Experimental evaluation of the nitrification kinetics for tannery wastewaters

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Abstract

The paper outlines results of the experimental assessment of nitrification kinetics applicable to tannery wastewaters and the inhibitory effects of selected pollutants on nitrification. The average net growth rate of nitrifiers was measured as 0.32 d^{-1} at 20°C and 0.10 d^{-1} at 10°C for tannery wastewaters subjected to plain settling. This kinetic coefficient was observed to increase to 0.43 d^{-1} at 20°C with chemical settling. Parallel experiments with synthetic waste containing only NH_4Cl revealed the strong inhibitory character of tannery wastewater. Chromium was observed to be partly responsible for the inhibitory effect which was mainly induced by chloride, inherently present in this type of wastewaters.

Introduction

Growing concern over improvement of receiving water quality imposes stringent restrictions on wastewater discharges. In this context, nitrogen is now rigidly controlled, especially in sensitive coastal areas (Orhon et al.,1999a). This approach necessitates review and re-evaluation of existing conventional treatment schemes for significant nitrogen sources.

Tannery effluents exhibit all the characteristics of a strong wastewater, mainly with respect to their organic carbon and nitrogen content. In a recent study conducted on wastewaters from an organised industrial district housing a large number of tanneries, the concentrations of conventional polluting parameters such as COD and TKN were assessed as 5 000 mg·ℓ^{-1} and 350 mg·ℓ^{-1} respectively, yielding a COD/N ratio of around 14 (Ates et al., 1997); as outlined in Table 1, plain settling was observed to lower the COD concentration to 2 200 mg·ℓ^{-1}; the corresponding TKN level obtained was 225 mg·ℓ^{-1}, corresponding to a reduction of only 37%. In the same study, chemical treatment provided a slight improvement in TKN removal as outlined in Table 2. The limitations of the physico-chemical treatment could be explained by the fact that TKN in tannery wastewaters involved a significant NH_3-N fraction remaining intact, if not slightly increased due to ammonification during settling. Consequently, aerobic biological treatment is prescribed for simultaneous carbon and nitrogen removal from tannery wastewaters (Macchi et al., 1991; Szpyrkowicz et al., 1991).

The limiting step for N removal is nitrification, a process which is sensitive to inhibitory effects and which requires long aerobic sludge ages. The latter is also a requirement for the breakdown of the slowly biodegradable matter constituting the major COD fraction in tannery wastewaters (Orhon et al., 1999b; c). In a study conducted with sequencing batch reactors, a sludge age of 20 d was found to secure maximum nitrogen removal (Yamamoto and Win, 1991). Similarly, a continuous-flow activated sludge system fed with raw tannery effluents with a COD/N ratio of 6 to 8 and operated at an F/M range of 0.25 to 0.34 kgCOD(kgVSS·d)$^{-1}$ was reported to achieve 94% COD and 97% NH_3-N removal (Szpyrkowicz et al., 1991).

Table 1
Characterisation of Raw Wastewaters

Parameters mg·ℓ^{-1}	Raw wastewater	Homogenisation outlet	Primary clarifier effluent
Total COD	5 094	4 506	2 216
Soluble COD	2 336	1 345	1 187
BOD_5	1 760	1 402	958
SS	2 229	2 988	794
VSS	-	-	506
TKN	358	367	226
Org N	223	209	62
NH_3-N	135	158	164
Total P	-	-	5.1
Total Cr(Cr^{+3})	116	132	41
Sulphur ($S^{=}$)	51	47	27

This study was designed to evaluate nitrification in tannery wastewaters in a way that is meaningful from the standpoint of both the mechanism of related microbial kinetics and practical problems generated by inhibitory effects. In this context, it basically involved the experimental assessment of the maximum specific growth rate for autotrophic biomass, $\hat{\mu}_A$. In parallel experiments, this parameter was also measured on synthetic waste and on samples specifically prepared to include different levels of chromium and salinity, for the evaluation of the inhibitory character of tannery wastewaters.

Experimental

The experiments were performed on settled wastewater samples, using the effluent from the plain sedimentation unit of the treatment plant serving the Istanbul Organised Leather Tanning Industrial District located in Tuzla/Istanbul. The organised district, planned for a capacity equivalent to a wastewater flow rate of 36 000 $m^3 \cdot d^{-1}$, presently houses around 110 tanneries processing both cattle hide and sheepskin and generating a wastewater flow in

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