes pois servirão como base de planejamento para trabalhos futuros, com possibilidades de aproveitamento de maiores áreas destinadas a compostagem e consequentemente maiores volumes de resíduos sólidos orgânicos deixarão de ser destinados a aterros, lixões ou em locais inadequados.

PALAVRAS-CHAVE: **Meio ambiente, Perda, Temperatura, Resíduo urbano.**

INTRODUCTION

In 2019 the world population was estimated at 7.7 billion people, with Brazil having around 211 million in habitants (UN, 2019). In a survey carried out by the Brazilian Institute of Geography of Statistics (IBGE, 2010), it was estimated that organic waste makes up about 51.4% of solid waste, produced in households in an urban area and liable to be reused. Of the total organic waste produced, only 89 thousand tons are destined for the composting process (ABRELP, 2019), which is equivalent to just over 1%, which is carried out either domestically or industrially.

Composting is a process of degradation of organic waste carried out in a controlled and natural way (BRASIL, 2018), seen as one of the main alternatives for the use and reduction of waste through the process of transformation into organic compost, having a strong social and economic impact because it can guarantee an efficient domestic treatment of organic waste through low cost, which makes it a simple process that can be carried out by the population in their homes and that guarantees the preservation of the environment (MARCHI & GONÇALVES, 2020 ; BARBOSA et al., 2019). During the process of aerobic composting, organic waste (OW) is used by microorganisms as a food source, which causes the components of the OW to be transformed into a dark and uniform colored compound at the end of the process, in addition to the release of CO_2 and water (PINTO, 2001; SIQUEIRA & ASSAD, 2015).

A large portion of materials of organic origin have reduced time to decompose. The reduction in the mass of composting, among other efficiency indexes, should be planned in the perspective of establishing essential technical factors for the coherent progress of the process and also allowing for an increase in the useful life of landfills (BRASIL, 2010; ARAÚJO et. al., 2013; BOINA et al., 2020). Several authors have reported that the temperature is one of the main factors that must be observed during the composting process for a good progress of the decomposition and transformation of the organic matter.

In view of the above, the objective was to evaluate the effect of temperature on household waste in reducing biomass through the domestic composting process carried out in plastic containers.

MATERIAL AND METHODS

Collection of organic waste

The domestic organic waste was collected together with 5 families (F1, F2, F3, F4 and F5) from a neighborhood located near the center of São Luis, soon afterwards they proceeded to sort and select the materials according to NBR 13591 of 1996.

Manufacture of composters

The composters were made according to what was described by Rodrigues & Stuch (2014) with modifications in the model proposed by the authors (Figure1).

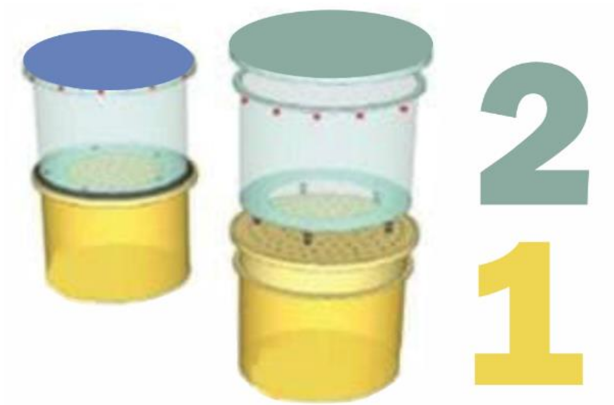

Figure 1. Model of adapted composter used in the research. Source: Rodrigues and Stuch (2014) modified by the authors in 2020.

Plastic containers were reused for making the compost containers, totaling 10 containers with a capacity of up to 16 kg of waste each. Holes were drilled in the lower and upper sides of the containers with an opening of 6 mm in diameter and 2 cm of distance between each other in which the waste was deposited. A circular cut of 21 cm in diameter was performed on the lid of the lower container for percolating the biofertilizer, a double layer of closed mesh was added to allow only the percolation of the biofertilizer to the collecting container.

The material used as a source of nitrogen to be decomposed was diversified food scraps (with the exception of meat, milk and dairy products and seasoned foods) obtained from families and as a carbon source, dry leaves of *Ficus benjamina* and *Ixora chinensis* were used because they are abundant and close to the composting unit based at the Federal Institute of Education, Science and Technology of Maranhão (IFMA - Campus São Luis, Monte Castelo), establishing a ratio of 2: 1 (two parts of dry leaves for one part of food waste).

Assembly and composting system

After being collected, the organic residues were weighed and shortly thereafter they underwent comminution between 0.3 cm and 1.5 cm, as described by Inácio & Miller (2009), as the ideal size.

The dried leaves were placed as a first layer on the bottom of the upper container in order to avoid obstruction of the holes and consequently prevent the percolation of liquid biofertilizer to the lower container, soon afterwards a layer of organic residues interspersed with dry material was added. The deadline of 30 days was established as the maximum time for filling the upper container, in view of the minimum composting time adopted of 95 days after the last deposit day.

The rotations were made every 3 days a week in the thermophilic phase and once a week in the mesophilic phase. The temperature of the compost was measured from Monday to Friday with the aid of a chemical thermometer positioned in the center of the compost at 15cm deep for 5 minutes, always at 9:00 am. Measurements were taken up to 35 days, a period in which temperature variations were no longer found in all composters.

Biomass loss from organic waste

To carry out the quantification of the residues, individual weightings of the residues deposited in each compost belonging to the respective family were made, the result was given individually by the sum of the residues collected during thirty days. After 95 days of the composting process, individual weighing of the contents of the composters was carried out, with the results given according to formula 1. All weightings were carried out on a semi-analytical digital scale with a capacity of up to 5 kg, measured and stabilized.

$$\textbf{Loss of biomass}\ (\%) = \frac{\text{Starting weight (kg)} - \text{Final weight (kg)}}{\text{Starting weight (kg)}} \times 100 \qquad (1)$$

RESULTS AND DISCUSSION

Biomass loss from organic waste

The percentage of biomass loss was evident in all the residues deposited in the compost bins, where after the curing period, F1 obtained the greatest loss among all families. Table 1 shows the comparative values of each family before and after the composting period.

Table 1. Comparison weight before and after composting.

Time	F1	F2	F3	F4	F5
Weight of waste in the beggining of composting (kg)	11,84	8,83	12,8	9,72	10,31
Weight of waste after composting (kg)	3,31	3,26	5,4	4,3	3,80
Loss of biomass (%)	**72**	**63**	**69**	**55**	**63**

Moura et al. (2020) obtained an average of 98% reduction of organic waste from tree pruning in the public cleaning system and university restaurant composted in plastic gallons, a reduction that contributes to the extension of the useful life of landfills, once which decreases the amount of waste destined for these deposition areas. In research using structural materials with organic substrates derived from fruits and vegetables, Vich et al. (2017) found around 58–61% reduction in wet mass in domestic composters made with plastic containers with a capacity of 10 liters. These biomass losses occur naturally due to the metabolic degradation of composted organic waste that has mineralized, in various inputs the loss of biomass must be taken into account for satisfactory performance to occur in the composting installation and management projects (PIMENTA et al., 2016; BREITENBECK & SCHELLINGER, 2004).

Another important factor is the type of material used for composting, which can favor or hinder this loss⁄material transformation, this being observed in F1, which had a greater presence of leafy vegetable residues in relation to F2, F3, F4 and F5. Vegetables have high water content in their composition which, combined with the thermophilic, mesophilic and recurring turns, favored the greatest loss of biomass.

The turns in the containers provided oxygenation of the compound, which helped to reduce biomass. The windrow method was pointed out by Ahmad et al. (2007) as simple and easy to maintain with overturns that provide aeration, stimulating the development of microorganisms and increasing porosity. The same author also reported that the method can be done 1-2 times a week, however in this research, rotations were adopted every three days in the first month and once a week in the second and third months of composting, which could have inferred in biomass loss above 50% in all compounds. Kiehl (1998) stated that rates above 50% of mass reduction are essential for the success of domestic composting, which is also highlighted by Yue et al. (2008) where the authors reported that this system may cause a loss of up to 83% reduction in initial volume, a value close to that found in F1.

Temperature

The composting process of household waste went through phases of natural heating of the compost. According to Inácio & Miller (2009) the mesophilic phase can reach up to 43° C, whereas the thermophilic phase is characterized by having temperatures above 40° C. The minimum and maximum temperatures of the compost suffered little variation between the compounds of each family, the minimum temperatures presented in Table 2. Among other factors that benefit the composting process, Guardia et al. (2012) cites temperature as a promoter in the drying of waste.

Table 2. Temperature variation of the composters in the period of 95 days.

Parameter	F1	F2	F3	F4	F5
Maximum temperature (°C)	43	45	41	43	41
Minimum temperature (°C)	30	30	30	30	30
Monitoring duration (days)	32	32	32	32	32
Duration of composting process (days)	95	95	95	95	95

It is noteworthy that temperatures above 70° C in composting processes are associated with large amounts of organic waste carried out in larger volumes or in windrows, as reported by Colon et al. (2010) containers with smaller volume capacity have little thermal insulation. In this research, the composting of the organic residues of each family was carried out separately in domestic compost containers with a capacity of up to 15 kg, however the residues provided by the families reached the appropriate temperatures for the progress of the process. The successive deposition of more residues could have contributed to a "cooling" of the temperature of the compounds together with the heat dissipation through the aeration of the compound, despite the fact that the deposition of more residues favored a reheating of the biomass.

After the thermophilic phase, the appearance of larger organisms is common, with a view to lowering the temperature, with fungi being the last organisms to appear in the process, because according to what was reported by Inácio & Miller (2009), most fungi grow at temperatures below 50°C.

Macrofauna

The macrofauna was represented by insects as ants spp. and larvae. Ants probably appeared because the composters were located in an open garden since, according to Korasaki et al. (2013) ants are dominant in most of the terrestrial ecosystem. These insects are good aerators, act in porosity and assist in soil drainage (VASCONCELOS, 2008), which may also have interfered in the reduction of biomass in composting since in addition to the presence of the insect, eggs were found that showed colonization and adaptation of the ants to the process after the thermophilic phase. The larvae of *Hermetia illucens* (L., 1758) (Diptera: Stratiomyidae) popularly known as black soldier fly may have come from fruit residues or from the environment itself. This insect species, in its larval phase, can act as a degrader of organic solid waste in composting with its use in continuous growth in the world, in addition to serving as a protein source in animal nutrition and not being able to transmit diseases in any stage of the life cycle of this insect (TEIXEIRA FILHO, 2018; SILVA & HESSELBERG, 2019). However, it is worth noting that, in F1, no larvae of that insect were found and that this compost was the one that suffered the greatest loss of biomass in relation to the others, another important factor is that in F1, mostly vegetable residues with little presence of residues were used of fruits.

CONCLUSIONS

That said, domestic composting proved to be viable for the reuse of solid household organic waste, with a reduction in the volume of waste produced by participating families that could be sent to landfills and landfills, in addition to originating an organic fertilizer that has great potential for use in family and urban agriculture.

All composters had a biomass loss greater than 50% in relation to the initial weight of the waste, temperature, aeration and the action of macroorganisms also favored this loss. These data are important because they will serve as a planning basis for future work, with the possibility of using larger areas destined for composting and, consequently, higher volumes of organic solid waste will no longer be sent to landfills, dumps or even in unsuitable places such as streets, alleys, vacant lots, among others.

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