Dynamics of Physicochemical Parameters During Composting of Olive Pomace and Cattle Manure

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ABSTRACT

The aim of this study is to evaluate the maturity of the compost product. This was performed by measuring some of the main physico-chemical parameters of the mixture of olive pomace and cattle manure that were composted in different proportions. It must be noted that the composting was conducted at a medium experimental scale. The proportions of olive pomace to cattle manure were as the following: 1/1, 2/1, 3/1, 4/1, with a control for each of the used raw materials. Several parameters of the piles such as temperature, density, pH, electrical conductivity, total nitrogen, organic matter, ammonium/nitrate ratio, available phosphorus and extractable potassium were periodically monitored. It was noticed a difference in the temperature for the treatments that were rich in carbon compared to the manure control. In addition, the results showed significant differences (P<0.05) between the different applied treatments during the composting process as follows: the pH tends, in all treatments, to shift to neutral (~7-8), while the electrical conductivity decreased but remained high in the manure control. The value of the ammonium/nitrate ratio was lower than one unit especially in the mixture (1/1). The Carbon/Nitrogen ratio (C/N) decreased in all treatments. The lowest C/N ratio and the highest phosphorus and potassium contents were noticed in the mixtures (1/1 and 2/1). This study shows that the mixture of olive pomace and cattle manure with the proportions 1/1, 2/1 were probably adequate to be used in the composting process of the used raw materials. However, the duration of composting must be over five months in order to obtain an adequate C/N ratio that may indicate a real state of the maturity of the compost.

Key words: Composting, cattle manure, nitrogen, olive pomace, organic matter

Introduction

The amount of solid waste has greatly increased in recent decades due to the population growth and the demands of the lifestyle of people. The lack of garbage dumps and solid waste combustion are currently a universal problem. There are many ways of treating waste or by-products (composting, recycling, and reuse). Therefore, it is necessary to evaluate properly their performance and limitations in order to choose the most appropriate. Any one of these choices must be made in compliance with the regulations and the lowest cost possible.

The technique of composting is a natural and biological process. It is based on the aerobic decomposition of the organic matter by the micro-organisms in the presence of oxygen. This technique should eliminate a part of the disadvantage from the uncontrolled use of olive pomace and the cattle manure, such as the odour, the bad decomposition, the contribution to weed seeds with the manure. Thus, this technique seems necessary and effective for odour control, the humidity level, and for reducing the waste product, and rather producing a valuable product (Van Horn and Hall, 1997; Summer, 2000).

Composting of the animal waste as manure rich in nitrogen, with by-products rich in carbon, has several advantages. Technically, the addition of manure can facilitate the composting of other wastes rich in carbon as the olive pomace, and thus improve their agronomic characteristics. This technique allows the acceleration of the natural process of bio-oxidation by controlling parameters such as humidity, temperature and dissolved oxygen that ensures the activity of microorganisms responsible for the biological transformation of organic substances. Some studies have demonstrated the possibility of composting of the olive pomace and the use of the compost product as a substrate in horticulture (Calvet et al., 1985; 1986; Estaún et al., 1985; Pages et al., 1985; 1986; Pera et al., 1986; Eklind et al., 2001). Furthermore, the incorporation of the olive waste in the soil has a suppressive action of phytoparasitism of the soil nematodes (Rodriguez-Cabana et al., 1995).

The product which can be used as fertilizer has physical, chemical, and biological benefits on soil and crops. Compost has the combined capabilities of feeding plants and it provides the soil with humus, without threatening the lives and health of living beings. However, it is considered that nitrogen from mineral fertilizers...
is more available for the plants than compost. On the other hand, nitrate levels and residual mineral nitrogen in compost are lower than mineral fertilizers, thus they reduce the risk of the groundwater pollution. In addition to provide organic matter to soil, compost increases the biological activity and the ability to retain water and it provides an important enrichment in phosphorus and potassium.

The quality of the compost has several characteristics. Among them the maturity or the stability of the compost because it is considered as the most important factor in controlling the composting process. According to Mathur et al., (1993), determining the biomaturity of compost is a difficult task due to the complexity of the process and the lack of understanding and appreciation of many of its appearance. However, several researchers have developed many analyzes that assess the maturity and the stability of compost, which are critical for determining whether or not a compost is usable, and marketable. These tests can be classified into four categories according to the empirical methods, physical, chemical or biological (microbiological) analyses and especially the humified organic matter (Forster et al., 1993; Avnimelech et al., 1996; Lasaridi and Stentiford, 1998).

According to Mondini et al., (2003a, 2003b), the evaluation of compost quality is based on physicochemical properties such as density, temperature, pH, cation exchange capacity, organic carbon, total nitrogen, ammonium and nitrate ratio, humic substances, and dissolved organic carbon. In some studies, other parameters were used as indicators for the maturity and the stability of the compost produced from various by-products, such as C/N ratio, NH₄/NO₃ ratio, germination index and microbiological parameters (respiration and activity of the dehydrogenase) (Iglesias-Jimenez and Perez-Garcia, 1992; Iannotti et al., 1994; Bernal et al., 1998; Wu et al., 2000; Butler et al., 2001; Sanchez-Monedero et al., 2001; Benito et al., 2003; Ko et al., 2008; Raj and Antil, 2011).

Despite all the methods proposed to determine the degree of maturity and stability of composts, no single method can be applied to all composts due to variations in raw materials and composting techniques (Benito et al., 2003; Bernal et al., 2009; Chang and Chen, 2010).

The objective of this work is to study at a medium experimental scale the ability of composting the cattle manure mixed with olive pomace in varying proportions. Furthermore, this work includes also the establishment of certain physicochemical properties of agricultural and agro-industrial by-products used in composting and the monitoring of their evolution throughout the process.

Materials And Methods

Composting was realized on the site of "Kfaryachit" located in north of Lebanon on a more or less stony ground. The study was focused on olive pomace and cattle manure, composted individually as controls, or composted as mixtures with different proportions by weight (olive pomace/cattle manure: 1/1, 2/1, 3/1, 4/1). The olive pomace was obtained from a traditional press in the region and has been stored about 6 months. While, the cattle manure comes from little loose housing of dairy cows and straw that has been stored for 6-9 months. The experiment was conducted at a medium experimental scale. Treatments are arranged by piles with an approximate volume of 1-2 m³ because of the size of the site and the availability of the quantities for the raw materials. The piles were prepared by mixing an alternating mass of the olive pomace and the cattle manure using an agricultural machine. From the beginning of the experiment, the raw materials were sprayed with water and returned in optimal conditions for a smooth process of composting.

The temperature was periodically measured on a daily basis during the first two weeks and then every 3-5 days until the maturation phase. The temperature of each pile was measured throughout the process of composting using a probe thermometer used generally in the soil. The 50 cm probe was used on different sides of the pile (3 times in total) to get the average temperature of the heap. The piles were aerated according to their internal temperature, by either manual or mechanical turning to maintain aerobic conditions responsible for the biodegradation of materials and to avoid anaerobic conditions. In addition, throughout the period of composting, the piles were sprayed with water especially during the months July and August, in order to maintain an optimum humidity around (30-40%) stimulating microbial activity, but without reaching a level of anaerobiosis.

Sampling was conducted throughout the composting process at days 1-8-15-22-37-51-65-80-150 after the beginning of the experiment. The sampling is performed in each pile at different points, and then blended to form a homogeneous sample. Sub-samples are stored below 4°C or 5°C up to 2 days in order to proceed with the determination of the ammonium and nitrate level, according to the Kjeldahl distillation using magnesium oxide and the Devarda’s alloy (Cu + Zn + Al) after extraction with potassium chloride (KCl 2M) (Rowell, 1995). The samples are then dried in an oven (105°C) and subsequently sieved (2 mm). The physico-chemical analyzes described in this paper, were performed on these sieved samples and the analyses were carried out on the following parameters: bulk density (BD), humidity (H) that was determined in an oven at 105°C for 24 hours, the organic matter (OM) by determining the organic carbon by calcination in an oven at 550°C, and the total nitrogen (N) determination using the Kjeldahl method. The pH was determined in an aqueous extract 1:10
(w/v) and the electrical conductivity (EC) 1:10 (w/v), the available phosphorus (P₂O₅) and the extractable potassium (K₂O) were also determined (Rowell, 1995; Ryan et al., 1996; Pansu and Gautheyrou, 2003).

The treatment allocation was performed using the statistical scheme "RCD" (Complete Randomized Design) or randomized complete block design with three replications. The statistical interpretation was performed by the analysis of variance examined with one factor (ANOVA), following the procedure of general linear model (GLM procedure) using the statistical package SAS (Statistical Analysis System, 2004). Comparison of the treatment means is established by the calculation of the least significant difference (LSD) at 5%.

Results And Discussion

Throughout the composting process, the evolution of some physico-chemical parameters was monitored to assess the state of maturity of compost. Ranalli et al., (2001) noted that the compost quality depends on the composition of the used raw materials. Composting of different piles, which lasted 150 days by spraying water and turning as needed, led to “mature” compost that is characterized by the following observations: it was granular, dark, homogeneous in appearance without a bad odour.

According to Boulter et al., 2006, the monitoring of the temperature throughout the composting process is a useful way to indicate the progress towards maturity, and it was relatively simple and inexpensive to perform. The starting temperature of the composting process is different depending on the composition of each pile. At the beginning of composting, the biological activity begins and the temperature rose in the heap. A rapid warming has been detected during the first days of composting in all treatments and it started from 30°C-35°C on average. Except the pile of manure, the temperature increased quickly in all treatments, where the values of 40°C-50°C (mesophilic phase) were reached by the 7th and the 10th day. Then a relatively higher temperature than 50°C was observed between the 31st and 35th day: very short (thermophilic phase) after the beginning of composting (Figure 1).

When the temperature was above 40°C, it did last almost until the 50th-60th day following the aeration by turning, this is important to increase the temperature of the mass piles. After this period, temperatures begin to fall and gradually merged at the end of the experiment with the ambient temperature, approximately after 100-107 days after composting, which indicated that there is no more microbial activity. These observations have been noted by other authors (Calvet et al., 1985; Pages et al., 1986; Znaidi, 2002; Raj and Antil, 2011). Satisha and Devaranjan (2007) have showed that the compost indicates a good degree of stability when the temperature during the composting approaches the ambient level.

Fig. 1: Evolution of the temperature of composted mixtures of olive pomace and cattle manure

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The control treatment of cattle manure showed the lowest temperature level during the first 60 days compared to other treatments. In fact, it was noticed that the temperature began to decrease from the 10th day. This decrease in the temperature resulted from a decrease in microbial activity. However, the temperature of manure piles remained higher than other piles after the 87th day but below 30°C. We can consider that the maturation phase started from 72-80th days of composting as there was no increase in temperature level despite turning and watering. During the experimental period the temperature was below 70°C, temperature above which there will be destruction of the living organisms and thus degradation of the quality of compost (Godden, 1986). The decomposition phase was coupled with a noticeable reduction in the volume of the pile. This reduction occurred during the first days after stockpiling. The transformation of the organic material such as the CO₂ and evaporation of the water were the other reasons of the pile’s volume reduction.

During the experiment progress, the humidity varied depending on the frequency of watering. In general, it was located approximately between 40-55% until the 15th day in the piles (1/1, 2/1, 3/1 and 4/1) with the exception of the pile of the composted pomace where it was down to reach a content of 17-28% (Figure 2). After 15th day of the experiment, the humidity was between 30% and 40% in all piles except the pile of manure that represented the highest value. This optimal value of 30% to 40% indicated a success in the process of aerobic fermentation. The humidity had never been above 60% at which there will be an inhibition of the gas exchange that led to an anaerobic conditions. Previously, Godden (1986) reported that the moisture content depends mainly on the starting materials.

For the density, the manure treatment started at a value close to 0.3 g/cm³ while the value of the other treatments containing olive pomace started at ~0.4 g/cm³. During the composting process, the density curve of manure treatment increased until the 51st day of composting to a value greater than 0.6 g/cm³ while remaining more or less stable. For the other treatments, the density reached a value of 0.5 g/cm³ and remained constant until the 65th days and then decreases to reach a minimum value of 0.4 g/cm³ at the 80th-150th day of composting (Figure 3). The increase in density value was obtained following the loss of the pile volume by releasing the carbon of the organic compounds as CO₂. It should be noted that as much as the windrow is rich in carbon, it loses more in volume during the composting process (Mustin, 1987).

![Figure 2: Evolution in humidity (%) of composted mixtures of olive pomace and cattle manure.](image)

**Errors bars represent standard errors:**

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Organic matter decreased slightly during the composting process. Since the beginning of the experiment till the 80-150th day, this decrease was the highest in the pile of manure ranging 30-60%. This is followed by the groups (1/1) and (2/1) where the decrease of the organic matter was around 19 to 15% and 16 to 12%, respectively. As for the control of olive pomace the loss was the lowest (9% -11%). Values decrease was noted in the case of piles (3/1 and 4/1) and were similar to those observed in other studies (Calvet et al., 1985; Pages et al., 1985; 1986) for olive pomace composted for a period of 97 days. Moreover, Raj and Antil (2011) mentioned that a loss of organic matter greater than 42% can be considered as an index value of maturity. Thus, according to our values, the obtained composts will not be considered at the maturity phase except for the manure treatment.

During this study and at the end of the process, the highest organic matter content was observed with the control group of pomace (80%), but in the manure control the content of organic matter was 30-40%. Between these control piles the contents of the organic matter of the other treatments had an average of 60% to 75% (Figure 4). These results are consistent with those found by (Calvet et al., 1985). By the 80th day, the differences were significant between the pile of manure and other treatments. However, the treatment (1/1) showed significant differences with the control group of olive pomace and other treatments (2/1, 3/1, and 4/1). By following the process until the 150th day, the two piles (1/1) and (2/1) did not show significant differences. It was noticed also that the organic matter content of the piles (2/1, 3/1 and 4/1) were not significantly different among each other.

Concerning the total nitrogen, this element followed an increasing trend over time in all plots (Figure 5). Since the beginning of the experiment until the 80th to 150th day, this increase was the highest in the piles (1/1, 2/1, 3/1 and 4/1) with an average of -40% -60%, followed by the control groups of the olive pomace (9-29%) and the cattle manure (9%). This increasing trend has been observed by several authors (Calvet et al., 1985; Pages et al., 1985; 1986). The initial nitrogen content of the pile of manure was significantly different from those of other piles (1/1, 2/1, 3/1 and 4/1) and that of the control of the olive pomace. The significant difference of such contents was only seen between the groups (1/1 and 2/1) on one hand and of the pile (4/1) on the other hand. However, in our study, the content of nitrogen in the pomace is lower than that found by other authors (Calvet et al., 1985; Pages et al., 1985; 1986) where the initial content was around 1.8%. This content was also low in the different treatments despite the high content in the pile of manure.

After 80 days, the nitrogen content of piles (1/1 and 2/1) was not significantly different from that of the control manure. However, significant differences remained between the manure pile and the piles (olive pomace as control, 3/1 and 4/1). It was noticed that after 150 days, the nitrogen content of all piles was not significantly different. However, the pile of manure showed a decrease in nitrogen content at the end of the experiment. Increasing the amount of the total nitrogen indicated the formation of a stock of the organic nitrogen during the composting process. According to Cappaert et al., 1976, the total nitrogen is in an organic form (99.99% of total
and in a high amount for the initiation of the decomposition. According to Mustin (1987), an increase in the percentage of the total nitrogen, during the composting process, results from the proteins degradation of the raw materials under the effect of the heat and the action of the micro-organisms. It can also be assumed that some of the increase of nitrogen level comes from the microbes and bacterial residues that have proliferated especially in the first phase of the composting process. A decrease in the percentage of nitrogen could be explained by its successive leaching following the spraying of water and rain.

![Graph](image-url)

Fig. 4: Evolution of the organic matter (OM % of dry matter) of composted mixtures of olive pomace and cattle manure. Errors bars represent standard errors.

In addition, another important parameter that characterizes the evolution of the composting process is the ammonium/nitrate ratio. At the beginning of the experiment, this initial ratio was the highest, above the unit, in the pile (1/1) compared to other piles where differences were not significant. During the composting process, the ammonium/nitrate ratio fluctuates, but then decreased in the mixtures, except in the two controls. This NH$_4$/NO$_3$ ratio decreases were also observed during the composting process by Ko et al., (2008). The NH$_4$/NO$_3$ ratio was below the unit during the progress of the process until the 80th day in all treatments (Table 1). According to some authors (Mathur et al., 1993; Eklind et al., 2001) the NH$_4$/NO$_3$ ratio is one of the parameters that are considered as an indicator for the compost maturity. Indeed, the mature compost has a low NH$_4$/NO$_3$ ratio, which must not exceed 1/1 (Bunt, 1988; Eklind et al., 2001). The ratios of NH$_4$/NO$_3$ less than 1.0 were considered as indicator of mature compost (Pare et al., 1998).

![Graph](image-url)

Fig. 5: Evolution of the total nitrogen content (Nt % of dry matter) of composted mixtures of olive pomace and cattle manure. Errors bars represent standard errors.
Table 1: Evolution of the NH$_4$/NO$_3$ ratio of composted mixtures of olive pomace and cattle manure.

<table>
<thead>
<tr>
<th>Treatment/mixture</th>
<th>Day</th>
<th>NH$_4$/NO$_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D1</td>
<td>D8</td>
</tr>
<tr>
<td>Olive pomace (100%Op)</td>
<td>0.283b±0.40</td>
<td>± 1.117a ± 0.07</td>
</tr>
<tr>
<td>Cattle manure (100%Cm)</td>
<td>0.387b</td>
<td>± 0.25</td>
</tr>
<tr>
<td>50Op/50Cm</td>
<td>1.99a ± 1.20</td>
<td>0.880a ± 0.12</td>
</tr>
<tr>
<td>66Op/33Cm</td>
<td>0.727b ± 0.35</td>
<td>0.810a ± 0.59</td>
</tr>
<tr>
<td>75Op/25Cm</td>
<td>0.457b ± 0.08</td>
<td>0.977 ± 1.53</td>
</tr>
<tr>
<td>80Op/20Cm</td>
<td>1.02±2.20</td>
<td>0.550a ± 0.75</td>
</tr>
<tr>
<td>CV%</td>
<td>52.17</td>
<td>66.02</td>
</tr>
<tr>
<td>LSD</td>
<td>0.75</td>
<td>0.93</td>
</tr>
<tr>
<td>Significance</td>
<td>** NS NS NS NS NS</td>
<td></td>
</tr>
</tbody>
</table>

1 Each value is an average of three samples (mean ± confidence interval)
2 Values followed by different letters in the same column correspond to values significantly different at 0.05 probability level (LSD or least significant difference).
3 The difference between treatments is: Not significant (NS), Significant at 5% (*), Highly Significant at 1%

A parameter as the C/N ratio is widely used to estimate the degree of maturity of compost during the composting process (Bernal et al., 1998). It reveals that the treatments (1/1, 2/1, 3/1, and 4/1) started with a value between 40 and 50 whereas the control pomace started at a higher value (C/N: 57) and the control treatment of the manure started at a lower value (C/N: 23). The high ratio can be explained by the richness of the olive pomace with organic matter. The C/N ratio followed a decreasing pattern that was proportional to the different amounts of pomace in different treatments: the pile (4/1), the pile (3/1), the pile (2/1) the pile (1/1) and finally the control manure (Figure 6). This decrease of C/N ratio had been reported by other studies (Calvet et al., 1985; Pages et al., 1985; 1986; Mathur et al., 1993). The initial C/N ratios were significantly different between treatments (1/1 and 2/1) and those of the other ones. These differences were significant at the end of the experiment. By the end of the process of composting, the C/N ratio of the treatments (1/1 and 2/1) were similar around 23-24. They were higher for the other piles with the exception of the control manure which was considered optimal in the area (C/N:15). Some studies have indicated that a C/N ratio below 20 is supposed to be an indicator of a mature compost (Golueke, 1981), and a C/N ratio of 15 or less is better (Morel et al., 1985; Bernal et al., 2009). On the other hand, some researchers have reported that C/N ratio was not a good indicator of a mature compost, because it presents a great variability depending on the raw materials and often gives a misleading indication of maturity, as it may not reflect a product that is sufficiently decomposed (Sellami et al., 2008).

Fig. 6: Evolution of the carbon and the total nitrogen (C/N) ratio of composted mixtures of olive pomace and cattle manure. Errors bars represent standard errors.
The C/N value of 25-35 seems to be favourable for composting manure (Godden, 1995), and optimal at the beginning of the process (Mustin, 1987). During the composting process, the C/N ratio will decline following the release of the carbon in the form of CO₂ to reach the end of the composting process when it stabilizes at a value of 10 (Mustin, 1987). Moreover, in a study of the olive pomace composting, the C/N ratio was 25.8 and considered as an optimal and desirable value for efficient composting as well as an agricultural waste (Calvet et al., 1985). Furthermore, it appears that composting materials with C/N ratios greater than 40 is more difficult. However, one study showed that materials with initial C/N:78 can produce mature compost with final C/N:35 (Gotaas, 1956). But, Ko et al., (2008), had proposed that the NH₄/NO₃ ratio is more suitable indicator for assessing compost maturity than C/N ratio.

The pH measurement is essential during composting. The fermentation process could be followed by controlling the pH (Mustin, 1987). According to the curve of the evolution of pH (Figure 7), it seems that all treatments and the control pile of olive pomace had initially an acidic pH between 5.8 and 6 except for the cattle manure where the pH was the highest ~7.5-8. The pH increases with the piles rich in olive pomace, except for the lot of manure in which pH decreases slightly and remained almost stable during the decomposition. This increase has been observed in some studies of composted olive pomace (Calvet et al., 1985; Pages et al., 1985; 1986). The pH increases were around 1.3 to 1.6 units in the treatments. In other studies, this increase was about 2 units for a period of 3 months (Pages et al., 1985; 1986). It should be noted that from 72-80th day of composting, the pH of the different treatments remained almost constant. This can be explained by the deceleration of the activity of microorganisms responsible for the change of the pH. At 150 days, the pH was close to neutral in almost all treatments as reported by several studies (Zucconi et al., 1981; Pages et al., 1985; 1986; Godden, 1986; Znaidi, 2002) and which is the preferred range for an effective microbial activity. However, the alkalinity and the acidity inhibit nutrient availability and the microbial activity. At the beginning of the process, the control groups showed a significant difference among themselves and with other treatments. At the end of the experiment, it was not observed a significant difference between all piles. At the beginning of the composting process, the production of ammonium following the breakdown of proteins leads to an increase in pH as the ammonium reacts as a base. During maturation, when the ammonium is converted to nitrate, the pH falls towards the neutrality. But a decrease in pH can be explained, according to Mustin (1987) by the production of organic acids due to the degradation of carbohydrates, fats and other substances.

![Fig. 7: Evolution of pHwater of composted mixtures of olive pomace and cattle manure. Errors bars represent standard errors.](image-url)
Among the indicators of the fertilizer value of compost are the minerals and the agricultural benefits essential for the plants, such as the available phosphorus and the extractable potassium. During the experiment, the phosphorus content followed a decreasing trend during the composting process of the controls, especially for the control of cattle manure. This decrease was also observed with the composting of the olive pomace (Calvet et al., 1985). In other piles, a slight decrease was observed until the 23rd day, then that content became more or less constant and increased slightly with time (Figure 9). At the beginning of the experiment, the differences were highly significant between the pile of manure and other treatments. These differences remained the same throughout the process between the piles. At the end of the experiment, the differences became significant between the piles 1/1 and 2/1 on the one hand and the other piles on the other hand. The phosphorus content was the highest in the control manure and the lowest in piles with a high proportion of pomace and especially in the control group of the olive pomace. The evolution of the potassium in the process of composting showed a decrease in the concentration over time with some variations mainly in the control manure (Figure 10). Initially the treatments had concentrations between 0.4% and 1% of potassium. The control treatment of manure had the highest starting concentration while the control treatment of the olive pomace had the lowest concentration of potassium. For the mixtures treatments, the potassium concentration dropped faster than that for control treatments and stabilized by the 22nd day. At the end of the composting, the manure treatment had the highest potassium concentration followed by the piles (1/1) and (2/1).
Fig. 10: Evolution of extractable potassium (K₂O % of dry matter) of composted mixtures of olive pomace and cattle manure. Errors bars represent standard errors.

Conclusion:

Under our experimental conditions, the results indicated that the mixtures of olive pomace and cattle manure in proportion (1/1 and 2/1) seem to be as the most suitable condition for composting. The content of phosphorus and potassium was the highest in mixtures (1/1 and 2/1) and in the control manure. The duration of 5 months was not sufficient for the C/N ratio to reach a value indicating the optimum phase of maturity of compost; hence there is a need to continue the process of composting for a longer period of time, up to 9 or 12 months. However, the duration of the process and the C/N depend on the nature of the used raw materials. The use of other important indicators of maturity and stability of compost, such as the spectroscopic ratio (E4/E6) of humus and other parameters that are based on respirometry (oxygen) and index gaseous Solvita (CO₂/NH₃) that give us more important information on the status of the compost, is essential.

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