GUIDELINES FOR THE MANAGEMENT OF WINERY WASTEWATERS

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1 INTRODUCTION

Winery Wastewaters (WW) are characterised by their high biological oxygen demand, organic contents and electrical conductivity, being regarded as one of the major environmental issues generated by wine production. Each winery is unique in WW generation (highly variable, 0,5-14 L per litre of wine) and disposal. Thus plans for environmentally friendly management of waste are not universal and should be tested for their effectiveness.

In Portugal, many wineries discharge directly their WW into the surface water bodies, sewage or irrigation, without planning. With careful planning and management, the use of WW in agriculture can be beneficial to the environment, contributing to recycle nutrients and saving water.

The sustainable development of landscape, and agricultural irrigation with WW, should be done using guidelines, which are an important step in the planning and implementation of safe use of WW for irrigation.

These guidelines are established in some wine-producing countries with high environmental concern, especially Australia and South Africa. However, it is important to know the quantitative and qualitative characteristics of the winery WW, the potential phytotoxicity associated with this type of WW and the edapho-climatic conditions of the vitiviniculture region, in order to create / adapt guidelines that are in compliance with Portuguese legal requirements.

The winery wastewaters (WW) are seasonally produced and its treatment and disposal represents a main problem to the winery sector, as a result of the amount and composition of the wastewater produced over the year. WW is generated mainly as the result of washing equipment and bottles and purges from the cooling process. As a consequence of the working period and the winemaking technologies, volumes and pollution loads greatly vary over the year (Duarte *et al*., 2004; Eusébio *et al*., 2005). Further, as each winery is unique in wastewater generation (highly variable, 0,5 to 14 L per litre of wine) and disposal, plans for environmentally friendly management of waste are not universal and should be tested for its effectiveness. In Portugal, many wineries discharge their wastewater directly into surface water bodies, only 17% of the wineries have environmental licence, 5% dispose a pre-treated wastewater for the municipal wastewater treatment and 7% dispose the treated wastewater into water body (MAOTDR, 2007).

In order to achieve the best available technology for wastewater treatment is also important to be acquainted with the wastewater final disposal. In Portugal, the sector with the highest water consumption is the agricultural sector (87%), followed by urban sector (8%) and finally the industrial sector (5%) (MAOTDR, 2001). The search for new water sources is based on different driving forces, in particular, the population growing and the increasing interest in treated wastewater as a source of supplemental irrigation (Ryder *et al*., 2004). In water scarce regions, there is a benefit when the treated wastewater is used as an economic additional water supply, in agriculture (WHO, 2006), which occurs in southern Portugal. Therefore, a number of concerns had to be taken into account and the knowledge of the treated wastewater composition is critical for safe use (Bustamante *et al*. 2004). Another important issue is the appropriate price for wastewater. According to Mekala *et al*. (2008) a very low price for wastewater may encourage inefficient use and may lead to the perception that it is a cheap and unlimited resource. This problem should be considered in Portugal, since the efficiency of water use in the agriculture sector is already very low (57%) (MAOTDR, 2001). However, with regard to the wine sector, the vineyards are usually in the surroundings of the cellar, so the cost of the winery wastewater treatment is charged to the producer.

The experience gained over several years in research projects, where different wineries were monitored, contributed to the improvement of technical and scientific knowledge in this area.

In this study, a diagnostic was made in several wineries, throughout the country, which were characterized in terms of type of wine produced; tonnes of grapes processed; water consumption, WW quality and

quantity, etc. In order to evaluate the organic load, the WW were collected and characterized, in the different stages of the process (harvest, racking, bottling). In some wineries, the monitoring of treated WW was also carried out. Preliminary tests of *Lepidium sativum* germination were carried out to study the phytotoxicity of these WW. The results show that the main problems related to the production of WW are the variability of flow and organic load during the year, peaks in pH, discharges of chlorinated compounds, among others. Moreover, the treated WW showed physico-chemical and microbiological quality for potential use in irrigation, evidenced by low phytotoxicity.

The purpose of this paper is to present recommendations for the management of winery WW, and its final disposal. These recommendations are intended to assist in developing a strategic plan for waste management that will facilitate compliance with environmental regulations.

2 METHODOLOGY

2.1 Setting up regulations

The World Health Organization published guidelines for the safe use of wastewater in agriculture (WHO, 2006). These guidelines are very broad and do not address directly the concerns of the wine industry, because many of the parameters considered do not apply to this type of wastewater (e.g. heavy metals, pathogens, organic load). In addition, most published guidelines, at European level, for the reuse of wastewater in irrigation include mainly microbiological parameters, since it deals with the reuse of domestic wastewater (Brissaud, 2009). The microbiological parameters are very important from the standpoint of public health, but only make sense in treatment systems that receive domestic sewage. In wineries that intended to reuse the treated wastewater for irrigation, domestic wastewater should be treated separately or discharged in the sewage. Moreover, chemical analysis could be insufficient to provide the potential ecological risk, since they do not allow an evaluation of possible combined effects of the different contaminants mixed together, as well as their bioavailability. Bioassays, which can mitigate these constraints, are, therefore, recommended for the assessment of ecological risks in soils or other matrices to be used as organic amendments (van Gestel *et al*., 2001; Fjällborg *et al*., 2005).

Since 1996, Marecos do Monte mentioned the need to establish European guidelines for the reuse of wastewater. In Portugal, the legislation (DL nº 236/98, Annex XVI) provides water quality for irrigation, based on some parameters as: salt content, suspended solids, nitrogen, chlorides and sulfates, pH and two microbiological parameters (faecal coliforms and eggs of intestinal parasites). As this legislation is not specific for reuse of treated wastewater, the indicator parameters of organic matter, such as COD or BOD, are not covered. In order to regulate the use of treated wastewater in irrigation, a Portuguese Standard was published in 2005 (NP 4434). However, this Portuguese Standard refers, only, the reuse of domestic wastewater, stipulating four classes of water quality, based on microbiological parameters. In this sense, the wastewaters, without faecal microrganisms, but containing other contaminants are not properly regulated.

Some countries with high environmental concerns have published guidelines for the management of waste and wastewater at winery. Among them is South Africa and Australia.

2.2 Diagnosis

The characterization of the wine sector is the first step in establishing guidelines for the management of wineries wastewater. In order to respond to most of the Portuguese wineries, it was necessary to make a comprehensive assessment of wineries of different sizes and characteristics, and site location in different country regions.

A proper diagnosis should conduct a survey report that includes all the information required for decision-makers. Regarding the production process, it should address all activities associated with it: vintage, racking and bottling. Knowledge of materials and supplies, as well as by-products generated during the process is essential in diagnosis. The uses of water consumption are critical, both in terms of quantity or quality. The survey of sewers in the property, particularly if the drainage system is separated or combined, and the points of wastewater discharge should also be covered. The wastewater flows should be evaluated through the installation of meters. The different streams of wastewater generated must be quantified in order to make an assessment, as rigorous as possible. The physicochemical characterization of the wastewater is essential for the proper sizing of any treatment system. This assessment is carried out by determining specific parameters such as pH, electrical conductivity, dissolved oxygen, chemical oxygen demand, biochemical oxygen demand, total phosphorus, total solids (Oliveira *et al*., 2009). In order to evaluate the fate of treated wastewater, we should know what are the surroundings of the winery, in particular, the existence of a sewage, the area associated with irrigation, the type of structures and areas available,

among others. In wineries that intend to reuse the treated wastewater for irrigation, domestic wastewater should be treated separately or discharged in the sewage. This decision is extremely important, since the wastewater from cleaning operations does not contain pathogenic microorganisms. Thus, this separation reduces the costs of wastewater treatment and monitoring, which are associated with the disinfection process.

3 RESULTS AND DISCUSSION

3.1 Guidelines for cleaner production

Over the last few years, our working group has pro-actively researched and addressed the most important environmental problems at wineries. This research resulted in guidelines (Table 1), to assist in developing a strategic plan for waste management that will facilitate compliance with environmental regulations.

A detailed analysis of the wine production process allows the consolidation of the monitoring data and to understand the origins and characteristics of residues. Wineries even using similar production processes differ in size, in procedures and in management strategies. The characteristics of a wastewater also depends on the operation and period, normally, the wastewater with high concentrations of pollutants are originated during the harvest and 1st racking. However, if solids from the second racking are not removed, the degree of contamination will be also very high, reaching values of COD more than 50 000 mgL^{-1}.

TABLE 1 **Guidelines to reduce water usage and water pollution**

Driving force	Effect
Separation collector	The incorporation of rainwater in the treatment system requires the existence of oversized reactors.
Reuse of treated wastewater	The treated wastewater should be used for beneficial crop irrigation
Water meter	The installation of water meters enables the control of water consumption. Where possible, the wastewater outflow should be also monitored.
Re-use wash water	Wash water, which contains KOH, can be re-used until the point is reached where it ceases to be effective as a bitartrate dissolving agent. This water should be recycled to recover tartaric acid.
Reduce the COD of the wastewater	This can be achieved by screening out solids larger than 0,5-1,0 mm with basket screens. The shorter the period that the solids remain in contact with the wastewater, the lower the COD of the wastewater will be. Replace the use of citric acid by phosphoric acid.
Eliminate the use of salts	This strategy may be sufficient to reduce EC to within legal limits for beneficial crop irrigation. Replacing disinfectants and cleaning agents with ozone, will reduce both the EC and the COD of wastewater.
Sewage water should not be combined with winery wastewater, if the objective is the reuse of treated wastewater for irrigation. This will ensure contamination by bacteria, viruses and parasites, requiring a disinfection step.	

Although in Portugal there is no legislation concerning the maximum of BOD_5 allowed for wastewater irrigation, this parameter is very important to prevent changes in soil properties (EPA, 2004). According to the World Health Organization (WHO) recommendations for wastewater reuse, the amount of organic matter to be applied in irrigation should not exceed 500 mgL^{-1}, expressed as BOD_5. The document also states that the application of an urban wastewater containing a BOD_5 between 110-400 mg L^{-1}, may be beneficial for culture (WHO, 2006).

As chemical analysis could be insufficient to provide the potential ecological risk, seed germination bioassays should be carried out, by using cress seeds as indicator, in order to evaluate the adequacy of the treated wastewater for crop irrigation. The cress bioassay is a standard procedure to evaluate the behaviour of crops to water contaminants. Results obtained in previous trials evidence the suitability of treated wastewater in relation to crop irrigation, thus minimizing water consumption (Oliveira *et al.*, 2009). While the quantity of wastewater available will account for only a small fraction of the total irrigation water requirements, these wastewaters could be used as additional water supply.

4 CONCLUSIONS

Wineries should develop procedures to sample and monitor influent water, wastewater, soil and other receiving environments. The monitoring plan must be reviewed regularly, to allow for changes in production methods and scale. As monitoring is an expensive and resource-intensive process, wineries must effectively use the data obtained for improvement of their process and environmental management practices.

These proposed recommendations are intended to assist in developing a strategic plan for waste management that will facilitate compliance with environmental regulations. Regulations based on good sense, which are enforced with fairness, should be good for the environment and for the business enterprises to which they are applied.

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