Treatment of synthetic wastewater containing heavy metal ions (cadmium, cobalt and lead) by nanofiltration

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ABSTRACT

Drinking water quality is very important for human health. Small amounts of hazardous contaminants are strictly forbidden. Due to the discharge of large amounts of metal-contaminated wastewater, industries bearing heavy metals, such as Cd, Cr, Co, Cu, Ni, As, Pb, and Zn, are the most hazardous among the chemical-intensive industries. The removal of heavy metals from wastewater has significant importance due to their high toxicity and tendency to accumulate in body tissues. In the present work, performance of a nanofiltration (NF) polyamide membrane has been studied to separate cadmium, cobalt and lead ions from synthetic wastewater solutions at different operating conditions. Rejection experiments were conducted with $Cd(NO_3)_2$, $Co(NO_3)_2$ and $Pb(NO_3)_2$ in single-salt solutions. The effect of feed pH, trans-membrane pressure and metal concentration on the ion separation and permeate flux was explored. The maximum observed solute rejection of Cd^{2+}, Co^{2+} and Pb^{2+} ions were 98.12%, 98.60% and 96.24%, respectively. It is observed that the ion rejection decreases with increase in feed pH and slightly increases with rise in feed concentration. Also, it is found that the metal rejection and the permeate flux, slightly reduces and significantly increases respectively, when the trans-membrane pressure increases. The low level of the ions concentration in permeate implies that water with good quality could be reclaimed for further reuse.

Keywords: Nanofiltration, Metal Removal, Wastewater Treatment, Water purification, Feed pH, Rejection, Permeate Flux

1 INTRODUCTION

The removal of heavy metals from wastewater is of critical importance due to their high toxicity and tendency to accumulate in living organisms and body tissues [1]. In addition, heavy metals are harmful to the environment because of their non-biodegradable and persistent nature [2]. Because of their high solubility in the aquatic environments, heavy metals can be absorbed by living organisms. With their entrance in the food chain, high concentrations of heavy metals may accumulate in the human body [3] and can cause eminent health problems, such as stomach cramps, skin irritations, vomiting, nausea, anemia, central nervous system damage, vomiting, cramps, convulsions, or even death [4-6]. With the rapid development of industries such as automotive operations, paper industries, battery manufacturing, fertilizer industries, tanneries, metal mining, electroplating, and pesticides, etc., heavy metals wastewaters are directly or indirectly discharged into the environment more and more [4, 7]. Toxic heavy metals of particular concern in treatment of industrial wastewaters include arsenic, cadmium, chromium, cobalt, mercury, nickel, lead and zinc [4].

Therefore, it is necessary to treat metal contaminated wastewater effluent that is discharged to the environment. Consequently there is a demand to develop efficient and low cost treatment methods for wastewater [8]. During the last decade, extensive research works have focused on the removal of heavy metal ions from wastewater by means of various techniques including membrane separation [7], chemical precipitation [1, 9], coagulation [8], ion flotation [10], ion exchange [11, 12], solvent extraction [13], electrochemical removal [14], and adsorption on solids such as activated carbon, metal oxides, clays, fish scales [7], orange peel cellulose adsorbents and recycled wool [15, 16]. Membrane separation has been increasingly used recently for the treatment of inorganic effluent in the chemical, petrochemical, biotech and desalination industries, due to its convenient operation [17, 18].

Due to the necessity of finding cheaper, efficient, and non-polluting separation methods, the membrane processes like reverse osmosis (RO), nanofiltration (NF), ultrafiltration (UF), and microfiltration (MF) have gained increasing popularity in wastewater treatment [19]. Nanofiltration has some advantages over other membrane techniques, for example higher rejection of divalent ions and lower rejection of monovalent ions, continuous separation, lower operating pressure, higher flux and lower energy consumption compared with others. These features confirm NF as a promising and innovative technology which can be widely applied in drinking water and the treatment of industrial effluents [19, 20].