Submerged membrane bioreactor and reverse osmosis technology for tannery effluent recycling

Wolfram Scholz[1], Thierry Poncet[2], Marie-Laure Touloumet[2] , Sven Baumgarten[3],

[1] W_2O Environment Ltd, 58, Cecil Road, Queen's Park, Northampton, NN2 6PQ, UK, wolfram@w2oenvrionment.net

[2] GE Process & Water Technologies Canada, 3239 Dundas Street West, Oakville, ON L6M 4B2, Canada sven.baumgarten@ge.com

[3] CTC Environnement, 4, rue Hermann Frenkel – 69367 Lyon Cedex 07, France, tponcet@ctcenvironnement.com

Abstract

A limiting factor for the reuse and recycling of tannery wastewater treatment is the high salt content, which persists even after conventional treatment. Reverse osmosis (RO) membrane treatment has been shown to significantly reduce the salt contents of tannery effluents. However, the high organic content of tannery effluent leads to rapid scaling and biofouling of RO membranes with a consequent reduction in performance. Membrane bioreactors (MBR) have been shown to be highly effective in the removal of organic pollutants and suspended solids from tannery effluent and are suitable as a RO pre-treatment.

Membrane bioreactors MBRs combine an activated sludge process with membrane ultrafiltration to facilitate complete retention of the biomass. This combination results in high biomass concentrations leading to an increased removal of organic pollutants and suspended solids from tannery effluent. This research investigated the use of a combined MBR and Reverse Osmosis (RO) treatment process to treat tannery effluents to achieve discharge compliance and to enable consistent high quality water recycling.

MBR pilot plants equipped with submerged plate membranes and hollow fibre membranes were tested in two French tanneries. The MBR permeate was then polished with Reverse Osmosis membranes and re-used for leather processing. The trials showed excellent results without causing any detrimental effects on leather quality. This combination of MBR and Reverse Osmosis technology showed to be a technical and economical feasible option for effluent treatment and high quality water recycling. An average reduction of 98% COD and 99% BOD and SS and a stable membrane performance was achieved, which complies with European discharge consents for tannery effluents.

Introduction

Submerged or integrated membrane systems can be operated at significantly lower pressures and hence energy consumption. In this case membranes are submerged into the bioreactor and permeate is pumped under negative pressure of only 0.2-0.4 bars. Coarse bubble aeration is applied to achieve the necessary cross-flow and to avoid membrane fouling. The energy requirements of submerged membranes are significantly lower with 0.5 kWh per $1m^3$ of permeate produced.

Results

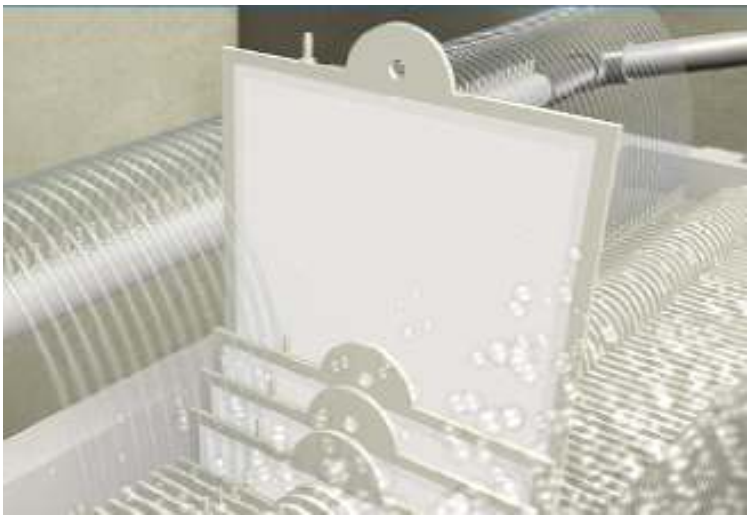
CTC is currently testing this novel submerged MBR application in the Tanneries de Annonay, France, for advanced biological effluent treatment (Photo 1). Primary treated mixed effluents are collected and filtered via a 1mm sieve and fed directly into the MBR for enhanced biological treatment. The MBR combines an activated sludge process with membrane filtration, which enables complete retention of micro-organisms and which achieves, due to the high microbial population densities high biodegradation rates.

Photo 1: Submerged Membrane Bioreactor:
Left to right: Process control unit, peristaltic pump, blower and bioreactor

The MBR consists of a 100- litre bioreactor, which is aerated with coarse bubble diffusers. A framed 1 m2 plate membrane rig (Photo 2) is submerged into the nitrification tank and permeate is drained via a suction pump. To start up the MBR process, the MBR plant was

inoculated with 100 litres activated sludge from a biological tannery wastewater treatment plant and the bioreactor was fed with 50 litres of effluent per day.

Photo 2: Submerged membranes; size A4, Courtesy photo from Copa UK



The first results showed an excellent performance of the MBR plant. A permeate flow of average 15 l/m^2/hr was achieved at maximum 0.35 bars differential pressure. The bioreactor showed to be very suitable to biodegrade the organic compounds of the effluent. In the course of the initial trials a COD and BOD reduction of up to 98 and 99 % was achieved (Table 1). The high biodegradation achieved compares well with previous reported results of submerged MBR treatment of beamhouse effluents [5]. In the future development of the research program a subsequent Reverse Osmosis treatment will be applied to enable recycling of high quality process water for the re-tanning and finishing processes.

Table 1: Membrane Bioreactor plant performance with average reduction of COD, BOD, Kjehldal nitrogen and chrome (October-December) achieved

Parameters (mg/l)	Feed	Permeate	(%)
COD (mg/l)	2,478	84	96.8
BOD	1,076	<3	99.7
Kjehldal - nitrogen	166.7	69.8	58.1
Chrome	1.1	0.36	67

Conclusions

The submerged membrane bioreactor technology has shown to be suitable for the biological treatment of mixed tannery effluents. The permeate concentrations in terms of COD, BOD and chrome achieved are below the discharge limits to surface waters. The excellent permeate quality can allow for direct recycling or if required for polishing with Nanofiltration or Reverse Osmosis. The obtained results have served as a basis to design an industrial scale

MBR for the tannery Simona Tanning Inc. in Huizhou City, China. The MBR and Reverse Osmosis plant has a treatment capacity of 2,400 m^3/day with up to 1,600 m^3/day RO water for recycling. The first results of leather processing with RO permeate gave a good and consistent leather quality.

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