Dynamics of a microbial biofilm in a rotating biological contactor for the treatment of winery effluent

G Coetzee, L Malandra, GM Wolfaardt and M Viljoen-Bloom*
Department of Microbiology, Stellenbosch University, Private Bag X1, Matieland 7602, South Africa

Abstract

Wastewater from wine-related industries is characterised by high variability in COD and pH. Disposal of these effluents with little or no treatment could lead to heavy financial penalties or pollution of soil and water resources. A pilot-scale rotating biological contactor (RBC) was evaluated for the treatment of winery effluent, with specific focus on the biofilms that formed on the RBC discs. On average, the RBC reduced the influent COD of the winery effluent by 23% (from 3 828 mg/ℓ to 2 910 mg/ℓ) and increased the pH by 0.95 units (from 5.77 to 6.13) at an average retention time of 1h. Similar results were obtained during evaluations at a wine-bottling plant where thick active biofilms, containing mostly yeasts, formed on the discs and proved stable and resilient to various physical and chemical shocks.

Keywords: microbial biofilm, rotating biological contactor, winery effluent

Introduction

Wineries, distilleries and other wine-related industries produce large volumes of wastewater, characterised by variable volumes due to the seasonal nature of production, high in organic load, low in pH and having high carbon-to-nitrogen ratios. These types of wastewater may result in the pollution of soil, ground- and surface water (Radford, 2002) if the wastewater is disposed of without treatment. Regulatory bodies therefore impose restrictions on the nature, amount and means of disposal of winery wastewater, e.g. wastewater should have a pH of between 5.5 and 7.5 and a chemical oxygen demand (COD) below 75 mg/ℓ (*National Water Act of South Africa*, 1998).

Due to the organic nature of winery wastewater, biodegradation is a viable option for the treatment thereof. A variety of systems for the treatment of biodegradable wastewater have been developed (Ramasamy and Abbasi, 2000; Caixeta et al., 2002; Petruccioli et al., 2002) and the rotating biological contactor (RBC) is one that compares relatively well with other methods for the treatment of winery wastewater. It is flexible enough to endure fluctuating organic loads, requires little personal attention, is cheap to run and does not require too much land. Its operation is based on discs on a rotating shaft that allows the discs to be partly submerged in the effluent and support the biofilm responsible for the degradation of the organic compounds in the effluent. The RBC has also been used in the treatment of effluents produced by various industries such as gold mining (Stott et al., 2001) and domestic sewage treatment (Costley and Wallis, 2001; Gupta and Gupta, 2001; Tawfik et al., 2002). Its efficiency depends heavily on parameters such as the hydraulic retention time (Yeh et al., 1997), disc rotational speed and disc submergence (Lu et al., 1997), and the composition of the discs (Apilánez et al., 1998).

* To whom all correspondence should be addressed.
☎+2721 808-5859; fax:+2721 808-5846; e-mail: mv4@sun.ac.za
Received 20 November 2003; accepted in revised form 26 April 2004.

Since biofilms play an important role in the efficient treatment of effluent in biological reactors, knowledge of the adhesion, development and dynamics of biofilms is important. Previous work on a laboratory-scale RBC showed that the biofilm that formed during the treatment of winery effluent consisted mainly of yeast and a few bacterial species (Malandra et al., 2003). The most dominant yeast isolates in the microbial biofilms were *Saccharomyces cerevisiae*, *Candida intermedia*, *Hanseniaspora uvarum* and *Pichia membranifaciens*. All these species are naturally associated with grapes and/or water, and with the exception of *H. uvarum*, they are able to form either simple or elaborate pseudohyphae (Malandra et al., 2003). Extensive research has been done on bacterial biofilms (O'Toole et al., 2000; Watnick and Kolter, 2000), but information on fungal biofilms is seriously lacking. The objective of this study was to evaluate the efficiency of a pilot-scale RBC on-site at a local winery for the treatment of wine-cellar effluent and to study the dynamics of the biofilm that developed on the RBC discs.

Materials and methods

Design and evaluation of the RBC

A small-scale RBC was tested on-site at a local winery during the 2002 harvest season (January to April). The RBC consisted of a 250 ℓ stainless steel trough with 52 polyurethane discs (r = 230 mm) on a rotating shaft (Fig. 1). The discs rotated at 6 r·min^{-1}with 40% of their surface submerged. Winery wastewater was pumped into the RBC after the excess stems, grape skins and seeds had been removed, and the RBC operated at an average hydraulic retention time of 1 h. Samples were taken at the inflow and outflow and the COD was determined spectrophotometrically based on Merck's chromo-sulphuric oxidation with the Thermoreaktor TR300 and Spectroquant Nova 60 (Merck, Darmstadt, Germany). The RBC was relocated in July 2002 to a bottling plant to be evaluated for its efficacy on wastewater generated during the bottling of wine products.