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Coupling of adsorption, coagulation, and ultrafiltration processes for the removal of emerging contaminants in a secondary effluent

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HIGHLIGHTS

▶ The removal of eleven emerging contaminants by combined treatments was investigated.
▶ PAC pre-treatment decreased membrane fouling and improved the quality of the permeate.
▶ Pre-coagulation with Fe(III) was slightly more favorable than with Al(III).
▶ The combinations PAC/UF and UF/GAC led to a significant removal of contaminants.

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ABSTRACT

The removal of eleven emerging contaminants (acetaminophen, metoprolol, caffeine, antipyrine, sulfamethoxazole, flumequine, ketorolac, atrazine, isoproturon, 2-hydroxybiphenyl and diclofenac) present in a WWTP effluent by applying several combined treatments has been investigated. These combinations were constituted by PAC adsorption and/or coagulation pre-treatments followed by UF, as well as by an UF treatment followed by GAC adsorption post-treatment. PAC pre-treatment decreased membrane fouling, with the advantage that PAC was separated from the final effluent in the UF step. Low PAC dose in the range 10–50 mg L^{-1} in the adsorption pre-treatment was enough in order to remove most of the emerging contaminants and to partially improve water quality parameters. However, if the goal is to reach a high improvement of water quality parameters in the pre-treatment step, a PAC dose above 500 mg L^{-1} was required. Although coagulation pre-treatment did not increase appreciably the permeate flux in the UF step, the final quality of the permeate was improved, especially when the combination Fe(III)/UF was applied. Finally, a significant positive effect of the GAC post-treatment after the UF treatment was appreciated, which led to an increase in the removal of the water quality parameters and a significant elimination of emerging contaminants.

1. Introduction

Currently new technologies and procedures for the reuse of effluents must be developed, because of increasing demands for water which coincides with the depletion of natural sources. Among other effluents, municipal wastewater may be suitable for reuse if after conventional purification processes further treatment is applied to remove resistant micropollutants [1]. Although at very low concentrations, there are a large number of chemical compounds involved in this pollution that have been detected in the outflows of the wastewater treatment plants (WWTPs) [2], many of which may have chronic toxic effects in aquatic organisms and may pose a risk to human health. Among these organic substances, a group commonly known as "emerging contaminants" plays an important role in the pollution of these waters. This group of contaminants includes, among others, pesticides, pharmaceuticals, personal care products, fuel additives, flame-retardants, plasticizers and numerous other industrial pollutants.

Separation processes by membranes, such as ultrafiltration (UF), are technologies increasingly used in the field of water and wastewater treatments, and produce clear water suited for different applications. However, single UF is sometimes ineffective for the removal of most of these emerging contaminants due to the limited retention capacity of UF membranes as well as to the membrane fouling. Then, membrane filtration processes must be combined with pre-treatments or post-treatments in order to produce a permeate that can be reused, such as coagulation and adsorption stages, which permit additional removals of organic compounds that play an important role in fouling phenomena. Specifically, powdered activated carbon (PAC) and granular activated carbon (GAC) in combination with UF are promising technologies for water

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