3rd International Biochar Conference
IBI 2010
Progressing from Terra Preta de Índios to the Whole World

Use of biochar as bulking agent for the composting of poultry manure: effect on organic matter degradation and humification

Dias, BO[a]*; Silva, CA[b]; Higashikawa, FS[c]; Roig, A[d]; Sanchéz-Monedero, MA[d]

[a]Bolsista PNPD/CAPES, Programa de Pós-Graduação em Manejo do Solo e Água – Centro de Ciências Agrárias – UFPB, CEP: 58.397-000, Areia, PB, Brasil. [b]Professor do Departamento de Ciência do Solo – UFLA, CP 3037, Lavras, MG, Brasil; [c]Doutorando do PPG – Ciência do Solo – UFLA, CP 3037, Lavras, MG, Brasil; [d]Pesquisador do Centro de Edafología y Biologia Aplicada del Segura – CSIC, CP 164, CEP 30.100, Murcia – Espanha.
*E-mail: b2dias@yahoo.com.br

Key words: *humic substances, maturity, waste organic*

Introduction

Biochars have been traditionally used as soil amendments because of their potential benefits to soils (1;2). More recently, their chemically stable structure and slow degradation rate has attracted the interest as a potential C sink (3). Despite the potential benefits associated to the agricultural use of biochar, a there is only limited amount of information regarding the use of this material as bulking agent for composting, and on its effect on organic matter stabilisation and humification during the process (4). The aim of this study was to evaluate the use of biochar a bulking agent for poultry manure composting.

Three composting piles were prepared by mixing poultry manure with biochar in a proportion of 1:1 (fresh weight). Biochar was obtained by slow pyrolysis of wood of Eucalyptus grandis in a kiln operating at atmospheric pressure and a temperature range varying from 300 - 450°C. One representative sample was collected at 0, 30, 60, 120, and 210 days of composting by piles six subsamples taken from different locations in the pile.

The total extractable C (CEX) was measured on a 1:20 (w:v) 0.1 M NaOH extract and fulvic acid C (FAC) was determined after precipitation of the humic-like acids at pH 2.0 (5); the humic acid carbon (HAC) was calculated by subtracting the fulvic acid carbon (FAC) from the extracted carbon (CEX). The following humification parameters were then calculated (5): humification ratio (HR) = (CEX/TOC) x 100; humification index (HI) = (HAC/ TOC) x 100; percentage of humic acids (PHA) = (HAC/EXC) X 100; and degree of polymerisation (DP) = HAC/FAC.

Data were subjected to univariate ANOVA and treatment means were compared using the Tukey test at $P \leq 0.05$, using the SPSS version 15.0 statistical package for Windows.

Results and Discussions

The evolution of the concentrations of the total extractable C (CEX), humic acid C (HAC) and fulvic acid C (FAC) during the composting process is shown in Table 1. The concentration of HAC increased significantly during the composting process for the PMB mixture from 8.1 g kg^{-1} in the initial phase of process up to 21.3 g kg^{-1} in the mature compost. The FAC content was reduced during the initial phase of composting, probably due to the microbial degradation of soluble compounds, and remained almost unchanged until the end of the process. In the PMB mixture, the increasing trend in the amount of CEX was due to the increase in the concentration of HAC, reflecting the degree of humification and maturity achieved by the mature compost (6).

Table 1. Humification indexes for during composting process.

Composting time (days)	CEX	FAC	HAC	DP	HR	HI	PHA
	--------- $g.kg^{-1}$	-------------					
0	23.1 a	15.0 a	8.1 b	0.54 d	5.40 c	1.89 d	35.16 d
30	16.5 b	4.1 b	12.4 b	3.01 c	5.64 bc	4.23 c	74.97 c
60	12.5 c	2.6 c	1.0 c	3.87 bc	5.17 c	4.11 c	79.38 bc
120	16.6 b	2.7 c	13.9 b	5.20 b	7.44 b	6.24 b	83.74 b
210	22.7 a	1.3 d	21.3 a	8.87 a	10.47 a	9.85 a	94.08 a

CEX: Extracted Carbon; FAC: Fulvic acid carbon; HAC: Humic acid carbon; DP: Degree of polymerization; HR: Humification ratio; HI: Humification index; PHA: Percentage of humic acids. Columns sharing the same letters do not differ significantly according to mean separation by Tukey tests at probability level $P < 0.05$.

Changes in the concentration of the alkali extracted fractions usually depend on the origin and chemical composition of the composted material, which may limit the validity of these fractions as indicators for comparing the maturation in different composting matrices.

The HR index increased during the composting, as a consequence of the increase in the proportion of alkali soluble carbon, reflecting the intense humification underwent by the organic matter. This increase was more intense at the end of composting, during the maturation phase. The increase of PHA and DP in mixtures PMB reflected the large increase of the HAC fraction. The use of biochar as bulking agents has favored the synthesis of more condensed molecules (HAC), rather than the fulvic acid molecules (FAC). The HAC fraction represented 94% of CEX. The high PHA may be related to the chemical composition of biochar, which is composed of a high proportion of condensed aromatic structures (7). The small size aromatic cluster formed during the degradation of biochar may have been incorporated into the structure of the humic acids.

The use of the biochar as bulking agents in the composting piles promoted an increase in the HAC fraction and in the humification indices (Table 2). The increase in humification index for PMB may be related to water-soluble carbohydrates and phenols in the humic structure, since these substances are precursors of humification processes (8). There was a highly significant correlation between the carbohydrate fraction and the HAC/CEX

Table 2. Correlation between water-soluble carbohydrates and phenols and different humification indices during composting time.

	HAC/TOC	HAC/CEX	HAC/FAC
Carbohydrates	NS	-0.930**	NS
Phenols	-0.732*	-0.974**	NS

NS – not significant; **,* - significant at a probability level of $P < 0.01$ and $P < 0.05$ respectively.

There was a highly significant correlation between the carbohydrate fraction and the HAC/EXC index in PMB, in the case another important contribution to the humification pathways may be related to its chemical composition. There was a significant increase of the HAC fraction during the process, because of the incorporation of aromatic fractions into the humic structures (9). During the formation of the biochar, lignin is broken into its building blocks, generating free radicals that regroup and reorganize, into highly aromatic final products (7).

Conclusion

The chemical nature of the organic matter of the poultry manure-biochar mixture is characterised by an enrichment of humic acids in relation to the fulvic acid fraction and by the presence of humic-like substances with the highest degree of polymerisation.

Acknowledgements

The authors thank CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior). This research was partially financed by a grant from the Spanish Ministry of Science and Innovation and a grant from the FAPEMIG (Fundação de Amparo à Pesquisa do Estado de Minas Gerais).

[1] Chan, K.Y.; Zwieten, L. Van; Meszaros, I.; Downie, A.; Joseph, S. 2007. *Aus. J. Soil Res.* 45, 629-634.
[2] Steiner, C.; Teixeira, W.G.; Lehmann, J.; Nehls, T.; Macêdo, J.L.V.; Blum, W.E.H.; Zech, W. 2007. *Plant Soil.* 291, 275-290.
[3] Lehmann, J. A handful of carbon. 2007. *Nature*. 447, 143-144.
[4] Hua, L.; Wu, W.; Liu, Y.; Mcbride, M.B.; Chen, Y. 2009. *Env. Sci. Poll. Res.* 16, 1-9.
[5] Sánchez-Monedero, M.A.; Roig, A.; Cegarra, J.; Bernal, M.P. 2009. *Bio. Tech.* 70, 193-201.
[6] Tiquia, S.M.; Tam, N.F.Y. Fate . 2000. *Env. Poll.* 110, 535-541.
[7] Trompowsky, P.M.; Benites, V.M.; Madari, B.E.; Pimenta, A.S.; Hockaday, W.C.; Hatcher, P.G. 2005. *Org. Geoc.* 36, 1480-1489.
[8] Stevenson, F.J. *Humic chemistry: genesis, composition, reactions*. 1999. 2. ed. New York, p, 496.
[9] Czimczik, C.I.; Preston, C.M.; Schmidt, M.W.I.; Werner, R.A.; Schulze, E.D. 2002. *Org. Geoc.* 33, 1207-1223