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Halophilic biological treatment of tannery soak liquor in a sequencing batch reactor

O. Lefebvre[a,b,*], N. Vasudevan[b], M. Torrijos[a], K. Thanasekaran[b], R. Moletta[a]

[a]*Laboratory of Environmental Biotechnology, Institut National de la Recherche Agronomique (INRA), Avenue des Etangs, 11 100 Narbonne, France*

[b]*Centre for Environmental Studies, Anna University, Guindy, Chennai 600 025, India*

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Abstract

Hypersaline wastewater (i.e. wastewater containing more than $35\,g\,l^{-1}$ total dissolved solids (TDS)) is generated by various industrial activities. This wastewater, rich in both organic matter and TDS, is difficult to treat using conventional biological wastewater treatment processes. Among the industries generating hypersaline effluents, tanneries are prominent in India. In this study, tannery wastewater from soak pit was treated in a lab-scale SBR for the removal of organic matter. The characterisation of the soak liquor showed that this effluent is biodegradable, though not easily, and highly variable, depending on the origin and the nature of the hides. TDS was in the range of 21–57 $g\,l^{-1}$ and COD was in the range of 1.5–3.6 $g\,l^{-1}$. This soak liquor was biologically treated in an aerobic sequencing batch reactor seeded with halophilic bacteria, and the performance of the system was evaluated under different operating conditions with changes in hydraulic retention time, organic loading rate and salt concentration. The changes in salinity appeared to affect the removal of organic matter more than the changes in hydraulic retention time or organic loading rate. Despite the variations in the characteristics of the soak liquor, the reactor achieved proper removal of organic matter, once the acclimation of the microorganisms was achieved. Optimum removal efficiencies of 95%, 93%, 96% and 92% on COD, PO_4^{3-}, TKN and SS, respectively, could be reached with 5 days hydraulic retention time (HRT), an organic loading rate (OLR) of 0.6 kg COD $m^{-3}\,d^{-1}$ and 34 g NaCl l^{-1}. The organisms responsible for nitrogen removal appeared to be the most sensitive to the modifications of these parameters.

Keywords: Hypersaline effluent; Tannery effluent; Sequencing batch reactor (SBR); Wastewater treatment

Abbreviations: ALR, ammonia loading rate; BOD_5, biochemical oxygen demand (5 days); COD, chemical oxygen demand; HRT, hydraulic retention time; MLVSS, mixed liquor volatile suspended solids; OLR, organic loading rate; SBR, sequencing batch reactor; SEPs, solar evaporation pans; SS, suspended solids; SVI, sludge volume index; TDS, total dissolved solids; TKN, total Kjeldahl nitrogen.

*Corresponding author. Laboratory of Environmental Biotechnology, Institut National de la Recherche Agronomique (INRA), Avenue des Etangs, 11 100 Narbonne, France. Tel.: +33 468425151; fax: +33 468415260.

E-mail address: olivier2703@yahoo.com (O. Lefebvre).

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1. Introduction

Hypersaline effluents are generated by various industrial activities. This wastewater, rich in both organic matter and total dissolved solids (TDS), is difficult to treat using conventional biological wastewater treatment processes (Ludzack and Noran, 1965). Use of halophilic bacteria is required (Larsen, 1962). The interest in treating that kind of wastewater is growing at a fast rate.

Among the industries generating hypersaline effluents, tanneries are prominent in India. Tanning is one of the oldest professions in India, with 2000 units spread mostly across Tamil Nadu, West Bengal, Uttar Pradesh, Andhra Pradesh, Karnataka, Rajasthan and Punjab. Leather tanning is almost wholly a wet process from which a large volume of liquid waste is continuously generated. Due to the variety of chemicals added at different stages of processing of hides and skins, the wastewater has complex characteristics. The tanning process and the effluents generated have already been reported in the literature (Wiegant et al., 1999; Sreeram and Ramasami, 2003; Stoop, 2003) and an overview is presented in Fig. 1.

In this study, tannery wastewater was collected after the soaking of hides and skins. Salt (sodium chloride (NaCl)) is used to preserve the fresh skins from decomposition immediately after they are stripped in the slaughterhouse, and the excess of salt has to be removed in the tannery before further processing. This is done by soaking, using a lot of water, which generates the first source of effluent. This soak liquor is characterised by high organic load, high suspended solids (sand, lime, hair, flesh, dung, etc.) and high salinity. Because of that high salt content, this wastewater is generally segregated and sent to solar evaporation pans (SEPs), as indicated in Fig. 1. The presence of high concentrations of dissolved organic matter and suspended solids (SS) retards the rate of evaporation in SEPs. Thus, tanneries require large areas to dispose the soak liquor and the salt obtained cannot be reused because of its high organic content. This salt is then discharged on open land and contributes to soil and water pollution. Treatment of this soak liquor, before sending it to SEPs, in order to remove the excess of organic matter, would accelerate the rate of evaporation, reduce the odour of the effluent and improve the purity of the salt obtained. This salt could then be reused in the tannery itself, during the pickling stage (treatment of the skins with an aqueous solution of acids and salt, which allows the skins to

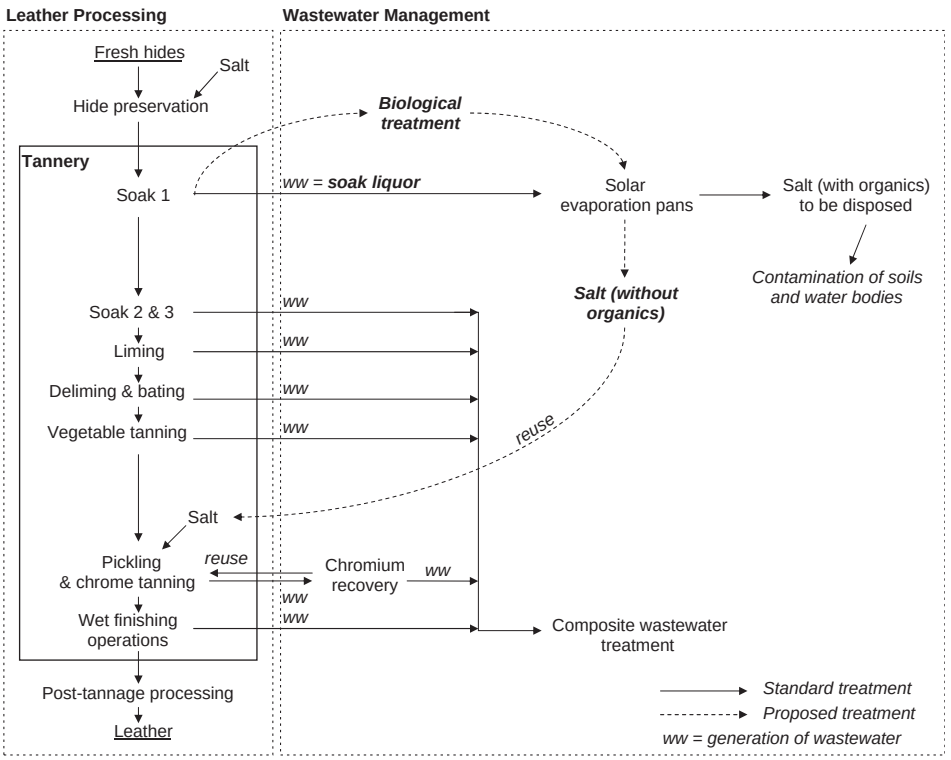

Fig. 1. Simplified leather production chain and management of the effluents associated.