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Evolution of the pathogen content during co-composting of winery and distillery wastes

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Abstract

The aim of this study was to monitor some microbial indicators and pathogen contents (sulphite reducers clostridia, total enterobacteriaceae, total coliforms, faecal coliforms (*Escherichia coli*), enterococci, *Staphylococcus aureus* and *Salmonella* spp.) throughout the co-composting of wastes from the winery and distillery industry with other organic residues, as well as the effect of the composting system used. Seven different piles using mixtures of winery–distillery wastes with other organic materials were prepared. P1 and P2 were made using grape stalk (GS), grape marc (GM), exhausted grape marc (EGM) and sewage sludge (SS), whereas in P3 and P4 were also used exhausted grape marc with cow manure (CW) and poultry manure (PM), respectively, using the Rutgers system. Additionally, P2 was watered with vinasse (V). The rest of piles (P5, P6 and P7) were prepared with grape marc, exhausted grape marc, cow manure and poultry manure, using the turning system. The effectiveness of the composting process to reduce the pathogen content was higher in the static aerated piles than in those elaborated with the turning. The relatively high temperatures (50–60 °C) reached in some of the piles produced a notable decrease in some microbial groups, such as total and faecal coliforms (*E. coli*), but the characteristics of the raw materials used notably influenced the pathogen contents of the end-product.

Keywords: Winery wastes; Distillery wastes; Compost; Pathogens

1. Introduction

The wine production of the Mediterranean countries represents about 65% of the entire worldwide production, being Spain, together with France and Italy, the greatest producers (Food and Agriculture Organisation, 2004). As a consequence of this powerful wine-producing activity, several wastes of great contaminating potential, mainly on account of their seasonal character (the peak production being during August–October) and some polluting properties, are generated. Grape stalk, grape marc and wine lee are the main solid wastes obtained during wine-making, while exhausted grape marc is the final solid waste from alcohol distilleries. On the other hand, winery wastewater and vinasse are the effluents produced in the different steps of wine production and after the distillation process, respectively.

In general, the winery and distillery solid wastes are characterised by an acidic pH, high organic matter, polyphenol and potassium contents, as well as significant levels of nitrogen, and phosphorus, being the last ones important factors in soil fertility. Winery wastewater and vinasse also show an acidic pH, a high organic load and notable polyphenol content, as well as significant heavy metal contents, especially in Pb (Bustamante et al., 2005).

Research studies on an agricultural use of the winery and distillery wastes are, nowadays, extremely limited and have

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been carried out using, especially, vinasse and grape marc. The direct incorporation of grape marc without any pre-treatment into agricultural soils, a common practice, may cause an adverse effect derived from the release of several degradation products which can inhibit root growth (Inbar et al., 1991). On the other hand, the production of urban wastes, such as sewage sludge, as well as that of residues with an animal origin (cattle manure, pig slurries, poultry manure, etc.) is also increasing, with the associated problems that imply their management. Among different strategies suggested for using and valuating these wastes, composting is one of the most promising since it allows taking advantage of the nutritional and energy properties of these residues without causing environmental damage. Composting is defined as the aerobic biological decomposition and stabilisation of organic substrates, under conditions that allow development of thermophilic temperatures as a result of biologically produced heat. The co-composting of winery and distillery wastes with other organic residues has been studied by different authors. Ferrer et al. (2001) studied the co-composting process of grape waste and hen droppings and the effect of the application of the compost obtained as soil conditioner for corn seed germination in greenhouse, and Bertrán et al. (2004) reported the evolution of different parameters throughout the composting process of mixtures elaborated with grape stalk and sewage sludge in different proportions. The final product, compost, is a stable material which provides valuable benefits for plant growing by increasing soil fertility (Golueke, 1982; Haug, 1993). However, depending on the characteristics of the raw material and the management of the process, composts may also contain substances harmful to the environment such as pathogens, bioaerosols, heavy metals and toxic organics (Déportes et al., 1995). Moreover, a composting process not properly managed can induce the proliferation and dispersion of potentially pathogenic and/or allergenic thermotolerant/thermophilic fungi and bacteria, such as *Salmonella*, *Shigella*, *Escherichia coli*, *Enterobacter*, *Yersinia*, *Streptococci* and *Klebsiella*, among the bacteria, and *Aspergillus fumigatus*, among the fungi, which can emerge and cause infections for compost handlers and agricultural users (Hassen et al., 2001). It is necessary, therefore, to guarantee the sanitary safety of any compost previously to its application. Traditional indicator organisms, such as faecal coliforms, faecal *streptococci* and *E. coli*, are generally monitored to ensure compost quality (Sidhu et al., 1999). On the other hand, the composting system used can also influence the efficiency of the process and, thus, the quality of the end-product obtained. The turning system in windrows (conventional composting method) is often labor intensive, creates air pollution (e.g. dust) and requires additional space for the pile, though allows a better homogenization of the mixture. In contrast, forced-aerated composting is a more efficient composting method, which ensures temperature in the upper thermophilic range and its control, ensures adequate aeration and saves space compared to the turning system (Tiquia and Tam, 1998).

This paper is focused on the study of the sanitation capacity of two different composting systems, Rutgers and turning, in relation to different human pathogens and microbial groups used as contamination indicators, such as sulphite reducers clostridia, *E. coli*, *Staphylococcus aureus* and *Salmonella* spp. and total enterobacteriaceae and total coliforms, respectively.

2. Methods

2.1. Composting procedure

Seven different piles were prepared using in all of them wastes from the winery and distillery industry. The Rutgers static pile composting system was used in four piles and the turning system was used in the rest.

2.1.1. Piles using Rutgers system

Four different piles (P1, P2, P3 and P4) were prepared with mixtures of grape stalk (GS), grape marc (GM), exhausted grape marc (EGM), sewage sludge (SS), cow manure (CM) and poultry manure (PM) (Table 1). Fresh collected vinasse (V) was used in P2 for watering. SS came from a treatment plant of municipal wastewater placed in Torrevieja (Alicante). CM was collected from a cattle farm placed in Santomera (Murcia) with a productivity of 35.000 heads per year. PM was collected from a poultry farm with 30.000–40.000 laying hens located in Orihuela (Alicante). GS and GM used were collected from a winery placed in Jumilla (Murcia) and EGM and V from an alcohol distillery placed in Villarrobledo (Albacete). The analyses of the raw materials are shown in Table 2.

The mixtures (about 1800 kg each) were composted in a pilot plant, in trapezoidal piles (1.5 m high with a 2×3 m base), supplied with forced aeration conducted through three basal PVC tubes (3 m length and 12 cm diameter). Aeration system imposed was 30 s every 30 min, with 55 °C as ceiling temperature for continuous ventilation. Turning treatments for improving both homogeneity and fermentation process were applied when necessary (Table 1).

2.1.2. Piles using turning system

Three different piles (P5, P6 and P7) were prepared with winery and distillery wastes: GM and EGM. To these wastes were added two organic wastes rich in nitrogen: CM and PM. GM was collected from an alcohol distillery placed in Villarrobledo (Albacete), whereas the origin for the rest of organic wastes was the same as that of the wastes used in the piles using Rutgers system.

The mixtures (about 140 kg each) were composted in domestic thermo-composter (85 cm high with a 70×70 cm base and a 350 L volume). Turning times are detailed in Table 1.

In all the cases, both static and turned piles, the bio-oxidative phase of composting was considered finished when the temperature of the pile was stable and near to that of