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Treatment of organized industrial zone wastewater by microfiltration/reverse osmosis membrane process for water recovery: From lab to pilot scale

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ABSTRACT

The global increase in industrialization has resulted into water scarcity. Research on water use efficiency and water reclamation is paramount in addressing this scarcity. In this study, laboratory and on-site pilot scale tests were conducted for water recovery from an industrial wastewater treatment plant. Different RO membranes (BW30, HP, and LE) were investigated with chemical treatment and ceramic microfiltration (MF) as pretreatment steps. Laboratory studies were conducted in dead-end filtration mode, whereas pilot scale studies were performed in cross flow mode with two spiral wound membranes. The removal efficiencies ranged from 40.0-86.3% for COD, 97.6- 99% for SO_4^{2-}, 69.2-94.9% for Cr ion, 89.3-100% for Pb ion, 66.3-98.2 for Fe ion, 97.5- 99.7% for Zn ion, 95.1-99.5% for Si ion, and 79.1-100% for total phosphorus (TP). For the laboratory studies with 80% water recovery, the permeate flux reduced from 27.2 to 7.1 L/m^{2}h, 35.7 to 1.3 L/m^{2}h and 25.6 to 0.8 L/m^{2}h for BW30, LE, and HP, respectively. On the other hand, four different operation modes were investigated to determine the effect of each mode on membrane performance and fouling properties. Average permeate flux of 18.7 and 21.3 L/m^{2}h, 12.7 and 12.8 L/m^{2}h, 13.4 and 14.6 L/m^{2}h, 12.5 and 14.1 L/m^{2}h were recorded for LE and BW30 membranes in the first, second, third, and fourth modes, respectively. Membrane autopsies were performed by atomic force microscopy (AFM), scanning electron microscopy (SEM), and energy dispersive X-rays (EDX). The system was effective in recovering the permeate to required industrial cooling and boiler water quality.

1. Introduction

Water is a finite resource with major scarcity in most parts of the world. Water demands are projected to grow with an increase in the human population and industrialization, which calls for an urgent need in technologies for water reclamation. Many researchers have shown interest in reclamation and reuse of water as a means of reducing freshwater consumption and meet the increasing water demands [1]. Since the water quality requirements depend on the intended use, water recovery technologies should treat water to meet the specific use criteria [2]. With an appropriate treatment technology that meets specific use criteria, the reclaimed water can be used for irrigation, industrial water use or even domestic uses such as laundry and toilet flushing [3].

The conventional wastewater treatment methods involving only physicochemical and biological processes do not produce water of sufficient quality for reuse. Many researchers have used membrane technologies including microfiltration (MF), ultrafiltration (UF), nanofiltration (NF), and reverse osmosis (RO) to exploit water reuse and reclamation strategies. Particularly, nanofiltration and reverse osmosis membranes are more effective in the removal of salinity, nutrients, and hardness resulting into very high quality reuse permeates [3–5]. Although both NF and RO are commonly used for water recovery, a study by Liu et al. [6] comparing NF and RO membranes for treatment of metal industry effluent indicated that NF membrane achieved only 79%

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