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ScienceDirect
Desalination 235 (2009) 88–92
DESALINATION
www.elsevier.com/locate/desal

Decolourisation of leather dye by ozonation

S.V. Srinivasan*, T. Rema, K. Chitra, K. Sri Balakameswari, R. Suthanthararajan, B. Uma Maheswari, E. Ravindranath, S. Rajamani

Department of Environmental Technology, Central Leather Research Institute, Chennai – 600020, India
Tel. +91 (44) 24450234; Fax +91 (44) 24911589; email: srinivasansv@yahoo.com

Received 10 July 2006; accepted revised 19 July 2007

Abstract

Sewage and industrial effluent treatment plants are installed with primary and secondary biological treatment units to reduce the discharge of pollution load into the environment. These treatment plants normally reduce the organic load in terms of BOD but not the pollution load in terms of inorganic salts (total dissolved solids—TDS) and colour in the effluent. To eliminate the contamination of ground and surface water bodies and to conserve water sources, the regulatory authorities have taken very stringent regulations to implement zero liquid discharge (ZLD) for industrial effluents, i.e., water recovery from wastewater and reuse. It is difficult to recover water from secondary treated wastewater directly, as it does not meet the reverse osmosis feed requirements. In order to achieve the feed requirements, different tertiary treatment methods are being tried. In this study, removal of colour due to residual dyes has been attempted using ozone. The main purpose of this study is to decolourise the dye used in leather processing. Also, the effect of pH and dye concentration on dye decolourisation has been investigated. From the study it has been observed that maximum decolourisation efficiency up to 97% could be achieved for the pH values (4,7, 9 and 11) and dye concentrations (30, 65, 180 and 360 mg/L) studied.

Keywords: Decolourisation; Leather dye; Ozonation; Tertiary treatment

1. Introduction

Pollution of ground and surface water due to the discharge of untreated/partially treated domestic sewage and industrial effluent has increased drastically. However, with the existing conventional treatment system, it is possible to reduce only the organic load in terms of biological oxygen demand (BOD) and chemical oxygen demand (COD) and not the pollution load in terms of colour and inorganic salts (total dissolved solids—TDS). Discharge of higher TDS levels in the effluent leads to the increase in TDS levels of the ground and surface water in the area thus making it unpalatable. Hence, regulatory autho-rities have enforced the regulation of zero liquid discharge (ZLD) for all industries. Zero liquid discharge can

*Corresponding author.

0011-9164/09/$– See front matter
doi:10.1016/j.desal.2007.07.032

be achieved by reverse osmosis system, which has been reported to recover water up to an extent of 80% and the remaining portion as rejects with very high concentration of TDS upto 60,000 mg/L depending on the inlet TDS levels. From the pilot scale and a few commercial scale studies carried out using secondary treated tannery effluent, it has been observed that the main drawback of the reverse osmosis system is membrane failure or fouling due to the presence of residual organics and dye molecules pre-sent in the effluent. In order to address this issue, an attempt has been made using ozonation as one of the pretreatment units to decolourise dye used in leather industry to achieve zero liquid discharge using membrane based reverse osmosis system.

The existing technologies for decolourisation of colored effluents, which are widely used like adsorption, precipitation, membrane filtration, chemical degradation and photochemical degradation, are expensive and commercially unattractive [1,2]. Commonly, physico chemical treatment is used for removal of dye or colour from textile wastewater. This method is effective for all the dyes expect for highly soluble dyes and it generates huge quantity of voluminous sludge, which requires dewatering and further treatment/disposal as it is considered as hazardous waste. Adsorption is efficient in removing dyes such as cationic dyes, mordant dyes, acid dyes and to lesser extent to disperse, direct and vat, pigment and reactive dyes. Adsorption method is not destructive process and requires regular regeneration and replacement of adsorbents after certain period, which makes this process method uneconomical [3,4]. Advanced oxidation processes (treatment with ozone, H_2O_2, Fenton's reagent and UV radiation) are the potential alternatives for the decolourisation of the dye coloured wastewater [5,6]. Among these treatment methods for decolourisation, oxidative degradation by chlorine and ozonation has been found to be effective [7]. The advantages of ozonation for dye removal when compared with other treatment methods such as physico chemical, adsorption, biodegradation, and photo-chemical degradation are (i) no generation of sludge/solid wastes for further disposal (ii) less operational cost and (iii) effective degradation.

Ozone can effectively decolourise the dye wastewater by breaking the conjugated double (–N=N–) bonds associated with the dye. Ozone cleaves the unsaturated bonds in aromatic molecules found in humic substances, the chromophores of the dyes and other pigmented compounds, thereby reducing the colour [8]. The mechanism of the reaction of ozone follows two main pathways, a direct path corresponding to the action of molecular ozone and an indirect path corresponding to the action of free radicals species resulting from the decomposition of ozone in water [9]. In this paper, the effect of pH and dye concentrations on decolourisation of leather dye was investigated, as pollutant concentration is an important parameter in wastewater treatment.

2. Materials and methods

2.1. Experiment

For the present study, Sandopel Brown BRR dye used in the leather processing was obtained from Clariant, Chennai, India. A laboratory ozone generator (Model No-SA001, India), was used to produce 3 g/h of ozone from ambient air as inlet gas of the ozone generator. Ozonation was carried out in a cylindrical glass reactor of 5 L capacity (8.5 cm diameter and height 125 cm), by bubbling ozone at a concentration of 1.6 mg/L. Samples (5mL) were taken at regular time intervals and analyzed for UV-visible absorbance at 433 nm (maximum absorbance) using UV/visible double beam Spectrophotometer (Perkin Elmer Lambda12, German). In order to study the effect of pH, the pH of the dye solutions (dye concentration — 30 mg/L) was adjusted to different pH values of 4, 7, 9 and 11 using 0.1 N H_2SO_4 or 0.1 N NaOH. Similarly, to study the effect of dye