Biowaste composting process - comparison of a rotary drum composter and open container

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Abstract

Composting is recognized as a sustainable waste management approach in which microorganisms treat and stabilize biodegradable waste under aerobic conditions to obtain compost as a final product. In this paper, composting of biowaste in a rotary drum composter (closed system) and an open container (open system) was compared. Temperature, pH, electrical conductivity, a carbon-to-nitrogen mass ratio (C/N ratio) and contents of moisture, carbon and dry and volatile matter, were measured during composting. Results showed decreasing profiles for moisture, volatile matter, and carbon contents, as well as for the C/N ratio, while increasing profiles for the dry matter content and electrical conductivity during composting in both systems. Leachates were formed only during the first three days of composting and were characterized with high organic loads, high ammonia concentrations, low pH, and high conductivity and turbidity. The organic matter content data during the composting process were analysed according to the first order kinetic model. Results suggested that there was a difference in the rate of organic matter decomposition, which was higher when composting in the open vessel than in the rotary drum composter.

Keywords: dry content; volatile mater content; moisture content; electrical conductivity; kinetic analysis, leachate charaterization.

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1. INTRODUCTION

Industrialization, growing population and a high standard of living are the main causes of a significant increase in the amounts of mixed municipal waste. The usual practice of municipal waste management in many countries all over the world is based on the waste disposal on landfills, which poses a risk to human health and may cause a long-term environmental pollution [1]. Thus, primary separation of municipal waste into its main fractions (such as paper and cardboard, plastics, glass, organic biodegradable fraction, medication, batteries, *etc.*) is highly recommended [2]. There are various regulations in the European Union (Directive 1999/31/EC or Directive 2008/98/EC) that promote the relocation of biodegradable waste from landfills to reduce its impact on leachate and gases formation [3]. Namely, the organic fraction in mixed municipal waste mostly contains food waste from households. This organic fraction decomposes in landfills, and may cause groundwater pollution, production of harmful gases and unpleasant odors. Therefore, finding adequate solutions for the organic fraction is essential. Composting is a recognized technological process of biowaste management in which this type of waste is treated and stabilized with the help of microorganisms under aerobic conditions, leading to production of quality compost along with the production of heat [4, 5]. It should be noted that uncontrolled biodegradation of waste is not considered as composting [6]. In order to guarantee safety

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during compost use, certain quality criteria should be fulfilled such as: contents of pathogens, heavy metals, organic matter, and nutrients, as well as stability and maturity [7].

Croatia, except for a few examples, lags behind the other EU countries in separation, collection and treatment of biodegradable fractions of municipal waste. According to the data in the Waste Management Plan in the Republic of Croatia 2017-2022 [8], the quantities of recovered municipal waste in the country increased only slightly in the period 2010-2015. In 2015, the percentage of recovered waste reached fairly 18 %, compared to only 4 % reported for 2010. In addition to 18 % of the recovered waste (whereby only 2 % refers to composting and anaerobic digestion), 80 % of waste ended up in landfills, and 2 % was stored municipal waste. The reason for such devastating results is the poor system for separated collection of biowaste. Thus, it is crucial to establish separate waste collection and separation of organic waste fractions, especially since these fractions cause unpleasant odors and other environmental hazards after just a few weeks. However, as the Republic of Croatia is lagging behind in solving the problem of biowaste separation from municipal waste and disposal of untreated waste on a system level, a possible solution may be in installment of decentralized smaller devices for biowaste treatment. One of the effective and promising such devices is rotary drum composter, which provides biowaste agitation, aeration and mixing to produce a consistent and uniform compost as the end-product [9]. Also, decentralized composting ensures a sustainable and safe environment by processing smaller quantities of waste at the source [10].

There are several examples in literature describing the use of rotary drum composters such as for composting a combination of vegetable waste, cattle manure and saw dust using compost as a bulking agent [9]. It was reported that the temperature was above 55 °C for two days, nitrification occurred after the sixth day, while decreasing in the BOD/COD ratio indicates the stabilization of the compost as only the non-biodegradable parts remained [9]. In the other studies of the same group, rotary drum was investigated for composting vegetable waste and tree leaves [11] as well as sewage sludge [12]. The results suggested that composting of sewage sludge with the optimal proportion of cattle manure and saw dust, especially at carbon-to-nitrogen mass ratio (C/N) = 30, can produce stable compost within 20 days of composting [12]. In another study, rotary drum composting was investigated as a low-cost method for removal of helminths (*Ascaris lumbricoides* and *Trichuris trichiura*) in fecal sludge compost [13]. Four different rotary drums at a pilot scale were used: metal or a plastic composter with paddles or baffles, showing the composter type had a significant impact on the helminth removal so that the best results were obtained in the plastic composter with paddles [13]. Jain *et al.* investigated the efficacy of rotary drum composting of invasive aquatic weed (*Hydrilla verticillata* (L.f.) Royle), which is one of the biggest challenges in the field of solid waste management. Different mixed proportions of *H. verticillata*, cow dung and sawdust were investigated, and the results suggested that the biomass of *H. verticillata* could be utilized to produce stable compost for potential use in agricultural systems [14]. The same technique was investigated for finding a suitable inlet composition containing flower waste to obtain nutrient-enriched compost. The bulking agent (sawdust and wheat bran) helped to maintain the prolonged thermophilic conditions, adequate moisture content, leachate production and aerobic conditions during the composting process [15].

It is evident that rotary drum composting is widely applied as an efficient and decentralized technique for transforming different sources of waste and bulking agents into compost. However, none of the mentioned studies compared composting in a rotary drum composter (as a closed system) and open container (as an open system). In the present work, a pilot scale rotary drum composter was used for monitoring and analysis of biowaste composting and evaluation of the resulting compost quality. Also, the resulting compost was compared to that obtained in an open rectangular container. In addition, the organic matter content data during composting processes in both investigated systems were fitted with the first order kinetic model.

2. EXPERIMENTAL

2. 1. Composters

In order to study the composting process, a rotary drum composter and an open container were used (Figure 1.). The rotary drum composter dimensions were 95×108×50 cm while the drum dimensions were: 80 cm in length and

48 cm maximum diameter with the capacity cca 150 dm^3. Outer dimensions of the open rectangular container were 30×45×35 cm with the capacity cca 46 dm^3.

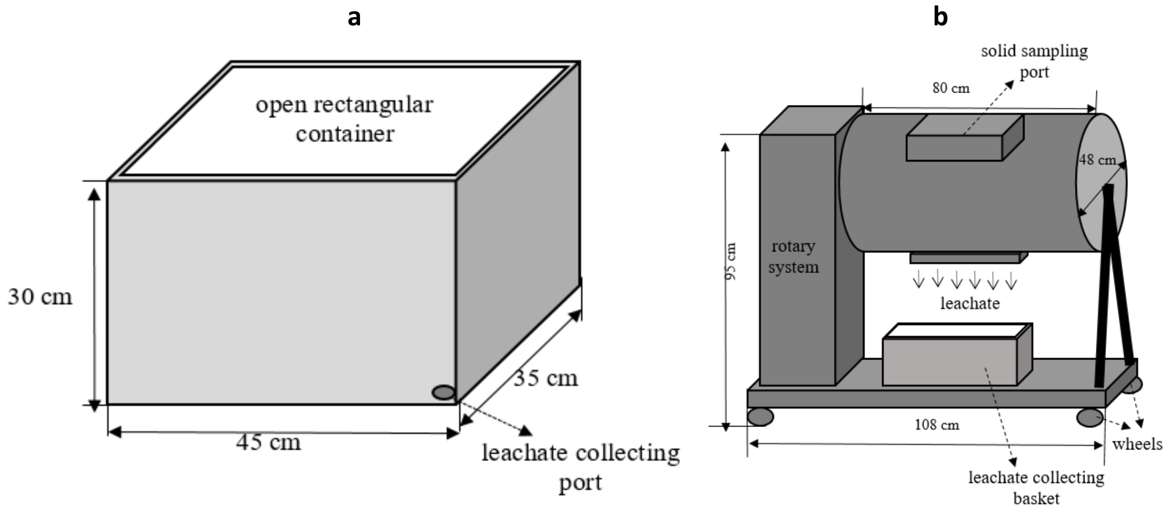

Figure. 1. Scheme of composters: a) open container; b) rotary composter

2. 2. Biowaste

The biowaste was collected in a student canteen located in the University campus of the University of Split, Croatia. Biowaste (substrate) comprised onion peels, lettuce, cucumber peels, orange peels, tomatoes, and coffee grounds. The total mass of biowaste placed in the composters was 23 kg. This biowaste was shredded using a shredder (Hurricane HMH-E 2440, iSC GmbH, Landau an der Isar, Germany), mixed with sawdust as structural material and divided into two parts of equal masses: one part was then placed in an open rectangular container (cca 12 kg) (sample A), while the other part (cca 12 kg) was placed in a rotary drum composter (sample B). The initial samples were characterized regarding the following parameters: temperature, moisture content, dry and volatile matter contents, carbon and nitrogen contents, C/N ratio, pH value and electrical conductivity.

2. 3. Composting performance

After placing the initial samples into composters, the composting process was started and investigated. During composting, sawdust was also added for better humidity regulation and a "biogarden" organic fertilizer (type Homeo-garden, HomeOgarden, Ljubljana, Slovenia) with 5 wt.% percentage of nitrogen and enriched with *mycorrhizal fungi* in order to adjust the C/N ratio containing 2 wt.% of *Endomycorrhizal fungi: Claroideoglomus etunicatum, Rhizophagus intraradices* and *Claroideoglomus claroideum;* without genetically modified organisms -GMO-free). The biogarden organic fertilizer was added during composting in both composters at day 10, 14 and 23 in the amounts of 50, 50 and 100 g, respectively. The moisture content of the compost mass was monitored daily. The composting process in both composter types lasted 25 days during which regular mixing was performed 2-3 times a day, with the addition of water, as needed (moisture content in range 60 – 80 wt.%). Sampling of the compost mass was performed manually by taking a sample) at six places (zig-zag) in amount of cca 200 g, prior mixing and homogenization. After each sampling, the following parameters were analyzed: room and compost temperatures, moisture content, dry matter content, volatile matter content, carbon content, C/N ratio, pH value and electrical conductivity, according to standard methods [16,17].

During the composting process, samples of leachate were also collected. The following water quality indicators were determined: pH value, electrical conductivity, turbidity, chemical oxygen demand (COD) and Kjeldahl nitrogen. All experimental analyses were performed by standard methods [16].

2. 4. Measurement methods

Temperature was monitored two times per day by using a digital thermometer throughout the composting period. pH value and electrical conductivity were determined in filtrate obtained by mixing 5 g of the sample with 100 cm^3 of deionized water and measured by using a pH/conductivity combimeter (Orion Star Series Meter Thermo Fischer Scientific Inc., Beverly, MA, USA). Moisture and dry matter contents were determined by drying the sample at 105 °C for 24 h, while volatile matter and carbon contents were determined by annealing in a muffle furnace at 550 °C for 4 h. Nitrogen content was measured according to the Kjeldahl method. The C/N ratio was determined by dividing the carbon content to the nitrogen content [16,17]. Chemical oxygen demand (COD) was determined by the dichromate method. All measurements were done in triplicates.

3. RESULTS AND DISCUSSION

3. 1. Analysis of the composting process

3. 1. 1. Temperature profile during the composting process

Temperature is an indicator of the progress of the composting process. The change in temperature is directly related to the biochemical activity of microorganisms, as decomposition of organic matter releases heat and causes an increase in temperature in the substrate. Change in the temperature in the compost mass causes changes in the number and types of members in the mixed culture of microorganisms involved in the decomposition of the substrate. Results of the monitored compost and room temperatures during composting are graphically shown in Figure 2.

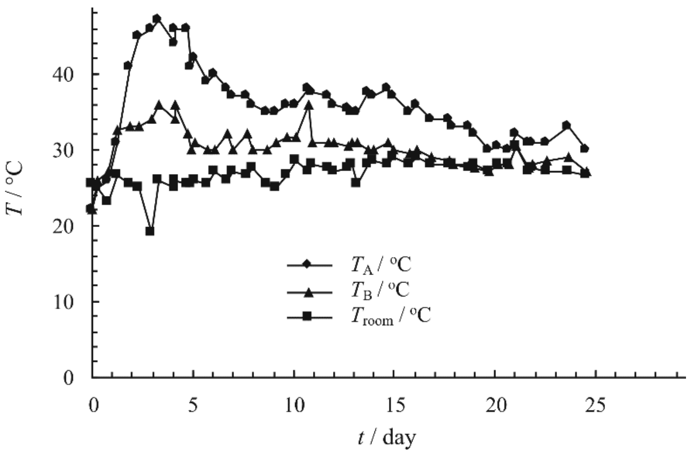

Figure 2. Results of continuous temperature monitoring of samples in the investigated open container (T_A) and rotary drum (T_B) and room temperature (T_{room}) over the course of the composting process. Note: standard deviation from the average value for temperature is in range ± (0.3-1.2).

Two phases of the aerobic process can be distinguished: a mesophilic and a thermophilic phase. Depending on the local conditions, during the aerobic mesophilic phase temperature is between 20 and 40 °C, and during the thermophilic phase temperature is in the range from 40 to 70 °C. The results show that the temperature of sample A rises sharply during the first three days, from the room temperature (22 °C) to 47 °C. This sudden rise in temperature occurred due to the activity of thermophilic microorganisms. The thermophilic phase lasted for three days followed by a cooling period up to day 11, when the temperature decreased to 38 °C. Further cooling was observed up to the end of the experiment (day 25). In sample B, during the first 3-5 days, the temperature first rose sharply from the room temperature to 36 °C and continuously declined to 30 °C. As soon as the temperature drops, it is a sign that either compost has been produced (food is exhausted) or that there is a threat to the life of microorganisms. It can be seen that the sample A has a satisfactory temperature rise (thermophilic phase), while sample B reached the temperature lower than 36 °C (mesophilic phase). This can be associated with different performances of the composting devices (open *vs*. closed). Also, we noticed that the temperature of the sample A (open container) in the core of compost mass was significantly higher when compared to the temperature of the mass surface, whilst in case of compost in a rotating drum the temperature throughout the whole mass was uniform. The obtained results of temperature change during composting corresponded to those found in literature [9,18].

3. 1. 2. Changes in moisture and dry matter contents during composting

Moisture content is one of the critical factors influencing the effectiveness of a biological treatment and must be monitored systematically throughout the process timeline on a regular basis [19]. Moisture loss during the composting process can be viewed as an index of decomposition rate, since heat generation, which accompanies decomposition, drives vaporization (*i.e*. moisture loss) [9]. Therefore, it is necessary to monitor the dry matter content (moisture content) throughout the composting process.

The monitored dry matter content during the composting process is graphically shown in Figure 3.

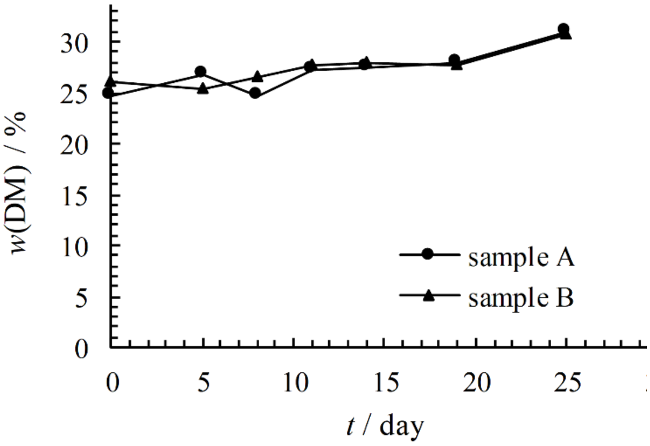

Figure 3 Dry matter content change) during the composting process . Note: standard deviation from the average value for dry matter content is in range ± (2.1-3.5)

Dry matter contents increased over time during the composting process in both devices and at the end of the process reached values of around 30 wt.%. This was expected as the compost mass becomes looser and water binding capacity decreases as the process progresses. Correspondingly, the initial moisture content was about 75.5 wt.% in both composts at the beginning of the process, while at the end it was 69 wt.%. Leachate from composting processes have to be collected and fully treated, in order to avoid pollution of underground and runoff water and detrimental effects on the environment. Interestingly, except at the beginning of the composting process, in both investigated systems there was almost no leachate generation. Similar behavior was reported in the literature [3,9,20]. The reason for such behaviour is probably connected with grinding of the collected biowaste by a shredder before filling composters in order to achieve smaller particles, which have larger surface area and can degrade more quickly. The highest amount of leachate was produced during the first three days (in sample A, total 1670 cm^3, and in sample B 1630 cm^3), after which leachate formation was not detected. According to literature [21], absence of leachate production might relate to the addition of sawdust, which preserves leaching. A very high C/N ratio achieved already in the initial stage can be associated with the leachate production in this stage, as biowaste grinding induced leaching nutrients from the biowaste. Thus, the leachate collected during the days 2 and 3 were analyzed and the results are compared with maximal allowed values according to the Croatian Regulation for discharge into surface water and public sewage system [22].

The leachate samples were cloudy and dark green in color (turbidity results shown in Table 1 are extremely high and range from 377 to 917 NTU). The increased values of electrical conductivity (in the range 5610 - 9510 μS cm^{-1}) indicate organic substances and the increased presence of salts, anions and cations. The pH values are slightly acidic (in the range of 4.62 - 5.10) which is attributed to the rapid conversion of soluble organic matter into volatile fatty acids (VFA). The low pH recorded in the leachate can accelerate the process of biological nitrification and, thus, complicate maintenance of the constant efficiency of a composting process [23].

Table 1. Results of physical and chemical characterization of leachate.

Parameter	Leachate after the 2nd day of composting		Leachate after the 3rd day of composting		Surface water	Public sewage system
	system A	system B	system A	system B		
pH	4.62±0.12	4.59±0.11	5.08±0.15	5.10±0.10	6.5-9.5	6.5 – 9.5
Conductivity, μS cm^{-1}	9230±40	5610±26	7800±32	9510±42	-	-
Turbidity, NTU	917±7.5	377±3.5	981±8.7	891±6.7	-	-
COD, mg O_2 dm^{-3}	34313 ±110.55	27410 ±101.85	24460±95.55	25380±105.95	125	700
TN_K, mg N dm^{-3}	288.54±11.55	182.09±9.85	1048.04±55.73	732.20±35.62	15*	50*

Note: system A - leachate from composting in an open container, B - leachate from composting in a rotary composter;
*values in last two columns are taken from Croatian regulations NN 26/20 [22]. However, values for total nitrogen are compared since values for Kjeldahl nitrogen are not specified in the Croatian regulation. The results are reported as the average values±standard deviation.

COD levels in the leachate are very high and in the range 24460 – 34313 mg O_2 dm^{-3}, which indicates the presence of organic and inorganic substances susceptible to oxidation with dichromate. The values significantly exceed the limit values prescribed by the Croatian regulation.

Increased concentration of ammonia indicates biodegradation of complex organic molecules and organic nitrogen, which results in the formation of ammonium ions. This is precisely why nitrogen was analyzed here as Kjeldahl nitrogen, as it includes organic and ammonium nitrogen. The resulting value is compared with the regulatory data for total nitrogen, as data for Kjeldahl nitrogen are not prescribed by the Croatian low. It can be seen that the values significantly exceed the limit values prescribed by Croatian regulations.

Phosphates, heavy metals and plasticizers in the leachate after composting were not determined in this work, although their presence has been proven in the literature [23].

3. 1. 3. Changes in volatile matter and carbon contents during composting

Experimentally determined volatile matter and carbon contents during the composting process are shown in Figure 4. The carbon content is calculated from the volatile matter content, according to the equation [24]:

$$w(\mathrm{C}) = \frac{w(\mathrm{VM})}{1.8} \quad (1)$$

where w(VM) / % is the volatile matter content and w(C) / % is the carbon content.

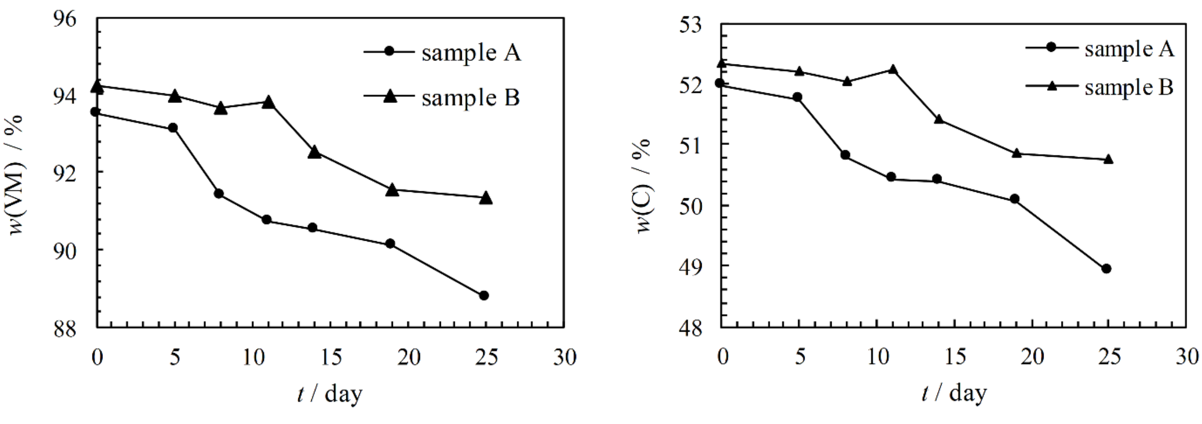

Figure 4. Contents of (a) volatile matter and (b) carbon during the composting process in the open container (sample A) and rotary drum (sample B). Note: standard deviation from the average value for volatile matter is in range ±(1.2-3.5), for carbon content in range ±(2.5-4.1)

There is a slight decrease in the volatile matter content in both samples, from the beginning to the end of the process, as is evident in Figure 4. Values ranged from ~94 to 89 % for sample A and to 91 % for the sample B indicating a more pronounced decrease in the open container as compared to that in the rotary drum. Similar results were reported in the literature [18]. Since the volatile matter content is related to the organic matter content in compost, in addition to the influence of the system design, the reason for this finding may be the structural material (sawdust) that was added to control humidity, which causes a high C/N ratio. Therefore, it might be better to use some other material to regulate humidity.

3. 1. 4. Changes in pH and electrical conductivity values during composting

The measured pH and electrical conductivity values during the composting process are shown in Figure 5. At the beginning of the process, the initial pH value was 6.36 in sample A and 6.17 in sample B. During the process, the pH value rose slightly, which can be attributed to the activity of microorganisms. The highest pH value was observed on day 19 and was 8.56 for sample A and 8.84 for sample B, probably due to the formation of higher amounts of ammonia in the latter case. After the thermophilic phase, under conditions of good aeration, ammonia oxidized to nitrate, which gradually reduced the pH value [9,21]. The final pH value after 25 days was 7.59 in both systems.

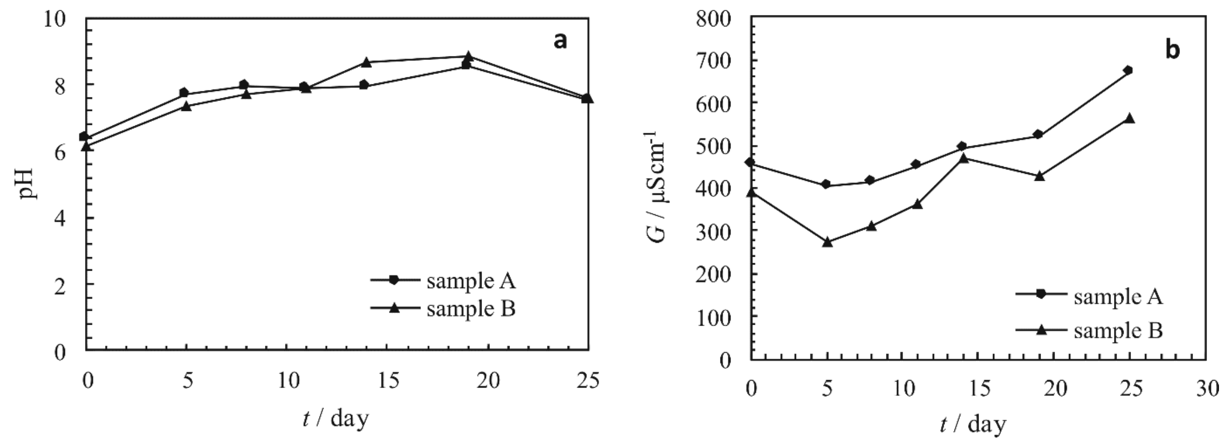

Figure 5. Measured (a) pH values and (b) electrical conductivities during composting in the open container (sample A) and rotary drum (sample B). Note: standard deviation from the average value for pH is in range ±(0.09-0.18), for electrical conductivity in range ±(8.8-32.5)

Electrical conductivity is an indicator of the contents of soluble salts in compost and it depends on the amount and type of ions in the solution. Low electrical conductivity value can induce lower fertility of a compost due to low contents of potassium, calcium, and magnesium. However, high salt concentrations may indicate potential phytotoxicity (germination arrest or slowed root work). A value of 3500 μS cm^{-1} was suggested as the upper limit for the substrate used for seed germination in container plant production [25]. According to the obtained results (Figure 5b), the values for sample A ranged from 455 to 671 μS cm^{-1}, and from 392 to 565 μS cm^{-1} for sample B.

3. 1. 5. Change in the C/N ratio during composting

The C/N ratio determines the level of the end product maturity and stability. It was therefore monitored over the composting process to monitor microbial activities in both composters. Rapid decomposition of organic matter results in a decrease in the organic carbon content, accumulation of nutrient and microbiological amounts, which leads to a decrease in the C/N ratio. As can be seen in Figure 6, in sample A, a constant decrease in the C/N ratio was observed, while in sample B the C/N ratio oscillated. The C/N ratio decrease in the former case was quite large (from 248 to 106, which represented a decrease of 60 % related to the initial value), which indicated a distinct degradation rate. However, a theoretical C/N ratio of about 30 was not achieved [26]. This result can be attributed again to the addition of sawdust whose C/N ratio was 325 and thus affected the reduced nitrogen content in the compost [27]. This result indicates that some other material (leaves, wood) would be more suitable as a structural material.

Also, a very high C/N ratio already in the initial composting stage can be associated with the higher leachate production in this stage, as grinding has leached out nutrients from biowaste.

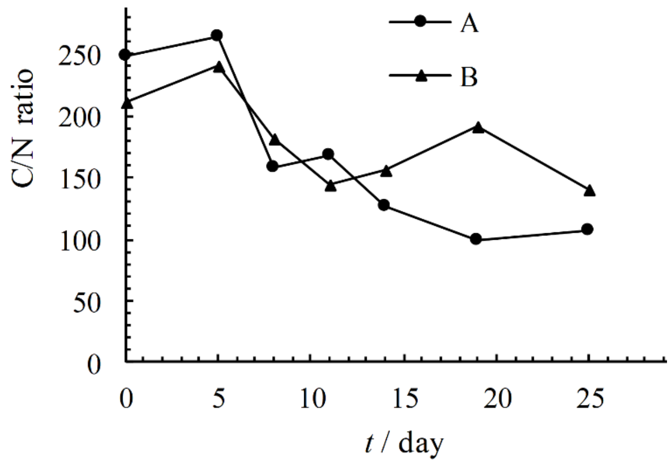

Figure 6. The C/N ratio during composting in the open container (sample A) and rotary drum (sample B). Note: standard deviation from the average value for C/N ration is in range ±(0.5-17)

3. 1. 6. Change in the nitrogen content during composting

Nitrogen contents during composting are shown in Figure 7.

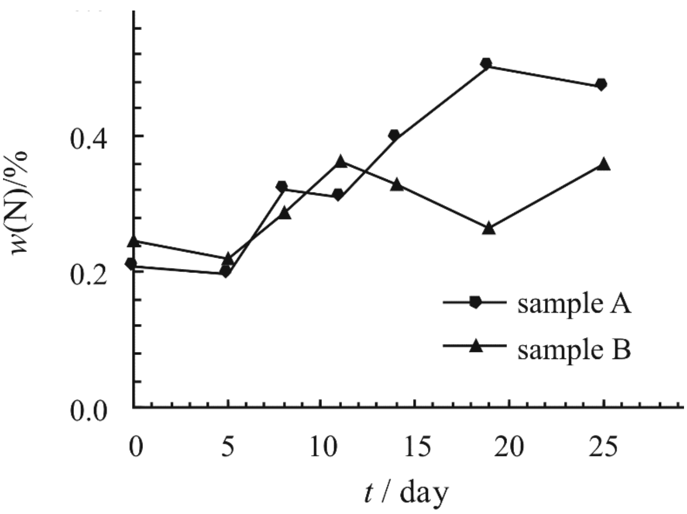

Figure 7. Nitrogen contents change during composting in the open container (sample A) and rotary drum (sample B). Note: standard deviation from the average value for nitrogen content is in range ±(0.09-0.12)

During the composting process there is a slight increase in the nitrogen content, which is attributed to the loss of mass and mineralization of organic matter. This increase is visible in sample A (from 0.21 to 0.50 %), while the nitrogen content shows oscillations in the sample B. The obtained nitrogen contents during composting are significantly lower than those reported in literature [9,25]. Obviously, the design of the reactor system affects the nitrogen content, and the open system is more favorable in this case. The open system also has its drawbacks, which are associated with gas emissions, unpleasant odors, and the appearance of insects in the compost. Also, the reason for such a low increase in the nitrogen content may be the excessive amount of sawdust in the compost, which has an increased carbon content and leads to the immobilization of the composting process.

3. 2. Comparison of physicochemical parameters of the initial sample and compost

A comparison of physicochemical parameters of the initial sample and the obtained composts after 25 days in both investigated systems are presented in Table 2.

Table 2. Comparison of physicochemical parameters of the initial sample and the obtained composts after 25 days in the open container (designation A) and rotary drum (designation B)

Parameters	A		B	
	initial sample	after 25 days	initial sample	after 25 days
T / °C	22±0.5	30±0.8	22±0.7	27±0.8
w(DM) / %	26±2.5	31±3.2	24±2.2	32±2.6
$w(H_2O)$ / %	74±3.7	69±2.2	76±2.8	69±3.1
w(VM) / %	94±2.8	88±1.4	94±2.7	91±2.8
w(C) / %	52±1.9	49±1.8	52±2.1	51±2.0
pH	6.36±0.23	7.54±0.17	6.17±0.22	7.59±0.15
G / µS cm^{-1}	455±15.6	671±20.2	392±12.6	565±18.5
C/N mass ratio	248±12	106±8	211±9	140±11

Note: The results are reported as the average values±standard deviation

It can be seen that the examined parameters are in accordance with the literature [25], except for the C/N ratio, which is higher than the reported values. During active decomposition, a pleasant earthy odor was recorded as an indicator of proper ventilation and the absence of anaerobic conditions. Changes in the appearance of the composting material were visible in terms of color and texture as the process progressed. Already, after 20 days, both investigated composts achieved dark brown color, fine texture without any visible organic waste and typical smell of earth. A gradual decrease in the compost volume was also observed during decomposition. Changes in physicochemical parameters reflected the progress and outcome of the composting process in accordance with literature findings [28].

3. 3. Composting kinetics

Kinetic models are used as tools to optimize the composting process. By using a kinetic model and controlling the process parameters, the waste decomposition degree can be predicted. Knowing the composting kinetics is essential for design and operation of a composting plant [19]. The composting process can be mathematically described by using a first-order kinetic model according to equation [29,30]:

$$\frac{dC}{\mathrm{d}t} = -kC \qquad (2)$$

where C is the content of biodegradable substances, k is the decomposition rate constant and t is time.

The decomposition rate constant is temperature dependent and various models can be found in literature to describe this dependence [19]. The content of biodegradable organic matter corresponds to the content of volatile matter in compost. Thus, by integrating eq. (2) and assuming that $C = C_0$ for $t = 0$, it follows that:

$$\ln\frac{C}{C_0} = -kt \qquad (3)$$

where C is the volatile matter content in compost at time t and C_0 is the volatile matter content in compost at the beginning of the composting process.

By the best linear fit of ln (C/C_0) *vs.* time, k is calculated from the slope of the line (Figure 8).

The model indicated that the rate of substrate decomposition was higher in the sample in the open system (k = 0.0023 day^{-1}) compared to the closed system (k = 0.0012 day^{-1}). Indeed, since the decomposition rate constant is temperature dependent, this suggests that these differences may be related to the difference in temperature rise in open and closed systems, which is to be expected given the differences in composting in an open and closed system. Good agreement of the model with the experimental data (R^2 = 0.941) in sample A is visible, which is expected since biowaste comprised easily degradable components (onion peels, lettuce, cucumbers, oranges, tomatoes, and coffee grounds). However, it should be kept in mind that the rate of decomposition of more complex substrates over time is not only a function of the substrate concentration but also of particle structure, system design (open *vs.* closed), humidity, temperature, and oxygen concentration.

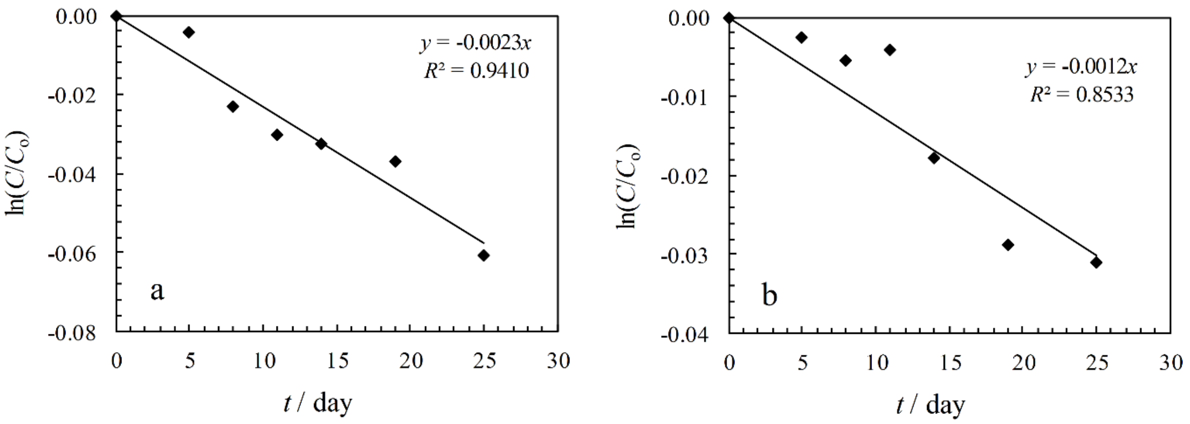

Figure 8. Interpretation of the experimental data according to the first order kinetic model (symbols) and the best linear fit (line) for composting in a) open container, b) rotary drum

4. CONCLUSION

In this work, the composting of samples of biowaste from the university canteen in a rotary drum composter and an open container was analysed. During composting in both systems, the temperature first rose sharply, followed by a continuous drop. In contrast to the open container, where a satisfactory temperature increase was observed (thermosphilic region), the sample in the rotary drum reached a temperature lower than 36 °C, which can be attributed to a different system design.

The process monitoring of the two experimental composters showed overall decreasing profiles versus composting time for parameters such as moisture content, organic carbon, volatile matter content and the C/N ratio, as well as overall increasing profiles for parameters such as electrical conductivity and the total nitrogen content.

The pH value of both initial compost materials was above 6, and after the end of the composting process, all composts had a pH value around 8, which can be attributed to the action of microorganisms.

The electrical conductivities of both samples were below the recommended upper limit of the value for the substrate used for seed germination in container plant production (3500 μS cm^{-1}). A constant decrease in the C/N ratio was observed in the open container, while it oscillated in the rotating drum. Leachate (approximately 1650 cm^3) was produced during the first three days of composting, after which period leaching was not observed. The leachate is characterized by its high organic content, high ammonia concentration, low pH, high conductivity and high turbidity. All measured values were significantly above the prescribed limit values by Croatian regulation.

A comparison of the physicochemical parameters showed that the open system exhibited better results compared to the closed system. In both systems, good compost was obtained in terms of color and texture. However, in the rotary composter temperature in the entire compost mass was uniform, which ensured uniform processing and stabilization of the compost throughout the mass.

The organic matter was reduced over time due to the microbial metabolism. Degradation rate of organic waste was modeled by the first order kinetic model. Composting in the open system exhibited higher degradation rate with the rate constant of 0.0023 day^{-1}, as compared to the closed system in which the rate constant was 0.0012 day^{-1}. These differences may be related to the difference in temperature rise in open and closed systems. Although both composting systems, the rotary drum, and the open container, can be successfully used for municipal waste composting and help to significantly reduce the amount of waste sent to landfills, the rotary composter is more suitable for urban areas because it helps to reduce the emission of unpleasant odors as well as the presence of insects in the compost. However, further research should focus on the analysis of different decentralized home composters suitable for home composting as well as for public facilities and educational institutions.

From these results, it can be concluded that the use of both rotary drum composter and open container for composting waste in community can help to significantly reduce the amount of waste and divert it from landfills.

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Kompostiranja biootpada – usporedba rotacijskog kompostera valjkastog oblika i otvorene posude

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Izvod

Kompostiranje je prepoznato kao održiv pristup gospodarenju otpadom u kojem mikroorganizmi tretiraju i stabiliziraju biorazgradivi otpad u aerobnim uvjetima, te se dobiva kompost kao konačni proizvod. U ovom radu uspoređen je proces kompostiranja biootpada u rotacijskom komposteru valjkastog oblika (zatvoreni sustav) i otvorenoj posudi (otvoreni sustav). Tijekom kompostiranja u oba sustava su praćeni slijedeći parametri: temperatura, sadržaji suhe i hlapive tvari, vlage i ugljika, pH vrijednost i električna vodljivost te C/N omjer. Rezultati su pokazali opadajući profil sadržaja vlage, hlapive tvari, ugljika i C/N omjera te rastući profil sadržaja suhe tvari i električne vodljivosti tijekom kompostiranja kod oba sustava. Procjedne vode nastaju samo tijekom prva tri dana kompostiranja i karakterizirane su visokim organskim opterećenjem, visokom koncentracijom amonijaka, niskim pH, visokom vodljivošću i zamućenošću. Podaci o sadržaju organske tvari tijekom procesa kompostiranja analizirani su prema kinetičkom modelu prvog reda. Dobivena su dobra slaganja modela sa eksperimentalnim rezultatima, a brzina razgradnje organske tvari je veća pri kompostiranju u otvorenoj posudi, u odnosu na rotacijski komposter.

Ključne reči: sadržaj suhe tvari; sadržaj hlapljivih tvari; sadržaj vlage; električna provodljivost; kinetička analiza, karakterizacija procjedne vode