Phenolic removal processes in biological sand filters, sand columns and microcosms

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At low influent concentrations, phenolics in winery wastewater and model synthetic wastewater were completely removed by a combination of biotic and abiotic influences in biological sand filters. High influent concentrations of model phenolics resulted in accumulation of metabolites in biological sand filters. Increased hydraulic conductivity strongly suggested a concomitant loss of biomass/biofilm due to accumulation of toxic concentrations of catechol. Acclimation of microbial populations to vanillin and gallic acid resulted in enhanced biodegradation of these phenolics when compared to a non-acclimated population.

This study evaluated the removal processes involved in the removal of the phenolic component of winery wastewater in biological sand filters, sand columns and sand microcosms. It was found that at low influent phenolic concentrations, complete organic removal was accomplished, but at high concentrations, there was incomplete substrate removal and an accumulation of potentially toxic metabolites, including catechol. The sand provided a suitable substrate for the treatment of phenolic-laden waste, and both biotic (48%) and abiotic (52%) removal mechanisms effected the removal of model phenolics. Prior acclimation of microbial communities increased the biodegradation rate of phenolic acids significantly.

1. Introduction

The winemaking process generates copious amounts of cellar effluent: it has been estimated that South Africa produces one billion liters and Australia 5–9 billion liters of winery wastewater per annum (Mosse et al., 2011; Sheridan et al., 2011). Winery effluent requires treatment before discharge, but remediation is complicated by the fact that the composition and volume fluctuates on a seasonal basis, depending on cellar activities (Arienzo et al., 2009; Malandra et al., 2003; Mosse et al., 2011). Typical chemical oxygen demand (COD) values of 800 to 12 800 mg/L are found during the vinification period, resulting from the presence of high concentrations of organic molecules with variable degradation rates (Malandra et al., 2003). Simple sugars, organic acids and alcohols commonly found in winery wastewater are readily biodegradable, while the phenolic component is characteristically slowly biodegradable (Serrano et al., 2010).

Plant phenolics may be toxic to microbes. It has been demonstrated that tannins, which are abundant in red wines, can inhibit microbial activity by precipitation of key metabolic proteins (Arienzo et al., 2009). The levels of phenolic compounds in winery wastewater, particularly in the effluent emanating from the production of red wine, are likely to inhibit microbial activity in soils, affecting soil and plant health (Mosse et al., 2011). It has been shown that the phenolic component of winery wastewater can adversely affect the growth of a variety of aquatic and non-aquatic plants, including cash crops (Arienzo et al., 2009).

Small to medium-sized wineries in rural areas are often not connected to municipal reticulation systems for the treatment of winery effluent and cannot afford to operate sophisticated