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Submerged membrane – (GAC) adsorption hybrid system in reverse osmosis concentrate treatment

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ABSTRACT

Wastewater reclamation plants using reverse osmosis as the final polishing treatment produce reverse osmosis concentrate (ROC), which consists of high salinity, nutrients and (recalcitrant) organics. The ROC collected from the water reclamation plant in Sydney was treated with a micro filtration (MF)–GAC hybrid system that removed natural and synthetic organics prior to its discharge into the environment. The MF–GAC hybrid system's performance was studied in terms of trans-membrane pressure (TMP) development, and organics removal. These features were measured using liquid chromatography–organic carbon detection (LC–OCD), Fluorescence Excitation-Emission matrix (F-EEM), and Liquid chromatography with tandem mass spectroscopy (LC–MS). Adding GAC into the membrane reactor reduced the TMP by reducing membrane fouling both through mechanical scouring and pre-adsorption of organics. F-EEM confirms the removal of humics-like and fulvic-like compounds by GAC from ROC. Pharmaceuticals and personal care products (PPCPs) were also removed by the MF–GAC hybrid system.

1. Introduction

RO is used widely in wastewater reclamation plants as the final treatment stage [1–5]. Hundreds of RO based reclamation plants are in operation in Australia, Asia, Europe, Africa, and America which includes Orange County plant in California, USA (265 MLD) and three plants in Singapore (Bedok, Kranji and Changi) [6]. In Sydney alone two major water reclamation plants are using RO after micro filtration (Homebush bay plant) [7] and ultrafiltration (St. Marys water recycling plant) of biologically treated wastewater. The resulting product from both plants is then used for irrigation and replenishing of Napean River, respectively. Though these RO plants lead to high quality reusable water, they also produce large volumes of RO concentrate (ROC) that are rich in dissolved organics, pharmaceuticals, persistent organic pollutants (PPCPs), pesticides, inorganics, etc. The direct disposal of ROC into water bodies can pose a severe eco-toxicological risk, threaten aquatic organisms and cause serious environmental problems. Consequently, proper treatment, sustainable management and safe disposal of ROC are mandatory requirements [8,9].

Forward osmosis, membrane distillation, advanced oxidation processes [9–11] have been applied to treat ROC; however, the costs associated with these technologies limit their wider application. In this context, GAC adsorption is recommended as a simple, cost effective option for removing organics from water and seawater [12,13]. GAC was found to remove humics, building blocks and LMWs efficiently from water as these components are easily adsorbed into GAC pores [14]. Coupling of membrane-(powdered) activated carbon hybrid system was studied by Guo et al., Vigneswaran et al. and Kim et al. [15–17] and reported to be efficient in terms of organics removal. Guo et al. [15] confirmed that 90% of total organic carbon (TOC) was removed with 5 g/L dose of Powder Activated Carbon (PAC). Vigneswaran et al. [16] noted the efficiency in removing TOC was 84% with 5 g/L initial dose and followed by 2.5% of daily replacement at filtration flux of 12 L/m^2 h. Guo et al. [15] revealed that the PAC dose of 1 g/L was effective in MF–GAC in terms of removing organics.

An area that has not been widely investigated is the use of activated carbon in granular form in membrane-hybrid systems. Kim et al. [17] studied MF–GAC hybrid systems and reported that employing GAC with membrane filtration reduced the trans-membrane pressure (TMP) development and frequency of chemical cleaning by half. A smaller development in TMP meant that the two chemical cleaning procedures without GAC were reduced to one when GAC was used. Absorbents with larger particles are better than smaller ones, because they produce better membrane scouring outcomes that means less fouling. This agrees with

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