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Recovery of organic wastes in the Spanish wine industry. Technical, economic and environmental analyses of the composting process

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ABSTRACT

The main organic wastes produced in modern wine industries include grape pomace (62%), lees (14%), stalk (12%) and dewatered sludge (12%). Some of these wastes are being used as by-products (grape pomace and lees) whereas the rest of organic wastes (stalk and wastewater sludge) has been traditionally incinerated or disposed in landfill. In this work, composting is proposed for the recovery of stalk and wastewater sludge to produce a sanitized organic amendment for application in the vineyard, closing the organic matter cycle. The environmental and economical analyses of the different alternatives to manage organic wastes from the wine industry are also presented. Composting costs are almost negligible when compared to other management options. From the environmental point of view, in-situ composting presents the best performance in 8 of the 10 impact categories analysed. Finally, the energy balance shows that the 4 composting systems involved less energy than the systems based on Mineral Fertilizer consumption.

1. Introduction

The wine industry is an important sector in the economy of some countries, especially those from the Mediterranean area. Spain has one of the largest vineyards in the world, with a wine production of 44 million hectolitres, of a total production in the European Union of 150 million hectolitres [1,2]. Wine production has been traditionally seen as an environmentally friendly process. However, it requires a considerable amount of resources such as water, fertilizers and organic amendments, and on the other hand produces a large amount of wastewater and organic wastes. Innovative solutions must be proposed and tested to develop a real sustainable industry [3].

Therefore, the objectives of this work are (i) to revise briefly the most significant impacts derived from the large-scale wine production and its waste generation and to characterize the present strategies for the organic wastes management, (ii) to carry out field composting experiments to determine crucial aspects for compost quality such as its stability and the fulfilment of the sanitation requirements in order to obtain a valuable product that can be used as a raw material for vineyard fertilization and (iii) to study in detail composting from a technical, economic and environmental point of view as an innovative technology to recycle stalk and wastewater sludge (organic wastes that at present are being incinerated or disposed in landfill) into a final product that can be applied to the vineyard cultivation as a complement and partial substitute for chemical fertilizers and organic amendments.

2. The environmental impacts associated with the wine industry

Environmental analysis of the wine industry shows that the main effluents of the sector are wastewater and organic solid wastes. To fulfil the increasing legislation requirements, wastewater problems have been solved by the construction of wastewater treatment plants for one single industry or a group of cellars in developed countries. These facilities had a positive effect on minimizing the environmental impact on the aquatic ecosystems. However, the production of sludge from these treatment plants has been increasing over the last years.

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In recent years, wine industry has invested not only in wastewater treatment but also in water saving and wine by-products and sludge valorisation. Problems associated with waste generation in the wine industry are of special relevance during the grape harvest, a very short period of time between September and October in the Mediterranean area.

It has been estimated that the Spanish wine industry generates between 2 and 3 million tons per year of wastes or by-products, mainly produced during the vintage period [1,2]. Most of the wastes generated in a cellar (80–85%) are organic wastes. In Fig. 1, an approximate distribution of the wastes generated in the wine industry is presented. Grape pomace is produced during grape press and is constituted by peels and seeds. The rest of wastes are lees, which are generated in the clarification of wine fermentation process; stalk, constituted by branches and leaves of the grapevine, and wastewater sludge from wastewater treatment.

Some of these wastes have been traditionally recovered by using them as raw materials in other industrial sectors [4,5]. Other materials, however, are not valorised due to their low economical value, such as stalk and wastewater sludge. The current management of these wastes is carried out via external companies. However, this is an expensive and difficult alternative for the wine industry, with high transport costs (low bulk density of stalk, transport required in short time, etc.), high disposal costs (incineration, landfill) and high environmental and social impacts. Additionally, international legislation on sludge application to soil is becoming more exigent and the direct application will be prohibited in the next future [6]. In these legislation drafts, treatment of sludge (by composting or anaerobic digestion) is required for sludge application to ensure a sanitized product.

3. Composting as a sustainable management of organic wine wastes

3.1. The role of composting in the organic matter recycling

Annually, the wine industry is using big amounts of chemical fertilizers and organic matter [4,5]. In this sense, the possibility of recovering organic wastes from the wine industry to vineyards may be presented as a sustainable strategy for the waste management.

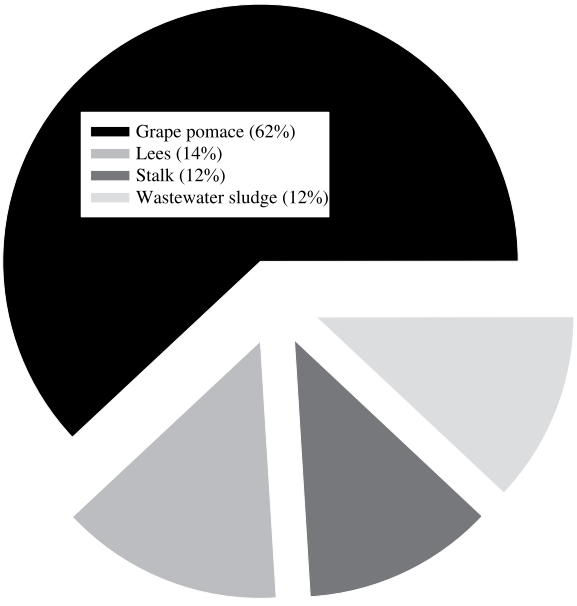

Fig. 1. Approximate distribution of the organic wastes produced in the wine industry.

However, according to the new legislation initiatives the sanitation of sludge before its application to land will be mandatory [6]. This fact, jointly with the prevention of possible diseases in the vineyard crops, presents composting as the most suitable process to reuse the organic wastes of the wine industry in the vineyard crops.

Composting is a natural aerobic process of organic matter biodegradation from fresh materials to stable and mature organic matter, similar to humus. Composting can be technically and economically viable for most of the wine industry companies to convert organic matter residuals to an organic amendment for vineyard growth, avoiding the risk of pathogen infections because of the thermophilic temperature reached in a composting process. Additionally, compost has been reported as a suppressor agent for different crop diseases [7]. Some of the main potential advantages for the wine industry related to composting its own organic wastes and recycling the organic matter in the vineyard crops are summarized in Table 1.

Nowadays it is not a common practice for a wine industry in the Mediterranean area to compost its own organic wastes. Usually, this process is undertaken by companies dedicated exclusively to solid waste treatment or the wastes are directly disposed in landfill or incinerated. A part of the compost resulting from this external treatment is then bought by wine industries to be used as a fertilizer or organic amendment. Moreover, there is a lack of knowledge in wine industries on the composting process from a technical point of view. Most papers related to composting wine industry wastes are focused on co-composting these materials with wastes from other origins usually carried out at laboratory or pilot scale [8]. Recent works at industrial scale in this field can be very useful for the development of a new culture in the waste management strategies of the wine industry [9,10].

3.2. Co-composting wastewater sludge and stalk

In a previous work at full-scale [10], we demonstrated that composting of stalk and wastewater sludge was possible using the windrow composting system with a volumetric ratio of 2:1 (stalk:wastewater sludge). The compost produced presented high organic matter content and high level of stability (respiration index lower than 1 mg O_2 g organic matter^{-1} h^{-1}). Sanitation was also achieved after a long thermophilic period. These properties make compost a suitable organic fertilizer for vineyard. However, the

Table 1
Potential advantages of in-situ composting for the wine industry.

Type	Advantages
Environmental advantages	-Avoid the environmental impacts associated with waste transport. -Self-management of organic wastes. -Minimization of wastes. -Close the organic matter cycle. -Minimization of fertilizer requirements.
Agronomic advantages	-Self-production and control of the organic fertilizers used in vineyard crops. -Easy transport and application to soil. -Effect of suppression of plant diseases. -General improvement of the soil.
Economical advantages	-No cost of transport and final disposal of stalk and wastewater sludge. -Total or partial reduction in the cost of organic fertilizers. -Possibility of obtaining public financial help. -General improvement of the company image and perception from society.