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Experimental study of dye removal from industrial wastewater by membrane technologies of reverse osmosis and nanofiltration

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Abstract

Currently, biological method has been utilized in the treatment of wastewater containing synthetic dyes used by textile industries in Iraq. The present work was devoted to study the operating feasibility using reverse osmosis (RO) and nanofiltration (NF) membrane systems as an alternative treatment method of wastewater discharged from Iraqi textile mills. Acid red, reactive black and reactive blue dyes were selected, based on the usage rate in Iraq. Effects of dye concentration, pH of solution, feed temperature, dissolved salts and operating pressure on permeate flux and dye rejection were studied. Results at operating conditions of dye concentration = 65 mg/L, feed temperature = 35°C and pressure = 8 bar showed the final dye removal with RO membrane as 97.2%, 99.58% and 99.9% for acid red, reactive black and reactive blue dyes, respectively. With NF membrane, the final dye removal were as 93.7%, 95.6%, and 97% for red, black and blue dyes, respectively. The presence of salt (particularly NaCl) in the dye solution resulted in a higher color removal with a permeate flux decline. It was confirmed that, pH of solution had a positive impact on dye removal while feed temperature showed a different image. A comparison was made between the results of dye removal in biological and membrane methods. The results showed that membrane method had higher removal potential with lower effective cost. The present study indicates that the use of NF membrane in dye removal from the effluent of Iraqi textile mills is promising.

Keywords: Membrane separation, Synthetic dyes, Reverse osmosis, Nanofiltration, Wastewater reuse

Introduction

Large quantities of wastewater which contains toxic organic residues are generated from the textile and dye manufacturing processes. Synthetic dyes are considered the most difficult to treat because they contain complex aromatic molecular structures, which make them more stable and more difficult to be biodegraded [1,2]. Due to their chemical structure, dyes are resistant to fading on exposure to light, water, and many chemicals [3].

There are many structure varieties such as acidic, basic, disperse, azo, diazo, anthroquinone based, and metal complex dyes. These dyes are very stable and can be decomposed only at temperatures higher than 200°C. For this reason, synthetic dyes often receive considerable attention from researchers in textile wastewater treatment processes [4].

The present work will focus on separation by two types of pressure-driven membranes which are reverse osmosis (RO) and nanofiltration (NF) membranes. NF is characterized by a membrane pore size between 0.5 and 2 nm and operating pressures between 5 and 40 bars. It is used to achieve separation between sugars, other organic molecules and multivalent salts on one hand and monovalent salts, ions and water on the other. RO or hyperfiltration is characterized by a membrane pore size in the range of 0.5 nm. The operating pressures in RO are generally between 7 and 100 bars. The importance of these membrane processes can be judged from the membrane area installed in various industrial sectors. The ability of RO membranes to remove both organic and inorganic compounds has made it attractive for the treatment of contaminated drinking water supplies [5]. Reverse osmosis processes can simultaneously remove hardness, color, many kinds of bacteria and

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