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REDUCTION OF PHYTOTOXICITY OF ORGANIC COMPOST

[1]Miguel David Fuentes Guevara, [2]Matheus Francisco da Paz, [3]Paula Paiva Hofmeister, [1]Rosane Maria Morales Guidotti, [2]Thayli Ramires Araujo, [3]William Terra Neves, [3]Luciara Bilhalva Corrêa and [3]Érico Kunde Corrêa

[1]Programa de Pós-graduação em Manejo e Conservação do Solo e da Água, Departamento de Solos - FAEM UFPel
[2]Programa de Pós-Graduação em Ciência e Tecnologia de Alimentos, Departamento de Ciência e Tecnologia Agroindustrial –FAEM UFPel
[3]Centro de Engenharias – CEng UFPel

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ABSTRACT

The Brazilian legislation for organic compost type A allows a maximum of 50% moisture for commercialization. Thus, the use of dryers may be an alternative to reach this percentage. The objective of this work was to evaluate the effect of the continuous dryer on physical-chemical, microbiological and phytotoxicological characteristics of organic compost. The compost was elaborated with sludge from a poultry and pork slaughtering treatment plant and sawdust. Continuous counter-flow cylindrical dryer was used, with collections before, during and after the dryer. The results were submitted to the Duncan test ($p < 0.05$), presenting reduction of parameters such as humidity, organic carbon and exchangeable acidity. In addition, the compost after the dryer had a higher concentration of mineral matter, N, S, Zn, Cu and Mn ($p < 0.05$), highlighting its agronomic potential. Parameters in the compost as pH, P, K, mesophilic and thermophilic microorganisms were not influenced ($p < 0.05$) before and after the dryer. Finally, the passage of the compound through the dryer promoted a decrease in phytotoxicity ($p < 0.05$), favoring the development of the bioindicators used. It is concluded that the use of the dryer can be a promising alternative for the valorization of the organic compost.

****Corresponding author***

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INTRODUCTION

In the current global scenario and future prospects, the cyclization of organic matter from waste from various sources becomes essential for the pursuit of sustainability and preservation of natural resources (HOTTLE *et al.*, 2015). Composting is characterized as one of the most efficient methods for this activity, a process in which aerobic microorganisms mineralize substrates making them suitable for incorporation into the soil without degrading the environment (ZHANG *et al.*, 2012). In addition, it contributes significantly to the issue of food security, as it promotes a reuse of organic resources, a reduction in the price of food by reducing the import of fertilizers and, consequently, increasing local economic development (HOSETTI and FROST, 1995; CORRÊA *et al.*, 2012; FELS *et al.*, 2014).

The composting process has a complex dynamics with interconnected parameters that directly influence the final product, such as humidity, microbial load present, pH, organic carbon among others, which, if outside the standards required by the legislation, can lead to actions harmful to the soil, fauna and flora (MENDES *et al.*, 2016). When composites are among the parameters required by legislation, humidity is characterized as one of the most important, since their excess can cause anaerobiosis and the formation of methane and other harmful components, whereas their absence may lead to low microbiological activity (PARTANEN *et al.*, 2010). According to the Ministry of Agriculture, Livestock and Food Supply (MAPA), regulation n° 25 of July 23, 2009, indicates that organic compound of type A, B, C have a maximum of 50% of humidity, and, for compounds of the Type D, 70% (BRASIL, 2009). However, if the source material of the compound

exceeds 70% moisture, high temperatures may not be reached due to O_2 entry restriction, thus affecting the microbiological activity, resulting in a final product with high humidity and higher values than those recommended by the legislation (BRITO *et al*., 2008; VALENTE *et al*., 2016). Currently, brazilian legislation does not require phytotoxicological tests to prove the maturity of the compost, however, according to literature consulted, the analysis of phytotoxicity by germination index is widely accepted and recommended, since it demonstrates the acute effect of the compound directly on plants (Himanem *et al*., 2012; Mendes *et al*., 2016; Gerber *et al*., 2017). The use of continuous dryer for mature compounds is a new technology that can be adopted by the organic fertilizer industries. Through the hot air intake, it promotes the volatilization of the water present, removing excess moisture. However, its application is still limited, as other important characteristics can be modified (Salinas and Vázquez, 2006).
In view of this, the Ministry of the Environment in Resolution No. 375 of August 29, 2006 establishes criteria for the quality of sewage sludge or derived products, and it is of interest to analyze the compounds from this substrate. Among the quality analyzes are determinations such as organic carbon, pH in water, moisture and total of macronutrients and micronutrients, also assuming importance to potential acidity; so with the evaluations both the fertility potential of the compound and possible toxicity (Brasil, 2006). Therefore, the objective of this study was to evaluate the effect of the use of a continuous dryer on compost from effluent treatment plant sludge in the characteristics of pH, humidity, mineral matter, organic carbon, exchangeable acidity, counts of mesophilic and thermophiles microorganisms, macronutrients and micronutrients, in addition to the phytotoxicological test.

MATERIAL AND METHODS

Organic compost

In the present study, the organic compost was obtained from an industrial composting unit, with 90 days of maturation, composed of sawdust and sludge from the slaughtering effluent of poultry and swine in the proportion 2: 1 V/V, respectively.

Dryer

For the experiment, a cylindrical continuous flow dryer with a conter flow was used, with 7 meters in length and 1,5 m in diameter; The temperature inside the cylinder was measured with digital probe control reaching 250 ° C. Samples of the compound were collected in three main stages of the process: before, during and after the use of the dryer. The test lasted three days, each day 5 samples were collected per stage.

Physicochemical analysis

Analyzes of pH and organic carbon were performed in triplicate by the Walkey-Black method according to Tedesco *et al*. (1995) and moisture and mineral matter by the AOAC method (1998). In the determination of the exchangeable acidity of the compost, the methodology proposed by Tedesco *et al*. (1995) was used with adaptations. A sample of 2.5g previously crushed and sifted compound was added, adding 50 mL of 1 mol.L^{-1} of KCl, used as the extractive solution. The solution was stirred for 30 minutes with magnetic stirrer and then allowed to stand for 24 hours until the entire solid fraction decanted. After an aliquot of 25 ml of the supernatant was transferred, four drops of the 0.1% phenolphthalein indicator were added, titrating with standard NaOH 0.0088 mol.L^{-1}, to the turning point of the solution for persistent pink color, and blank proofs were also produced.

The exchangeable acidity was calculated by the following equation:

$$EA\ (cmolc\ kg^{-1}) = \frac{(V - V') \times C \times 100 \times 2}{P} \quad \ldots\ldots\ldots\ldots\ldots(1)$$

At where:

V is the volume of NaOH spent on titration of the sample;
V' is the volume of NaOH used in the blank test;
C is the actual NaOH concentration used in the titration;
P is the weight of the sample in grams.

In order to determine the agronomic potential and the effect of the dryer on the nutrients of the compound made with sludge substrates from agroindustry treatment plant and sawdust, nutrients were determined in the three treatment stages according to the methodology of Tedesco *et al*. (1995) using the respective instruments, evaluating the levels of N (steam trawl distiller-microkjeldahl), S and P (spectrophotometer), K (flame photometer), Ca, Mg, Mn, Zn, and Cu (absorption photometer). The nutrient evaluation in the steps was carried out according to the recommendations of resolution n ° 375 of August 29, 2006, which states that products derived from sludge from stations should be subjected to nutrient evaluation. Observing the effect of continuous dryer use on the different nutrients per treatment step.

Microbiological analyzes

The count of mesophilic and thermophilic microorganisms were performed according to APHA – *Compendium of Methods for Microbiological Examinationof foods* (2005), with modifications. The procedure was performed by aseptically weighing 25 g of sample and transferred to 225 mL of sterile peptone water followed by homogenization. After that, the serial dilution was performed and the plating occurred in PCA (Plate Count Agar) medium and taken to the incubator, where the mesophiles remained at 35 ° C for 48h and thermophiles at 45 ° C for the same period of time. The visible colonies were counted and the microorganisms were expressed in CFU mL^{-1}.

Phytotoxicity

Phytotoxicity analyzes were performed according to Mendes *et al*. (2016) with modifications. The seeds of lettuce (Lactuca sativa) and cucumber (Cucumis sativus), purchased in local commerce, were used, respecting the same lot for all replicates. Ten seeds of each species were arranged in triplicate with 5 ml of 10% (w/v) solution of the compound in distilled water and incubated at 25 ° C for 48 h under light shelter. After the period, the germinated seeds were counted and their radicles were measured in millimeters (mm) with the aid of a digital caliper. Germinated seeds were those with radicles larger than 1 mm. Petri dishes were also used with distilled water, serving as control (blank).

The germination index was calculated by the following equation:

$$GI (\%) = \frac{N2 \ X \ C2}{N1 \ X \ C1} \ X \ 100 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

At where:
N2 is the number of germinated seeds;
C2 length of radicles;
N1 is the number of germinated seeds in the control;
C1 is the length of the radicles of the control.

The experimental design was completely randomized, with 3 collection points (before, after and in the dryer) in 3 days and 5 repetitions at each point, following a unifactorial arrangement, being the treatment factor the different collection points, and the response parameter pH, moisture, mineral matter, organic carbon, exchangeable acidity, macronutrients, micronutrients and phytotoxicity by germination index. Atypical data were removed by analyzing the deleted studentized residuals and the variables were normalized and submitted to analysis of variance by the F test ($p < 0.05$). Statistical significance was determined by means of the Duncan test ($p < 0.05$).

RESULTS AND DISCUSSION

As can be seen (Table 1) the value found in relation to the moisture of the compound was 71.22% before the use of the dryer. This value can be explained by virtue of the raw material used to prepare the composting process. According to Alvarenga (2015), treatment plant sludge have moisture between 83.9 and 65.7%, depending on their origin, which may contribute to a final compost with high moisture. There was a reduction in the amount of water of the compound ($p < 0.05$) as it passes through the dryer, with final humidity still higher than 50% (Table 1).

Table 1. Properties of the compound during the drying process

	BeforetheDryer		In theDryer		AftertheDryer	
Physical and chemicalproperties						
Moisture (%)	71,22±1,27	a	65,95±1,64	B	51,69±1,97	C
MM (%)	7,24±2,11	b	9,23±1,57	A	10,21±1,32	A
C (%)	55,08±0,08	a	54,54±0,13	B	54,53±0,13	B
pH	8,50±0,00	a	8,40±0,03	Ns	8,8±0,06	ns
EA ($cmol_c$/kg)	4,05±0,11	a	1,84±0,02	C	3,13±0,14	B
TN (%)	0,71±0,02	b	1,20±0,05	A	1,14±0,04	A
P (%)	0,27±0,02	ns	0,28±0,04	Ns	0,24±0,01	ns
K (%)	0,62±0,02	ns	0,58±0,266	Ns	0,62±0,02	ns
Ca (%)	1,38±0,05	b	4,34±0,182	A	1,55±0,05	B
Mg (%)	0,23±0,02	b	0,54±0,027	A	0,25±0,02	B
S (%)	0,11±0,002	b	0,13±0,005	A	0,14±0,01	A
Zn (mg/kg)	19,57±0,60	c	39,54±2,34	A	31,18±0,36	B
Cu (mg/kg)	30,39±2,44	c	60,14±1,37	A	48,18±2,44	B
Mn (mg/kg)	189,89±1,55	c	375,26±10,47	A	202,03±2,85	B

Mean ± standard deviation, MM: mineral matter, C: organic carbon TN: total nitrogen EA: exchangeable acidity.
Different letters indicate significant differences ($p < 0.05$) between treatments by the Duncan test

The result found remains above that required by Brazilian legislation, for compounds of classes A, B and C with a need for greater intensity of the heat source or longer time of exposure of the compound to this source. However, must be taken into account that much lower moisture values of the compound may be harmful to the quality of the compound by altering the physicochemical characteristics and decreasing microbial activity (KULIKOWSK and GUSIATIN, 2015). On the other hand, high values of humidity can contribute to the maintenance of toxic elements within the compound due to anaerobic reactions (FELS *et al*., 2015). There was a reduction of the amount of organic carbon (Table 1) in the compound before and after the dryer ($p < 0.05$). This result can be mainly explained by the volatilization of some low molecular weight organic compounds concomitantly with water (Doublet *et al*., 2011; Himanen *et al*., 2012). Regarding the mineral matter content (MM), there was an increase ($p < 0.05$) of these components when compared with the compound with high humidity, an increase already inside the equipment was observed (table 1), also explained by the removal by volatilization of organic compounds and concentration of mineral matter in the sample (Himanen *et al*., 2012). For pH, the values found for the compound showed no difference ($p > 0.05$) between treatments (Table 1). The pH of matured compounds should present alkaline values, as found in this investigation, mainly due to the synergistic action between the degradation of organic acids and the conversion of amines to ammonia (Li *et al*., 2013; Fels *et al*., 2014). In this sense, the use of the dryer is beneficial, since besides a significant reduction of humidity, does not alter the pH, important parameter of indication of compound maturity.

The compound in the different stages of the dryer did not present acidity (Table 1). It is noted that there was a reduction of the exchangeable acidity of the compound ($p < 0.05$) after passing through the dryer; Due to the pH values with tendency to alkalinity, similar to the results in composting and vermicomposting processes analyzed by Dores-silva *et al*. (2013), where the tendency in increasing the pH value reflects in the decrease of the acidity of the samples. The cause of the compound does not present acidity is also due to the high values of organic matter that has the capacity to complex the exchangeable Al^{3+} (responsible for the acidity). In this sense, the low Al^{3+} levels found in the study can also be attributed to the alkaline pH of the compound in the three treatment stages, in which the free aluminum activity is decreased (hydrolyzed) by the decrease in H^+ activity and increase in OH^+ Thus being in a less toxic form ($Al(OH)^{2+}$) and in a precipitate form (JUO and Kamprath, 1979; Nolla *et al*., 2007). As observed (Table 1), most of the nutrient contents were concentrated in the compound inside the continuous dryer because of the high temperature of 250 ° C inside the dryer cylinder which contributed to the loss of moisture per unit of mass. After removal of the compound from the dryer it was observed benefits of the dryer in the significant changes in concentrations of macronutrients and micronutrients ($p < 0.05$) such as S, N, Zn, Cu and Mn thus allowing a greater use of the compound as fertilizer as a source of organic matter and nutrient for the plants, once it is incorporated in the soil, bringing benefits to agriculture; in addition, if it is framed as a form of reuse of residues (substrates) in an environmentally adequate way, complying with the maximum permitted limits of zinc (Zn) and copper (Cu) in sludge by-products established by the Enviromental Protection Agency - EPA (1992). It should be noted that the micronutrient contents in the compound after the dryer, were lower than those found in compounds made from municipal solid waste, matured compounds not matured (PASCUAL *et al.*, 1997; BUSTAMANTE, *et al.*, 2008).

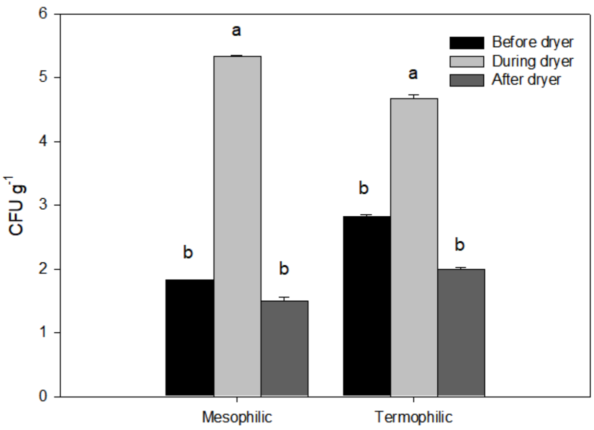

Figure 1. Microbiological profile of the compound subjected to the dryer

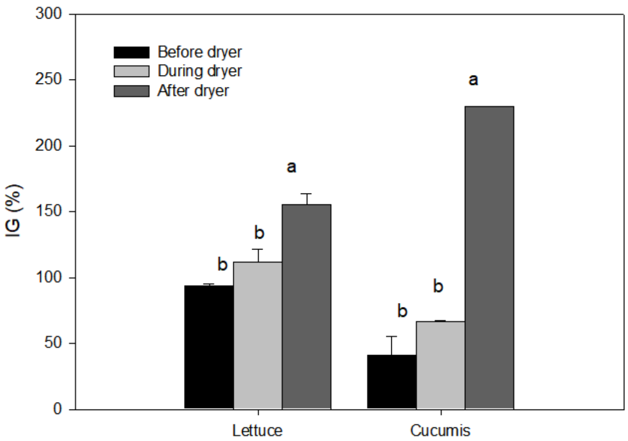

Figure 2. Index of germination (%) of lettuce and cucumber seeds in compost before, during and after the use of the dryer

The high percentages of carbon in relation to the nitrogen composition in the final compound are due to the substrates used in composting, case of sawdust with a C/N> 100 ratio, (Table 1) being rich in slow decomposition carbon such as cellulose and lignin, contributing to the absorption of water in the mixtures with substrates of high moisture content, (HANG *et al.*, 2015). The final nitrogen and carbon contents in the final compound were higher than the minimum limits established by the Brazilian legislation of 0.5% and 15% respectively (BRASIL, 2009). The increase of nitrogen (N) content in the compound after passage through the dryer intensified its capacity as fertilizer, since this nutrient is categorized as essential in the growth and development of plantsDores-Silva *et al.* (2013), similar concentrations of nitrogen were found in the final composting process performed by Hang *et al.* (2014), using meat manure in intensive systems (*feedlot*) with sawdust and wood chips. Concomitant with the minimum acceptable nitrogen content for an organic compound of 1% and a maximum of 10% (KOLLING *et al.*, 2013).

Concerning phosphorus (P) and potassium (K) in fertilizers are widely studied because they are the most demanding macronutrients in plant nutrition followed by nitrogen (N); the phosphorus being the determinant factor of the photosynthesis and transfer of energy and potential of the crop productions; and K improving the efficiency of water use in plants, increasing crop growth (HEJCMAN *et al.*, 2012; LIM *et al.*, 2015). In the study the final concentration of K in the compound was high, and the dryer temperature did not produce a significant difference ($p < 0.05$) (Table 1), these similar values were reported by Morales *et al.* (2016), who obtained composting with sewage sludge from food industry (LIM *et al.*, 2015). The K values observed after the dryer are above the acceptable minimum of 0.5% potassium for organic fertilizers (KOLLING, *et al.* 2013). In the microbiological profile of the matured compound before, during and after the dryer (Figure 1) it was observed that there was no difference ($p < 0.05$) between the treatments before and after the use of the equipment, nevertheless, in the interior it was verified a greater presence of microorganisms, both for mesophiles and for thermophiles. According to Li *et al.* (2013), a pH tending to alkalinity tends to inhibit the growth of thermophilic microorganisms, which may explain the low development of thermophiles inside the equipment, considering favorable conditions. It can be observed that there was an increase ($p < 0.05$) in the germination index (%) after the use of the dryer (Figure 2), both for lettuce seeds, from 93.91 to 155.37%, And for cucumber, with results of 41.55 to 230.12% with the use of the dryer. These results can be explained by the volatilization of some low molecular weight acids and the reduction of exchangeable acidity after the dryer, which, although not directly interfering with the pH of the compound, have a deleterious effect on the germination and root lengthening of the plants (HIMANEM *et al.*, 2012; DORES-SILVA *et al.*, 2013). According to the California Citrus Quality Council (CCQC, 2001), values lower than 80% in the germination index indicate phytotoxic characteristics. The use of the drier gave the compound, in relation to the cucumber seed, the transformation of phytotoxic agent to germination promoting agent, with values greater than 200% in relation to germination with distilled water, indicating that the use of the dryer provided reduction of phytotoxicity of matured compound.

Conclusions

The use of the continuous cylindrical dryer provided a reduction in moisture content, organic carbon content and exchangeable acidity. It did not influence the pH, the phosphorus and potassium contents nor the microbiological profile of the compound before and after the passage through the dryer. The dry compost showed higher content of mineral matter, nitrogen, sulfur, zinc, copper and manganese. Finally, the drying of the compound promoted a greater germination of lettuce and cucumber seeds, favoring the development of these plants. Thus the use of the dryer can be a promising alternative for the valorization of the organic compound.

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