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Experimental evaluation of microfiltration–granular activated carbon (MF–GAC)/nano filter hybrid system in high quality water reuse

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ABSTRACT

In order to achieve high quality water reuse, a dual membrane hybrid system (combining microfiltration–granular activated carbon (MF–GAC)) adsorption hybrid system followed by nanofiltration (NF)) was used. This system's performance was evaluated in terms of organic matter, pharmaceuticals and personal care products (PPCPs), and removal of inorganic matter. Biologically treated sewage effluent (BTSE) collected from a water reclamation plant in Sydney, Australia was used as the water source. The removal efficiency of dissolved organic carbon (DOC) of MF–GAC strongly depends on the dose of GAC and filtration flux. MF–GAC system effectively removed hydrophobic organics (45–80%) as well as hydrophilic organics (50–80%). The removal of various PPCPs ranged from 33% to 92%, and as expected, the amount of inorganic matter removed by the MF–GAC system was very small. Hence, the NF system, as a second membrane system, was employed to polish the effluent from the MF–GAC hybrid system. The NF system rejected most of DOC (> 95%), sulfates (99%) and a substantial amount of calcium (70%), and magnesium (60%) from MF–GAC effluent. Further, more than 90% of PPCPs were removed by the NF system. Overall the dual membrane hybrid system proved to be very effective in removing organics, PPCPs and inorganic matter. The MF–GAC followed by NF results in high quality water reuse and this system can serve as an effective treatment option for water reuse schemes.

1. Introduction

The application of membrane technology for treating wastewater is becoming increasingly popular worldwide and it is considered to be a promising technology for producing better quality water for water supply and water reuse. Microfiltration or ultrafiltration (UF) is a cost effective option but the removal of DOC is limited because the MF/UF's pore size is not small enough to retain dissolved organics. The nanofilter or reverse osmosis (NF/RO) membranes are pressure driven systems and consume large amounts of energy. However, NF/RO is highly efficient in removing dissolved organics/ions. However, while NF/RO produces high quality water, numerous challenges still prevail such as fouling and scaling issues, large energy requirement, incomplete removal of a few trace organics and there are issues regarding RO concentrate management.

Fouling is the main obstacle in RO and in all the membrane-related water treatment processes. It compromises the performance of a membrane filtration due to the deposition of suspended solids, dissolved organic and inorganic substances on the membrane surface and subsequent blocking of membrane pores. Consequently, a cost effective pre-treatment strategy is required to minimize membrane fouling which in turn will help to reduce operational costs by less frequent membrane cleaning and extending the membrane's life. Various technologies have been developed and tested to reduce membrane fouling. Of these, the common strategy to minimize the impact of fouling is to aerate the membrane surfaces (of submerged membrane system). Applying aeration can reduce the deposition of solids' particles on the membrane surface by air scouring effect [1]. However, irreversible membrane fouling caused by the deposition or attachment of soluble organic matter inside the membrane pores cannot be controlled by aeration alone. It is therefore important to use different types of adsorbents as suspended media coupled with membrane filtration in a membrane reactor to reduce both reversible as well as irreversible membrane fouling through: (i) mechanical scouring; and (ii) adsorption of potential foulants.

Previous studies reported that the addition of adsorbents as suspended media in the membrane reactor provides mechanical scouring on the membrane surface, which helped to reduce

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