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Short Communication

Organic matter humification by vermicomposting of cattle manure alone and mixed with two-phase olive pomace

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Abstract

The chemical changes occurring in a cattle manure (CM) and a mixture of two-phase olive pomace and CM (OP + CM) after vermicomposting with *Eisenia andrei* for eight months were evaluated. Further, humic acid (HA)-like fractions were isolated from the two substrates before and after the vermicomposting process, and analyzed for elemental and acidic functional group composition, and by ultraviolet/visible, Fourier transform infrared and fluorescence spectroscopies. Before vermicomposting, the HA-like fractions featured a prevalent aliphatic character, large C contents, small O and acidic functional group contents, a marked presence of proteinaceous materials and polysaccharide-like structures, extended molecular heterogeneity and small degrees of aromatic ring polycondensation, polymerisation and humification. After vermicomposting, the total extractable C and HA–C contents in the bulk substrates increased, and the C and H contents, aliphatic structures, polypeptidic components and carbohydrates decreased in the HA-like fractions, whereas O and acidic functional group contents increased. Further, an adequate degree of maturity and stability was achieved after vermincomposting, and the HA-like fractions, especially that from OP + CM, approached the characteristics typical of native soil HA. Vermicomposting was thus able to promote organic matter humification in both CM alone and in the mixture OP + CM, thus enhancing the quality of these materials as soil organic amendments.

Keywords: Cattle manure; Humic acids; Humification; Two-phase olive pomace; Vermicomposting

1. Introduction

According to recent data from the Spanish Ministry of Agriculture, Fisheries and Food, approximately 90 million tonnes of cattle manure (CM) are collected annually from farm buildings and yards in Spain. Further, more than 90% of the Spanish olive oil mills operate with the use of a two-phase centrifugation system for oil separation after pressing of olives (Alburquerque et al., 2004), which generates a semisolid waste, i.e., the two-phase olive pomace (OP) called "alperujo". As CM, OP is generated in great amounts (4 millions tonnes in Spain), thus making its disposal a major social, economic and environmental problem (Nogales and Benítez, 2006).

Composting of organic wastes is a well established method to obtain their chemical stabilization, biological maturation and sanitization before application to agricultural land (De Bertoldi et al., 1996). Vermicomposting is a special composting process that involves the addition of certain species of epigeic earthworms to enhance the conversion of organic wastes (Edwards, 2004). Earthworms are able to fragment the organic substrate and stimulate greatly microbial activity, leading to rapid mineralization and humification processes in which unstable organic matter is partially transformed through decomposition, resynthesis and polymerization reactions to relatively stable and complex organic compounds that resemble native

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soil humic substances (HS) (Edwards, 2004; Benítez et al., 2005).

Soil HS, which represent quantitatively and qualitatively the most important components of soil organic matter, enhance plant growth directly through positive physiological effects and indirectly by affecting the physical, chemical and biological properties of soils (Stevenson, 1994; Senesi and Loffredo, 1999). In particular, humic acids (HAs), which represent the major fraction of HS, serve as sources of N, P and S for plants and microbes, affect the activities of microorganisms, and promote good soil structure, thereby improving aeration and moisture retention (Stevenson, 1994; Senesi and Loffredo, 1999). Consequently, the greater is the amount of the HA-like fraction in an organic amendment, and the more its compositional and structural properties approach those of native soil HA, the more agronomically efficient and environmentally safe is the organic amendment (Senesi et al., 2007).

Although a number of studies have been conducted on conventional composting of CM and OP (e.g., Alburquerque et al., 2006; Tanga et al., 2006), relatively little attention has been devoted to vermicomposting of these wastes. Further, no data are available on the compositional, functional and structural features of the HA-like fractions in vermicomposted CM and OP, in comparison to native soil HAs. Thus, the objective of this work was to study the chemical properties of a CM and a mixture of OP and CM, and of the HA-like fractions isolated from these substrates before and after the vermicomposting process.

2. Methods

The CM sample used in this work was collected from a farm located in the Granada province (Spain). The OP sample was obtained from a commercial olive oil manufacturer (ROMEROLIVA, Deifontes, Granada, Spain), which employs a two-phase decanter centrifuge system for extravirgin olive oil separation. Clitellated and non-clitellated earthworms of the species *Eisenia andrei* were obtained from a culture bank at the Estación Experimental del Zaidín (CSIC), Granada, Spain.

The CM alone and a mixture of OP and CM (OP + CM) at a ratio of 4:1 (dry weight basis) were vermicomposted for 8 months in two 1 m^2 beds composed of a wooden frame lined with a net and a layer of plastic with an outlet for leachate drainage, and placed in a 25 m^2 non-controlled greenhouse (Benítez et al., 2002). Each bed was filled with 80 kg of substrate and inoculated with 400 g of earthworms (~800 earthworms). The moisture content of the substrate in each bed was kept at 80–85% by irrigation during the entire period of vermicomposting. Before and after vermicomposting three subsamples were collected randomly from three sites of each bin. After the earthworms were removed a composite sample was prepared for each bin by mixing equal amounts of the three corresponding subsamples.

Prior to analyses, samples of CM and OP + CM collected before and after the vermicomposting process were air-dried and crushed to pass through a 0.5 mm sieve. The principal chemical properties of the samples were determined by conventional methods in triplicate analysis of each sample. Further, the HA-like fractions were isolated from CM and OP + CM sampled before and after the vermicomposting process using a conventional procedure (Schnitzer, 1982), and analyzed for elemental and acidic functional group composition, and by ultraviolet/visible, Fourier transform infrared (FT-IR) and fluorescence spectroscopies. The chemical methods of substrate analyses, the HA isolation procedure, and the methods of HA analyses are described in detail elsewhere (Romero et al., 2007).

3. Results and discussion

3.1. Chemical properties and humification parameters of substrates

With respect to CM-B, OP + CM-B has smaller pH, electrical conductivity (EC) and total N content, and much larger total organic C (TOC), total extractable C (TEC), and humic and fulvic acid C (FAC and HAC, respectively) contents, C/N ratio and humification ratio (HR% = 100 × TEC/TOC) and humification index (HI% = 100 × HAC/TOC) values (Table 1). After the vermicomposting process, the pH value and total N content in OP + CM-A increase, whereas the pH value remains almost constant and total N content decreases in CM-A. Further, EC, TOC and FAC contents and C/N ratio decrease markedly in both substrates, whereas TEC and HAC contents, and HR and HI values increase markedly (Table 1). After vermicomposting, OP + CM-A shows the same pH value, much larger EC, total N, TOC, TEC, FAC, HAC contents and C/N ratio, and slightly larger HR and HI values, as compared to CM-A (Table 1).

The pH increase in OP + CM-A may be attributed to the mineralization of proteinaceous materials to yield alkaline ammonia and/or to loss of volatile acids, whereas the EC decrease in CM-A and OP + CM-A could be due to loss by leaching and/or microbial immobilization of soluble salts, and/or to formation of insoluble salts. The decrease of total N content in CM-A may be ascribed to volatilization of ammonia N and to the occurrence of nitrification and denitrification processes, whereas the increase of N in OP + CM-A may be mostly attributed to mineralization of C-rich materials and, possibly, to the action of N-fixing bacteria (Plaza et al., 2005). The decrease of TOC and FAC contents measured after vermicomposting indicates the occurrence of a net organic matter mineralization in the substrates because of the combined action of microorganisms and earthworms. The small C/N ratio and large TEC and HAC contents and HR and HI values in both substrates after vermicomposting would indicate the achievement of a large degree of maturity and stability and the occurrence of an extended synthesis of organic