Ecological Engineering 85 (2015) 301–306

Contents lists available at ScienceDirect

Ecological Engineering

journal homepage: www.elsevier.com/locate/ecoleng

Short communication

Vermicomposting of different types of tanning sludge (liming and primary) mixed with cattle dung

Guilherme Malafaia[a,b,*], Dieferson da Costa Estrela[a], Abraão Tiago Batista Guimarães[c], Fernando Godinho de Araújo[d], Wilson Mozena Leandro[e], Aline Sueli de Lima Rodrigues[a]

[a] Laboratório de Pesquisas Biológicas, Departamento de Ciências Biológicas, Instituto Federal de Educação, Ciência e Tecnologia Goiano – Câmpus Urutaí, Urutaí, Goiás, Brazil
[b] Programa de Pós-Graduação em Biodiversidade Animal, Universidade Federal de Goiás, Câmpus Samambaia, Goiânia, Brazil
[c] Laboratório de Pesquisas Biológicas, Instituto Federal de Educação, Ciência e Tecnologia Goiano – Câmpus Urutaí, Urutaí, Goiás, Brazil
[d] Laboratório de Pesquisas Biológicas, Departamento de Agronomia, Instituto Federal de Educação, Ciência e Tecnologia Goiano – Câmpus Urutaí, Urutaí, Brazil
[e] Departamento de Agricultura, Universidade Federal de Goiás – Câmpus Samambaia, Goiânia, Brazil

ARTICLE INFO

Article history:
Received 30 March 2015
Received in revised form 4 October 2015
Accepted 7 October 2015
Available online 28 October 2015

Keywords:
Vermiculture
Solid residues
Earthworms
Agroecology

ABSTRACT

The complexity of the generation of solid residues is a present issue, because of the polluting potential of many materials produced. Therefore, the objective of this study is to assess vermicomposting of different types of tanning sludge (liming and primary), aiming at reuse in agriculture. Thus, the types of tanning sludge known as liming and primary (tannery industry from, Pires do Rio, Goiás, Brazil) were mixed to cattle dung in different proportions (10, 20, 30, 40 and 50%, dry basis) and then earthworms of the species *Eisenia foetida* were introduced. After 120 days, the composts were chemically analyzed. Our results demonstrate that the vermicomposting of different types mixtures of the of tannery sludge with cattle dung (10–50% concentrations) is capable of increasing concentrations of N, K, Ca, Mg and Na. Primary sludge mixtures with cattle dung, at higher concentrations (20–50%) reduce the concentration of the Cu, while liming sludge mixtures with cattle dung (20–50% concentrations) increase the concentration of the element. On the other hand, mixtures containing primary sludge reduces the concentration of Fe and increase the concentration of Zn. Finally, independent of the sludge mixed and the concentrations of the cattle dung used in this study, these substrates reduce the TOC concentration and C/N, which are one of the most traditional indicators of the maturation of a compost.

1. Introduction

Large-scale urbanization and population growth – consequences of economic development – have caused increasing production of residues in many countries. Therefore, the concern about these materials has also grown, because many residues, if disposed improperly in the environment, can cause serious environmental and public health problems. Some of these residues that have been produced in large quantities are those coming from leather (tanning) industries (Godecke et al., 2012).

Tanning is the chemical process that converts animal hides and skin into leather and related products. More than one hundred different chemicals nearly (350,000 tons/year of inorganic and heavy metal salts, soaps, oils, waxes, solvents, dyes, *etc.*) used in tanning processes are found in process wastes and wastewaters (Godecke et al., 2012). The major components of the sludge include sulfide, chromium, volatile organic compounds, large quantities of solid waste, suspended solids like animal hair and trimmings. For every kilogram of hides processed, 30 l of effluent is generated and the total quantity of effluent discharged by Indian industries is approximately 45000–50,000 m^3/day. Tannery industry plays an important role with respect to environmental pollution due to disposal of large volume of solutions of tanning baths. The discharge of chromium rich tannery sludge is a serious threat for environment with high concentrations of organic and inorganic component that they create risk to human health and environmental aspects (Cetin et al.,

* Corresponding author at: Instituto Federal Goiano – Câmpus Urutaí, Rodovia Geraldo Silva Nascimento, 2.5 km, Zona Rura, Urutaí, Goiás, Brazil.
E-mail addresses: guilhermeifgoiano@gmail.com (G. Malafaia), diefersonestrela@gmail.com (D. da Costa Estrela), abraaotbgbio@gmail.com (A.T.B. Guimarães), godinhoaraujo@hotmail.com (F.G. de Araújo), wilsonufg@gmail.com (W.M. Leandro), alineifgoiano@gmail.com (A.S. de Lima Rodrigues).

http://dx.doi.org/10.1016/j.ecoleng.2015.10.010
0925-8574/

2013). Tannery industry is one of the important industries in India (Kushwaha and Upadhyay, 2015) and in many regions of Brazil (Godecke et al., 2012; Meunier and Ferreira, 2015), for example, which earns large foreign exchange through the leather export.

The development of studies that contribute with forms to treat or reuse such materials has been stimulated. An interesting option is vermicomposting, a process that not only is a form of tanning sludge treatment (Carlesso et al., 2011; Teixeira and Almeida, 2013), but is also a biotechnology able to transform these residues in noble composts, feasible to be used in other sectors, such as agriculture (Suthar, 2010). As discussed by Varma et al. (2015), during vermicomposting, different important nutrients that are present in the residues are converted, by means of the joint action of earthworms and their intestinal microbiota, in much soluble and available forms to plants than the forms presented in *in natura* residues.

When it comes to vermicomposting of tanning residues, few studies can be found in the literature (Bidone, 1995; Gondek and Filipek-Mazur, 2003; Ravindran et al., 2008; Vig et al., 2011; Teixeira and Almeida, 2013; Malafaia et al., 2015), which point to the vermicomposting potential as a form to treat these residues. Such studies assess the vermicomposting process that involves tanning residues co-disposed with different substrates (vegetal and animal), under the action of different earthworm species. However, taking into account that the residues produced in tanning industries present characteristics that are too variable, even within the same industry, the development of more studies is necessary, in order to contribute in a systematic way to the generation of knowledge that will help assess the viability of reuse of these residues by means of vermicomposting. Thus, the objective of the present study was preliminary to assess vermicomposting of different types of tanning sludge (liming and primary), co-disposed with cattle dung in different proportions, so that composts of high nutritional content are produced with nutritional potential for plants.

2. Materials and methods

The experiments were conducted with Oligochaeta – Lumbricidae, species *Eisenia foetida* (Californian red earthworms), which is capable of converting weakly decomposed organic residues to stabilized material, as shown in other studies (Yadav et al., 2012; Singh and Kalamdhad, 2013; Ashiya et al., 2015; Tereshchenko et al., 2015; Yadav, 2015; Nayeem et al., 2015).

Two types of tanning sludge were used, which are generated in a tanning industry located in Pires do Rio (Goiás, Brazil): lime sludge (resulting from unhairing and liming) and primary (coming from the Effluent Treatment Station of the same industry). The chromium-bearing effluents generated in that industry during tanning are treated separately from the effluents generated in other stages. To enable the vermicomposting process, the tanning sludges (liming and primary) were dried before mixing with (dried and tanned) dung. Table 1 presents the characteristics of the residues used in this study, which were obtained according to the method proposed by Tedesco et al. (1995).

The treatment arrangement consisted of six experimental units for each type of tanning sludge, distributed in a completely randomized design, with seven repetitions each: (1) cattle dung (E100); (2) lime sludge at 10% + cattle dung at 90% (Lc10); (3) lime sludge at 20% + cattle dung at 80% (Lc20); (4) lime sludge at 30% + cattle dung at 70% (Lc30); (5) lime sludge at 40% + cattle dung at 60% (Lc40); (6) lime sludge at 50% + cattle dung at 50% (Lc50); (7) primary sludge at 10% + cattle dung at 90% (Lp10); (8) primary sludge at 20% + cattle dung at 80% (Lp20); (9) primary sludge at 30% + cattle dung at 70% (Lp30); (10) primary sludge at 40% + cattle dung at 60% (Lp40) and (11) primary sludge at 50% + cattle dung at 50% (Lp50). As in our

Table 1
Main characteristics of tanning sludge of liming and primary types and cattle dung used in the vermicomposting process with *Eisenia foetida*. Urutaí, Goiás, 2014.

Variables	Substrates		
	Cattle dung	Tanning sludge of the liming type	Tanning sludge of the primary type
pH ($CaCl_2$)	8.7	7.6	9.0
N (%)	0.6	0.8	3.5
P (Melich – mg dm^{-3})	700.0	52.0	7.0
K (mg dm^{-3})	3200.0	280.0	140.0
Ca (cmolc dm^{-3})	3.2	28.0	27.9
Mg (cmolc dm^{-3})	4.9	19.6	10.1
Al (cmolc dm^{-3})	0.0	0.2	0.0
H + Al (cmolc dm^{-3})	0.6	5.8	11.7
CTC (cmolc dm^{-3})	19.1	18.2	44.4
Na (mg dm^{-3})	500.0	1400.0	1000.0
Cu (mg dm^{-3})	3.6	0.6	0.5
Fe (mg dm^{-3})	268.0	13.0	8.0
Mn (mg dm^{-3})	43.0	3.0	4.0
Zn (mg dm^{-3})	31.0	32.5	12.9
Organic matter (%)	16.0	6.3	20.0
Sat Al (%)	0.0	3.0	0.0
Sat base (%)	97.0	68.0	74.0
Total organic carbon (%)	14.1	–	–
Cr (mg dm^{-3})	<LQ	<LQ	<LQ

Legend: (–): parameter not assessed. <LQ: less than the limit of quantification of the technique used – 5.0 mg dm^{-3}. The organic substrate mixed to the tanning sludge was cattle dung. It was chosen because it is a good source of food for the earthworms and is considered the most used organic compound in vermicomposting processes (Aquino et al., 2005).

previous study, the experimental units were installed in 3-l plastic pots. Each pot contained a total of 1 kg of substrate (tanning sludge + cattle dung), according to Vig et al. (2011) and Malafaia et al. (2015).

After establishing the experimental units, the mixtures were manually turned every 24 h for 20 days, so as to eliminate possible volatile toxic gases. After this period, a sample of each treatment was collected for analysis of the parameters pH, N, P, K, COT, C/N, Ca, Mg, Na, Cu, Fe, Mn and Zn, according to the method described in Embrapa (1997). Then, each pot received 20 adult earthworms. All pots were covered with a plastic material for shading (plastic screen commercially known as Sombrite), to avoid the escaping of earthworms and to promote the aeration of the substrate. The substrate was moistened with water until humidity reached 30–40%. These percentages were maintained during the whole experiment with periodical manual watering. After 120 days of vermicomposting, the resulting composts were sieved, air-dried and stored in plastic bags for new chemical and physico-chemical analyses.

The data relating to initial and final concentrations of the vermicomposts were compared using Student's *t*-test. The normality of the data was checked using Anderson–Darling and Shapiro–Wilk tests. The data concerning the nutrient concentrations in the composts underwent analysis of variance at 5% significance. When significant differences were detected between tanning sludge doses, regression analysis was performed. Graphs with (linear or quadratic) regression models that represented the best fit of the sample data were drawn. The selection of the best regression model was based on the coefficient of determination (R^2) and on the F value. All statistical procedures were performed using the freeware ASSISTAT, version 7.7 beta.

3. Results and discussion

As can be observed in Table 2, significant increase in N concentration occurred at the end of the experiment in all treatments, including the control treatment (E100 – 100% cattle dung) and those composed of tanning sludge of the liming and primary types,