OPTIMIZATION OF COMPOSTING FROM THE SOLID PHASE OF PIGGERY DIGESTATES: ADDED VALUE PROPERTIES

Bustamante, M.A.¹,², Restrepo, A.¹, Moral, R.¹, Paredes, C.¹, Pérez-Murcia, M.D.¹, Medina, E.M.¹, Marhuenda-Egea, F.C.³, Alburquerque, J.A.², Bernal, M.P.²

¹Dept. of Agrochemistry and Environment, Miguel Hernandez University, EPS-Orihuela, ctra. Beniel Km 3.2, 03312-Orihuela (Alicante), Spain.
²Dept of Soil and Water Conservation and Organic Waste Management, Centro de Edafología y Biología Aplicada del Segura, CSIC, PO Box 164, 30100 Murcia, Spain.

Abstract

The aim of this work was to study the co-composting process of the solid phase of the digestate (PSD) obtained from the anaerobic digestion of pig slurry, with agricultural and agro-food wastes, such as wheat straw (WS), vine shoot pruning (VP), pepper plant pruning (PP) and exhausted grape marc (EGM), as well as the final added-value properties of the composts obtained. All the composting mixtures piles reached thermophilic conditions, except the pile elaborated with the solid phase of digestate and exhausted grape marc. In general, all the composts showed adequate suitable physical properties for their use as growing media and suppressive effect against the phytopathogen Fusarium oxysporum.

Keywords: composting, digestate, anaerobic digestion, phytopathogen suppressive effect, compost quality.

1. Introduction

Agricultural and farm management is quickly changing, including concepts related to energy, environmental issues and sustainability, without forgetting the gross production. Anaerobic digestion constitutes one of the main alternatives to manage these wastes and is based on the anaerobic conversion of organic matter, obtaining biogas and a digested substrate called digestate. Swine generates one of the main waste fluxes from farming in the world and coupled with other by-products or wastes, has a very significant capacity to obtain biogas. Piggery digestate management includes decisions such as direct use on agriculture (diluted fertilizing capacity, phytotoxicity, etc), phase separation (that reduces the organic charge and the treatment cost but usually includes PAM and/or metals); pelletization (high energy cost) or composting (sanitization and quality assessment issues) of the solid phase, etc. Nowadays, the composting process and the final product must present enhanced properties such as nutrient balance, suitable physical properties, suppressive effect against phytopathogens and more humified and policondensated organic matter (Moral et al, 2008). These properties allow compost to cover specific uses such as growing media. Substitution or reduction of the participation of peat and/or perlite in seedlings and soilless culture by compost must be based on the obtaining of a similar behavior in commercial conditions, especially referred to substrate stability and water-nutrient dynamics. In this experiment, we present a case study of optimization of composting of the solid phase of piggery digestates (PSD), obtained from a centralized treatment plant of pig slurries in Catalonia by mesophilic anaerobic digestion, with wastes from the agricultural activity (wheat straw (WS), vine shoot pruning (VP) and pepper plant pruning (PP)) and from the agro-food sector (exhausted grape marc (EGM)). We analyzed the added values properties of these composts in terms of physical properties,
suppressive effect against the phytopathogen *Fusarium oxysporum* f.sp. *melonis* (FOM), and humification.

2. Materials and methods

Pig slurry digestate (PSD) was obtained from a centralized treatment plant of pig slurries located in Catalonia using thermophilic anaerobic digestion. The solid phase of this digestate was separated by centrifugation and used in the elaboration of the composting piles without any additional preparation procedure. To carry out our objectives, five mixtures were composted in 350 L thermo-composters by the turning composting system. These mixtures (P1, P2, P3, P4 and P5) were established mixing in all of them the solid phase of PSD with WS (P1 and P2), with EGM (P3), with VP (P4) and with PP (P5). In all the scenarios, 70-75% of PSD was used, in terms of dry matter content. In addition, P2 was watered with the liquid phase of the anaerobic digestate of pig slurry (LPS); 0.22 L LPS per kg was added on the first day and the remaining volume, up to 0.45 L kg\(^{-1}\) was added gradually up to 27 days of composting, while the rest of piles were watered with water, maintaining a moisture content higher than 40%. When the bio-oxidative phase of composting was considered finished, composts were left to mature for a month, approximately. Selected physical properties were determined in the composts elaborated according to the methods described by Bustamante et al. (2008). Electrical conductivity (EC) and pH were measured in a water-soluble extract or suspension (1:5, v/v), respectively. The characteristics of the composts related to maturity were determined according to the methods used by Bustamante et al. (2008). The suppressive direct effect of composts on FOM growth was determined according Szczech (1999) by measuring the presence of an inhibitory zone around the compost samples. A PDA plate with FOM was used as fungal growth control.

3. Results and discussion

3.1. Composting process and end-products

In general, thermophilic temperature was reached in the first week of the composting process, showing piles P1, P2, P4 and P5 the highest temperature values. All piles reached 50ºC except P3, which did not reach thermophilic conditions throughout all the experiment. Each pile was turned between once (piles 4 & 5) and twice (piles 1 to 3). These piles did not reach the temperature requirement established by the Working Document on Biological Treatment of Biowaste (2nd Draft), mainly due to the composting scale used, only showing piles P1 and P4 the most exothermic behavior with ceiling temperatures closer or higher than 60ºC. However, sanitization standards were achieved in almost all the composting piles (except pile 4).

3.2. Physical and physico-chemical properties of the composts

All composts showed pH values close to neutrality and slightly higher than the range established for an ideal substrate (Abad et al., 2001) (Table 1). On the other hand, the electrical conductivity values were also higher than the reference level (<0.5 dS/m) established as optimum in a substrate and showed a strong dependence on the co-composting agent used in the mixture. In general, these composts displayed suitable values for the physical properties, especially for bulk density, total pore space and shrinkage. Composts P1 and P2 showed the highest values of the total pore space (TPS) and the lowest shrinkage, probably due to the co-composting agent used (wheat straw). On the other hand, the air capacity values were high in all composts, which produced a decrease in the total water holding capacity (Bustamante et al., 2008). In addition, all composts displayed a good degree of maturity, showed in the adequate values for the maturity parameters studied (CEC and
CEC/TOC ratio), according to the values suggested by Harada e Inoko (1980) and Iglesias-Jiménez and Pérez-García (1992).

3.3. Organic matter evolution and humification issues
Quality issues vs. humification could be studied using instrumental tools such as fluorescence, thermogravimetry and NMR. Fluorescence excitation–emission matrix spectroscopy provides more detailed information about the fluorescence properties of dissolved organic matter (DOM). With this technique, a three-dimensional picture is generated of fluorescence intensity as a function of excitation and emission wavelength. This technique has been applied to the study of DOM from different sources. Fluorescence regional integration (FRI), a new analytical approach (Chen, 2003) has been used as a tool to analyse quantitatively EEM spectra. EEM spectra were divided in five excitation–emission regions and the quantitative analysis included the integration of the volume beneath each region, associated to humic acids, fulvic acids, microbial by-products, etc. (Figure 1a). In our experiment, P1 had the highest humic acid increment compared to the initial mixture, associated to component 1 and especially component 3 (Figure 1b).

3.3. Suppressiveness against phytopathogens
The suppressiveness of several composts from different origin toward soil-borne fungal plant diseases has been described in numerous papers and should be a key criterion for selection between compost of commercial production. In this experiment, FOM inhibition appeared in all the composts only in non-sterile conditions (Figure 2). Hoitink and Fahy (1986) reported that, in most cases, this capacity has been eliminated after heating.

4. Conclusions
Composting of the solid phase of digestate (PSD) from pig slurries could be a feasible option to obtain an ingredient for substrates in soilless crop. In our experiment, the composts proposed using wastes from the agricultural activity (wheat straw (WS), vine shoot pruning (VP) and pepper plant pruning (PP)) and from the agro-food sector (exhausted grape marc (EGM) as co-composting agents showed suppressive effect against FOM and the composts using wheat straw were the most humified according to fluorescence analysis.

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5. References


TABLE 1. Physical and physico-chemical properties of the digestate derived-composts

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Ideal substrate</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
<th>P5</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>5.3-6.5</td>
<td>6.83</td>
<td>6.77</td>
<td>6.83</td>
<td>6.84</td>
<td>6.71</td>
</tr>
<tr>
<td>EC (dS/m)</td>
<td>≤0.5</td>
<td>4.62</td>
<td>4.64</td>
<td>6.76</td>
<td>4.48</td>
<td>6.33</td>
</tr>
<tr>
<td>RD (g/cm³)</td>
<td>--</td>
<td>1.669</td>
<td>1.656</td>
<td>1.705</td>
<td>1.699</td>
<td>1.775</td>
</tr>
<tr>
<td>CBD (g/cm³)</td>
<td>--</td>
<td>0.129</td>
<td>0.119</td>
<td>0.462</td>
<td>0.340</td>
<td>0.364</td>
</tr>
<tr>
<td>BD (g/cm³)</td>
<td>≤0.4</td>
<td>0.05</td>
<td>0.04</td>
<td>0.29</td>
<td>0.19</td>
<td>0.41</td>
</tr>
<tr>
<td>TPS (% vol)</td>
<td>&gt;85</td>
<td>95.9</td>
<td>97.6</td>
<td>83.0</td>
<td>88.9</td>
<td>76.7</td>
</tr>
<tr>
<td>Air capacity (% vol)</td>
<td>20–30</td>
<td>71.3</td>
<td>67.8</td>
<td>72.8</td>
<td>77.6</td>
<td>70.0</td>
</tr>
<tr>
<td>Shrinkage (% vol)</td>
<td>&lt;30</td>
<td>3.3</td>
<td>5.0</td>
<td>15.0</td>
<td>12.1</td>
<td>9.7</td>
</tr>
<tr>
<td>TWHC (mL/L)</td>
<td>550–800</td>
<td>157</td>
<td>119</td>
<td>290</td>
<td>213</td>
<td>278</td>
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<tr>
<td>CEC (meq/100 g MO)</td>
<td>&gt; 60²</td>
<td>131</td>
<td>132</td>
<td>176</td>
<td>171</td>
<td>182</td>
</tr>
<tr>
<td>CEC/TOC (meq/g Cot)</td>
<td>&gt; 1.9³</td>
<td>2.67</td>
<td>2.64</td>
<td>3.59</td>
<td>3.36</td>
<td>3.48</td>
</tr>
</tbody>
</table>

1According to Abad et al. (2001), ²Harada and Inoko (1980), ³Iglesias-Jiménez and Pérez-García (1992)

EC: electrical conductivity; RD: real density; CBD: compacted bulk density; BD: bulk density; TPS: total pore space; TWHC: total water holding capacity; CEC: cation exchange capacity; TOC: total organic carbon.

Figure 1. Fluorescence analysis of dissolved organic matter from composites.

Figure 2. Direct inhibition of composites on *Fusarium oxysporum* f.sp. *melonis* (FOM) growth in sterile and non-sterile conditions.