Optimization of the physicochemical treatment of an effluent from a textile industry with ferric chloride and polymer

D. Sakhi[1], Y. Rakhila[1], A. Elmchaouri[1], M. Abouri[2], S. Souabi[2], A. Jada[3]
[1]Department of Chemistry, Faculty of Science and Technology of Mohammedia, Hassan II University, Mohammedia, Morocco
[2]Department of Process Engineering and Environment, Faculty of Science and Technology of Mohammedia, Hassan II University, Mohammedia, Morocco
[3] Institut de Sciences Des Matériaux De Mulhouse (IS2M-UMR 7361 CNRS - UHA), Mulhouse, France
Keywords: textile wastewater, coagulation flocculation, optimization, plan of experiments, surface response method.
Presenting author email: amane.jada@uha.fr

Abstract

Nowadays, wastewater is one of the most critical environmental issues faced by countries around the world. One of the most hazardous effluents is the textile wastewater because it is highly charged with organic and mineral matters. Then, these textile effluents require treatment before their discharge to the receiving environment. In recent years, many techniques have been developed for the treatment of these effluents. The present work is dedicated to the optimization of the coagulation flocculation process for wastewater treatment originating from textile industry located in Casablanca, in Morocco. To achieve this objective, a plan of experiments was used to reduce the number of tests and optimize the operating conditions leading to a maximum elimination rate of the polluting load .The effluent is treated by a coagulation flocculation process, using ferric chloride as coagulant, polymer (polyethylene) as a flocculant. First, a preliminary study on the coagulation-flocculation of these same waters was carried out to investigate the effects of the operating parameters on the responses of the system and also to find an optimal compromise between the objectives of the study. According to this preliminary study, the optimal conditions to be applied at the level of the experimental design by coagulant, flocculant and the pH range are respectively: 0.64 mg/L, 2.8 ml /L and 8.1.

Introduction

During the dyeing process in the textile industries, a large amount of water is consumed and generates a significant amount of wastewater. This wastewater is rich in dyes, which can affect humans, aquatic life and the environment, Wang and Laccase (1999). The treatment is very complex due to the presence of high values of colour, COD, turbidity, BOD_5, toxicity, MES, etc. Many processes are employed for the treatment of dye wastewater, coagulation -flocculation is among the techniques commonly used. The main purpose of coagulation is to destabilize the particles in suspension and facilitate their agglomeration. In practice this process is characterized by the injection and dispersion of coagulants. The purpose of flocculation is to promote the contact between the destabilized particles with a slow mixture. These particles agglutinate to form a floc that can be easily removed by decantation and filtration processes, Martin et al. (2011). The aim of this paper is to characterize the effluent from a textile industry in Casablanca city (Morocco) and to optimize the coagulation–flocculation process using a plan of experiments, in order to remove pollution. The methodology of the experimental designs based on the surface response method was used to optimize the operating factors and improve the efficiency of the treatment after the study with the orthogonal centred composite plane.

Materials and methods

A random sampling method was employed to collect wastewater from a textile industry located in Casablanca city (Morocco). Sample of effluent is collected in 30 L polypropylene carboy, transported immediately to the laboratory and stored in refrigerator at 4 °C before proceeding for the analysis. The physicochemical analyses (pH, conductivity, turbidity, COD, BOD_5,) were carried out to the Standard Methods of the APHA. (APHA, 2005). The experimental set-up used for the coagulation–flocculation experiments at laboratory scale consisted of a Jar-test devices (Jar Test Flocculator FC -6S Velp Scientific) in which six stirring blades were connected to a motor that operated under adjustable conditions. The system permitted the experiments to be performed easily and the different variables affecting the removal of suspended fat and organic matter to be interpreted such as pH, stirring time and speed, retention time or reactant concentrations.

Results and discussion

The physicochemical characteristics of textile wastewater are shown in Table 1. It has a moderately basic pH, its turbidity reached 100 NTU, and represents a mineral pollution which is translated by high value of Fe (µg/l) =572; Cu

(µg/l) =72; Pb (µg/L)=17. It is also loaded with organic matter, represented by a COD about 768 mg O_2/l and BOD_5 about 8 mg O_2/l.

Table1: Characterization of the textile effluent investigated

Parameter	Value
pH	**8.02**
Conductivity (ms/cm)	**1.87**
Turbidity (NTU)	**100**
BOD_5 (mgO_2/l)	**8**
Coloration	**0.547**
COD (mg O_2/l)	**768**
MES (mg/L)	**10**
Cl (mg/l)	**321**
Na (mg/l)	**178**
K (mg/l)	**43**
Ca (mg/l)	**284 .62**
NO_3 (mg/l)	**51.25**
NH_3 (mg/l)	**3.01**
NT (mg/L)	**62.54**
Mg (mg/l)	**51**
Phenol (mg/L)	**0.95**

By taking into account the cost factor, the optimum dose of F_eCl_3 used was 0.64 mg/L which has allowed removal of 76.3% of turbidity, 74.5% of coloration and 80 % of COD, with 40 ml/l of decanted sludge. On the other hand, the optimum dose of flocculant used was 2. 8 ml/L, which has allowed removal of 91.3% of turbidity, 62.5% of coloration and 84 % of COD with 36 ml/l of decanted sludge. The optimum of pHwas 8.1 that has allowed removal of 87.8 % of turbidity, 23 % of coloration and 80 % of COD.

Conclusion

The textile wastewater treatment using batch coagulation/flocculation technique was optimized using 4^2 central composite experimental design and response surface methodology. The influence of three decisive factors such as the coagulant dose, the flocculant dose and the aqueous phase pH, were modelled and optimized to increase the removal of four response variables (turbidity, coloration, COD and decanted sludge). In overall, the pH, the coagulant dose and the flocculant dose are significant parameters for pollutant removal from wastewater. However, these three factors are fundamental for maximizing the performance of the optimization through response surface methodology system. These findings are directly applicable to the commercial use 4^2 central composite experimental design and response surface methodology for the treatment of the textile wastewater.

References

1.Y. Wong, J. Yu Laccase, *Catalyzed decolorization of synthetic dyes,* Water Res., 33 (1999), pp. 3512-3520.

2. M.A Martin, I. Gonzalez, M. Berrios, J.A Siles, A. Martin. *Optimization of coagulation-floculation process for wastewater derived from sauce manufacturing using factorial design of experiments*. Chemical Engineering 172 (2011), 7.