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Feasibility study of treatment of amoxillin wastewater with a combination of extraction, Fenton oxidation and reverse osmosis

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Abstract

Wastewater from the synthesizing of amoxillin is characterized by its very high TOC and low biodegradability and the presence of organic solvents and dissolved salts. These hamper direct biological or membrane-based treatments. A combined process of extraction (EX), Fenton oxidation (FO) and a two-stage reverse osmosis (RO) was proposed to treat such wastewater. EX and FO were performed in a serial approach to function as the pretreatments to remove the solvents and other organics before RO treatment. It was noted the appropriate phase ratio (A/O) was 1:1 and the contact time was 3 h. Appropriate dosages of $FeSO_4$ and H_2O_2 were 10 g/l and 2 g/l, respectively. Under the appropriate conditions, TOC can be reduced by 50.6% and 37.8% in the EX and FO units, respectively. TOC can be further reduced 10.1% and 1.2% in the first and second RO processes, respectively. There was consequently an overall TOC removal efficiency of 99.7% after the whole process of EX–FO–RO–RO. Dissolved salts were also greatly removed during the two-stage RO process. The observations by using SEM showed that the RO membrane can be protected well by the pretreatments of EX and FO.

Keywords: Amoxillin wastewater; Extraction; Fenton oxidation (FO); Reverse osmosis (RO); TOC removal

1. Introduction

Pharmaceutical wastewater generated during the synthesizing of amoxillin usually has strong color and odor and contains large amounts of organic solvents and a high concentration of salts. Direct discharge is strictly regulated due to its potentially severe impact on the receiving aquatic systems. Currently, such wastewater may be incinerated by supplementing additional fuel, but this treatment method is costly in terms of the

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supplementary fuel required. Therefore, it is desirable to seek an alternative to treat such wastewater.

In wastewater treatment, biological processes have often been found to be an economical and simple option [1,2]. However, there are wastewaters which are impossible to treat directly biologically because of their low biodegradability or potential inhibition. Recently, membrane separation has been increasingly applied to wastewater treatment [3–5]. RO systems have also been successfully used in the treatments of some high-strength wastewater [6–8]; but where organic solvents are present, as in amoxillin wastewater, RO, if used directly, may suffer membrane structure deterioration.

A review of the literature revealed that successful operation of RO is also strongly dependent on the feed quality. For example, in the case of landfill leachate, the COD value in the RO feed was 1797 mg/l [6]. Into [8] reported that the TOC in the feed to the RO plant was 2500–4000 mg/l. When the TOC or COD is overloaded, as in amoxillin wastewater, pretreatment schemes to protect the RO membranes should be considered.

Fenton's reagent has been reported in the treatment of refractory high-strength industrial wastewaters, such as pharmaceutical wastewater, landfill leachate, dye wastewater, and semiconductor wastewater [9–14]. Amoxillin wastewater is characterized by its very high TOC and low biodegradability and the presence of organic solvents and dissolved salts. These hamper direct biological or membrane-based treatments. In a previous study, Fenton oxidation (FO) was used to treat such a wastewater in our laboratory. However, a process based solely on an oxidizing reagent could also be prohibitively costly because of the quantity required.

Extraction (EX) is a very common process, which is the selective dissolution of certain substances from a liquid mixture by the aid of a liquid solvent. The selected substances can be easily transferred from the feed phase to the receiving phase. EX has been reported in the treatment of refractory wastewaters, such as dye wastewater, EDTA wastewater and phenol wastewater [15–17]. Like some of these, amoxillin wastewater is characterized by the presence of biorefractory solvents and low biodegradability. EX was considered for transferring solvents to the organic phase in the first step. This may reduce the burden of the following treatment units.

The purpose of this study was to explore a possible alternative for amoxillin wastewater. In this study, EX and FO were used as pretreatments prior to RO treatment to remove solvents and other organics before the wastewater entered the RO system. This was done to reduce the burden on the RO system as well as to protect the RO membrane from possible attack by extremely organic solvents and to prevent membrane fouling. A two-stage RO treatment was used to remove salts and residual organics. RO permeate was potentially suitable for a municipal sewage system and bio-treatment.

2. Experimental

2.1. Materials

All reagents used in the study (H_2O_2, $FeSO_4.7H_2O$, H_2SO_4, NaOH, and dichloromethane) were of analytical grade. The wastewater used in this study was obtained from a plant manufacturing amoxillin whose production of such wastewater was about 20 m^3/d. The wastewater samples were stored at 4 °C if not used immediately. Sufficient wastewater was stored for the study.

2.2. Extraction

2.2.1. Optimization of extraction conditions

An appropriate extraction condition was determined by serial experiments. Dichloromethane was selected as the extracting solvent in this