[1.]Daniela MILOŞTEAN, [2.]Mihaela FLORI

STUDY OF BIODEGRADABLE WASTE COMPOSTABILITY THROUGH SELF-HEATING TEST

[1,2.]Faculty of Engineering Hunedoara, University Politehnica Timişoara, ROMANIA

Abstract: In general, composting is done both to reduce the amount of biodegradable waste, which would otherwise be sent to storage, and to obtain a material that can be used in agriculture. In this paper is studied the degree of compostability for 4 proposed recipes that contain biodegradable materials such as: garden waste and kitchen waste. By measuring the temperature of the mixture of organic materials, introduced in thermos vessels and aerated during 7 days, conclusions can be drawn about the degree of compostability of each sample.
Keywords: organic waste, compostability, temperature, self-heating test

1. INTRODUCTION

Biodegradable waste should be recovered as efficiently as possible, and this can be done for example through composting. This process is quite complex, and of course there are a number of factors that influence the decomposition processes of organic matter, namely:

— *The quality of the raw material* - is of great importance because a correct choice of input materials will lead to the obtaining of a high quality compost. And certainly, a high quality compost can be produced only with organic materials that must not contain pollutants and other unwanted materials [1,2].

— *Temperature* - it appears partly as a result of the decomposition processes, and on the other hand as a reaction that determines and modifies the decomposition process [3]. This factor influences both the process itself and the rate of decomposition. The different temperature ranges that occur in the decomposition process favor various groups of microorganisms. The activity of microorganisms increases with increasing temperature, but is not allowed to exceed 70°C [2].

— *C/N ratio.* Decomposing organic materials contain nutrients necessary for the development of microorganisms. These are: carbon (C), nitrogen (N), phosphorus (P), and potassium (K). The relative amounts of carbon and nitrogen in the raw material greatly influence the composting process and are thus used as primary indicators of nutrient content [4]. From a practical point of view, it can be considered satisfactory if the C: N ratio is between 20:1 and 35:1[2].

— *Granulation and homogeneity of the raw material.* The preparation of input materials plays an important role in the decomposition of the material to be composted. Materials with a smaller grain size provide a much larger surface area for microorganisms than those with a large grain size [3]. For example, if the wood is properly shredded and well defibrated, microorganisms have access to the material more easily and also the aeration is improved [1]. Homogeneity, i.e. the uniform distribution in the mass of compost of various components with different characteristics and properties is an important factor, since an inhomogeneous distribution of the C:N ratio or humidity, for example, negatively affects the process [3].

— *Air saturation.* Depending on the air saturation, two types of decomposition limit can be distinguished, namely: anaerobic and aerobic. Their knowledge is very important because it depends on them: the rate of decomposition, what kind of intermediate products are formed, what health effect the composting will give and what value will the final product have in terms of its use in agriculture. It is much more advantageous if aerobic decomposition predominates in the composting process [3].

— *Humidity* - is an essential factor in the activity of microorganisms [5,6] as drying of the composted material greatly impedes their activity, while if the humidity is too high oxygen is not able to enter the pile in sufficient quantities to maintain aerobic fermentation. It is considered satisfactory to have a moisture content between 40 and 65 percent [4].

— *PH value* - decisively determines the activity of any living microorganism. It may encourage, hinder or make this activity impossible. The range of pH values of microorganisms taking part in the composting process is approximately between the limits of 4 and 9, because different microorganisms thrive at different pH levels. In the case of acidic conditions, the fungi have a more intensive activity, while in the case of basic ratios - bacteria. [3].

According to the specialty literature, the optimum domain for microbial activity is between 6.5 and 8.0 [4,7], but pH values in the interval 7 and 11 are also good [8].

This paper analyzes the compostability degree of biodegradable materials through the laboratory self-heating test. This test can be considered as an appropriate biological test analysis to obtain rapid information on the compostability of the tested materials [3]. By measuring the temperature of the organic materials mixture from the thermos vessels, conclusions can be drawn about the compostability degree of each recipe.

2. MATERIAL AND METHODS

Garden waste (leaves, grass, shell, branches, sawdust, moss, weeds, etc.) and kitchen waste (leftover vegetables, fruit, salad, eggshells, coffee grounds, bread) are the most suitable organic materials for composting [2]. In order to carry out the self-heating test it is necessary, first of all, to prepare this organic matter. So, the following steps must be performed:

— *Step 1 – Shredding.* The preparation of raw materials aims to accelerate the biochemical reactions that take place in the decomposition process. The particle size of the materials after crushing must be less than 10 mm [2], as can be seen in the images below (figure 1).

Figure 1. Biodegradable materials in the initial form and after shredding

— *Step 2 – Homogenization.* According to the existing studies [2], a composting mixture must consist of 50% structural material (in volume) and 50% kitchen waste or 50% green garden waste (see figure 2 and 3). It's not good to mix kitchen waste with garden waste. The structural material comes from garden waste and consists of: branches, tree bark, plant stems, dried leaves, straw and sawdust. They are carbon-rich materials and at the same time intensify the natural aeration of the pile [2]. To have a proper humidity water is added. The moistened samples are mixed several times and after a break of 1 h they are inserted loosely into the thermos vessel. During the test, a constant temperature of the external environment is maintained. Also to activate the fermentation forest soil can be added. This soil contains microorganisms and helps to begin the process of decomposition.

Figure 2. Mixture of biodegradable waste (c) consisting of: structural material (a) and kitchen waste (b)

Figure 3. Mixture of biodegradable waste (c) consisting of: structural material (a) and green garden waste (b)

The equipment needed to perform the self-heating test consists of: thermos vessel with a capacity of 1-2 liters, perforated metal tube, thermometer, technical balance, biodegradable waste, forest soil.
Figure 4 shows schematically the installation used for self-heating samples.
The role of the perforated metal tube is to allow air to enter the mixture so that the decomposition is aerobic.
The thermometer is used to measure the temperature of the mixture and the temperature of the room in which the thermos vessels were kept during the tests.

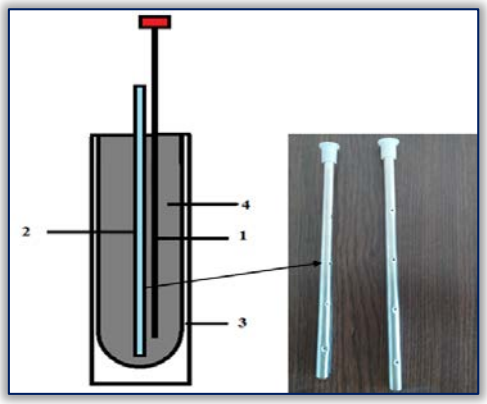


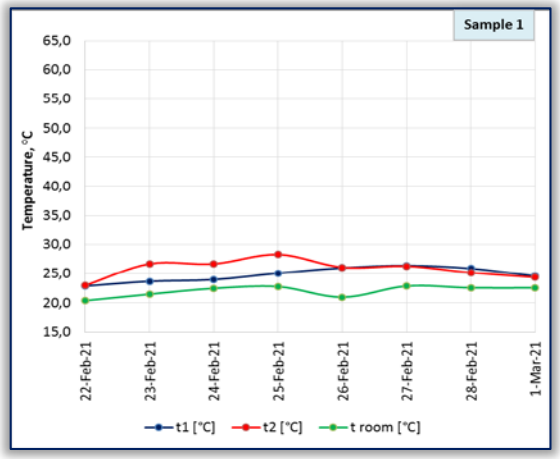
Figure 4. Scheme of biodegradable waste self-heating installation
1 - thermometer; 2 - perforated metal tube; 3 - thermos type vessel; 4 - biodegradable waste sample

3. RESULTS AND DISCUSSION

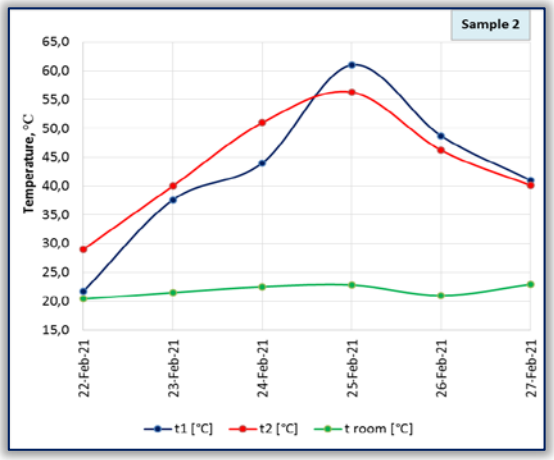
Four recipes have been established that contain in different proportions biodegradable waste/materials and sometimes forest soil, according to table 1.
The samples were inserted into the thermos vessels and then the temperature was measured, twice a day. According to the literature [2] if no heat is released the mixture is not suitable for composting, but if the temperature of the mixture rises above 40°C the material is proper to be composted.

Table 1. Recipes

Biodegradable waste \ Sample	1	2	3	4
Structural material: straw, branches, reeds, corn stalk, dried leaves, tree bark	50%	40%	50% (without reed)	45% (without reed)
Kitchen waste: vegetables (carrots, potatoes, peppers) and fruits (apples) etc.	-	60%	-	55%
Green garden waste: grass, weeds, lettuce	50%	-	50%	-
Water	100 ml	50 ml	100 ml	It was not necessary
Forest soil	30 gr	30 gr	-	-



a)



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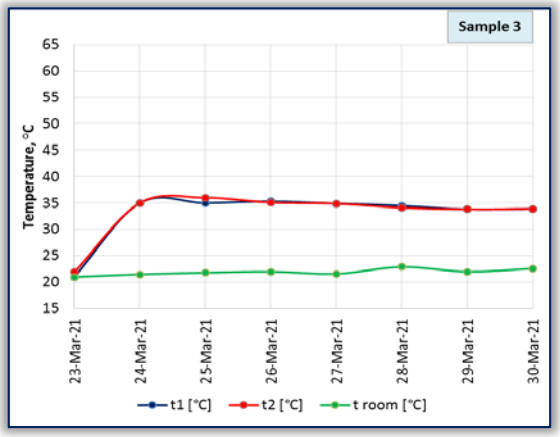
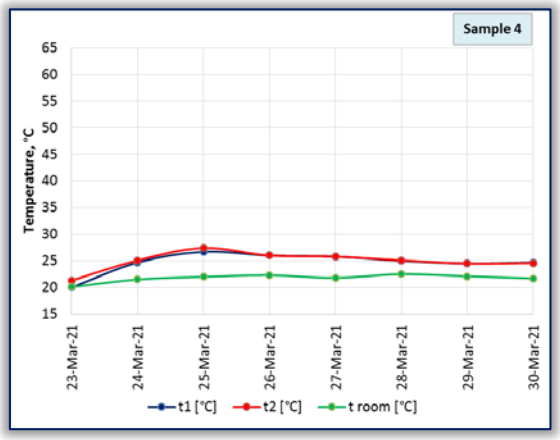


c)



d)

Figure 5. The temperature variation of samples 1-4

Figure 5.a-d) shows the temperature variation of samples 1-4, whose composition is registered in table 1. The curve marked with t_{room} indicates the temperature of the room in which the thermos vessels were kept during tests. As can be seen this remained approximately constant in the range of 20-22°C. The curve marked with t_2 represents the temperature measured during the morning between 7:30-9:00, and the curve t_3 indicates the temperature measured in the afternoon, between 16:00-17:30.

In figure 5-a) is presented the temperature variation of sample 1, during 7 days. Studying the graph it is found that the temperature did not exceed 28°C, so the mixture is not suitable for composting. Although the recipe is in accordance with the existing information in the literature, it seems that there were still factors that negatively influenced the process and the temperature did not rise.

By analyzing figure 5-b) it can be seen that the temperature of the biodegradable materials mixture increased in 24 hours by approx. 17ºC. The upward trend in temperature was maintained until the third day when the maximum temperature of 61°C was reached, after which it started to decrease (figure 6). Since the temperature has risen above 40°C it can be concluded that the material mixture is suitable for composting.

Figure 6. The temperature of sample 2 during the first 3 days of test

In the graph from figure 5-c) it can be seen that the temperature increased in 24 hours by about 15ºC. The maximum temperature reached was 35.3°C, so the material is suitable for composting only if an additions material is added. As can be seen in Table 1, this sample does not contain forest soil.

Figure 5-d) shows that the temperature of the biodegradable materials mixture increased very little during the 7 days. In conclusion, the degree of self-heating of this sample indicates that the material is not suitable for composting. It should be noted that the recipe corresponding to sample 4 did not contain reeds, so the humidity has become too high and the fermentation anaerobic.

4. CONCLUSIONS

Based on this study, the following conclusions can be drawn:

— Sample 2, which contains 60% kitchen waste (carrots, potatoes, apples and peppers), 40% structural material (straw, branches, reeds, corn stalk, dried leaves and tree bark) and forest soil reached the maximum temperature of 61°C after 3 days from the start of the test. In conclusion the recipe is suitable for composting;

— In general, if the temperature of the mixture during the test rises above 40°C the material is suitable for composting, but if no heat is released, the material is not appropriate for composting [2];

— All factors of the organic materials decomposition process are extremely important, because every one of them can negatively affect the process.

References

[1] Van der Wurff A.W.G., Fuchs J.G., Raviv M., Termorshuizen A.J. (Editors), Handbook for Composting and Compost Use in Organic Horticulture, 2016, BioGreenhouse COST Action FA 1105, www.biogreenhouse.org
[2] Bachert C., Bidlingmaier W., Wattanachira S., Open windrow composting manual, (Manual privind producerea compostului în grămezi (şiruri) neacoperite), Published by European Compost Network ECN/ORBIT, Weimar (Germany), 2008
[3] Feher G., Disposal and recovery of household waste (Evacuarea şi valorificarea deşeurilor menajere), Technical Publishing House, Bucuresti, 1982
[4] ***Part 637 Environmental Engineering National Engineering Handbook, Chapter 2. Composting, 2020 https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=28910.wba
[5] Ayesha Ameen, Jalil Ahmad, Shahid Raza, Effect of pH and moisture content on composting of Municipal solid waste, International Journal of Scientific and Research Publications, Volume 6 (5), 2016
[6] Wang Y., Ai P., Cao H., Liu Z., Prediction of moisture variation during composting process: A comparison of mathematical models, Bioresource Technology, Volume 193, pp. 200-205, 2015
[7] Dincă M. N. et al., Recovery of organic waste through composting process, Acta Technica Corviniensis – Bulletin of Engineering, Tome XII (1), pp. 119-122, 2019
[8] Caba I. et al., Improving the composting of waste materials from agricultural farms, a step towards sustainable agriculture, E3S Web of Conferences, 8th International Conference on Thermal Equipment, Renewable Energy and Rural Development (TE-RE-RD 2019), Volume 112, 2019

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665