World Academy of Science, Engineering and Technology
International Journal of Chemical and Materials Engineering
Vol:15, No:06, 2021

Ultrafiltration Process Intensification for Municipal Wastewater Reuse: Water Quality, Optimization of Operating Conditions and Fouling Management

Authors : J. Yang, M. Monnot, T. Eljaddi, L. Simonian, L. Ercolei, P. Moulin

Abstract : The application of membrane technology to wastewater treatment has expanded rapidly under increasing stringent legislation and environmental protection requirements. At the same time, the water resource is becoming precious, and water reuse has gained popularity. Particularly, ultrafiltration (UF) is a very promising technology for water reuse as it can retain organic matters, suspended solids, colloids, and microorganisms. Nevertheless, few studies dealing with operating optimization of UF as a tertiary treatment for water reuse on a semi-industrial scale appear in the literature. Therefore, this study aims to explore the permeate water quality and to optimize operating parameters (maximizing productivity and minimizing irreversible fouling) through the operation of a UF pilot plant under real conditions. The fully automatic semi-industrial UF pilot plant with periodic classic backwashes (CB) and air backwashes (AB) was set up to filtrate the secondary effluent of an urban wastewater treatment plant (WWTP) in France. In this plant, the secondary treatment consists of a conventional activated sludge process followed by a sedimentation tank. The UF process was thus defined as a tertiary treatment and was operated under constant flux. It is important to note that a combination of CB and chlorinated AB was used for better fouling management. The 200 kDa hollow fiber membrane was used in the UF module, with an initial permeability (for WWTP outlet water) of 600 $L{\cdot}m\text{-}2{\cdot}h^{-1}{\cdot}bar^{-1}$ and a total filtration surface of 9 m^2. Fifteen filtration conditions with different fluxes, filtration times, and air backwash frequencies were operated for more than 40 hours of each to observe their hydraulic filtration performances. Through comparison, the best sustainable condition was flux at 60 $L{\cdot}h^{-1}{\cdot}m^{-2}$, filtration time at 60 min, and backwash frequency of 1 AB every 3 CBs. The optimized condition stands out from the others with > 92% water recovery rates, better irreversible fouling control, stable permeability variation, efficient backwash reversibility (80% for CB and 150% for AB), and no chemical washing occurrence in 40h's filtration. For all tested conditions, the permeate water quality met the water reuse guidelines of the World Health Organization (WHO), French standards, and the regulation of the European Parliament adopted in May 2020, setting minimum requirements for water reuse in agriculture. In permeate: the total suspended solids, biochemical oxygen demand, and turbidity were decreased to < 2 mg·L-1, ≤ 10 $mg{\cdot}L^{-1}$, < 0.5 NTU respectively; the Escherichia coli and Enterococci were > 5 log removal reduction, the other required microorganisms' analysis were below the detection limits. Additionally, because of the COVID-19 pandemic, coronavirus SARS-CoV-2 was measured in raw wastewater of WWTP, UF feed, and UF permeate in November 2020. As a result, the raw wastewater was tested positive above the detection limit but below the quantification limit. Interestingly, the UF feed and UF permeate were tested negative to SARS-CoV-2 by these PCR assays. In summary, this work confirms the great interest in UF as intensified tertiary treatment for water reuse and gives operational indications for future industrial-scale production of reclaimed water.

Keywords : semi-industrial UF pilot plant, water reuse, fouling management, coronavirus
Conference Title : ICPIPSE 2021 : International Conference on Process Intensification and Process Systems Engineering
Conference Location : Toronto, Canada
Conference Dates : June 15-16, 2021