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Effluent organic matter removal from reverse osmosis feed by granular activated carbon and purolite A502PS fluidized beds

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ABSTRACT

Applying pre-treatments to remove dissolved organic matter from reverse osmosis (RO) feed can help to reduce organic fouling of the RO membrane. In this study the performance of granular activated carbon (GAC), a popular adsorbent, and purolite A502PS, an anion exchange resin, in removing effluent organic matter (EfOM) from RO feed collected from a water reclamation plant located at Sydney Olympic Park, Australia were evaluated and compared through adsorption equilibrium, kinetics and fluidized bed experiments. The maximum adsorption capacity (Q_{max}) of GAC calculated from the Langmuir model with RO feed was 13.4 mg/g GAC. The operational conditions of fluidized bed columns packed with GAC and purolite A502PS strongly affected the removal of EfOM. GAC fluidized bed with a bed height of 10 cm and fluidization velocity of 5.7 m/h removed more than 80% of dissolved organic carbon (DOC) during a 7 h experiment. The average DOC removal was 60% when the bed height was reduced to 7 cm. When comparing GAC with purolite A502PS, more of the later was required to remove the same amount of DOC. The poorer performance of purolite A502PS can be explained by the competition provided by other inorganic anions present in RO feed. A plug flow model can be used to predict the impact of the amount of adsorbent and of the flow rate on removal of organic matter from the fluidized bed column.

1. Introduction

Clean water consumption is expected to increase throughout the world in the near future with increasing demand from domestic and industrial users [1]. Unusual drought conditions are also increasing water storage requirements. An imbalance between the quantity of clean water available and the demand is leading to the alternative of manufactured water. This situation is currently critical in many countries such as Singapore and Australia. Water reclamation plants are widely implemented in these countries [2] especially reverse osmosis (RO) units which are becoming popular due to their efficient and high removal efficiency.

In many water reclamation plants, biological treated sewage effluent (BTSE) is used as the RO feed. The EfOM present in BTSE often has a low concentration but it can lead to organic and biofouling of the RO membrane [3–6]. Membrane fouling is a significant problem in RO applications because it leads to more energy consumption, frequent chemical cleaning and shorter membrane life. This ultimately increases plant treatment costs. Pre-treatment of the feed water is considered to be the most promising solution for controlling the fouling due to its simple and easy implementation. Our recent study with seawater [7] shows that a submerged membrane coagulation–adsorption hybrid system (SMCAHS) can be used for pre-treatment of seawater RO. This pre-treatment removed only 48% of DOC from seawater (DOC of 2.4 mg/L) but it helped to reduce the deposition of low molecular weight organic matter (185 Da and 90 Da) on the RO membrane. In turn this decreased initial biomass accumulation (from 4.10E08 cells/cm^2 with raw seawater to 2.75E08 cells/cm^2 with seawater pre-treated by SMCAHS).

Adsorption by GAC is often the best and most economical advanced technology for removing organic compounds from wastewater [8]. GAC adsorption proved to be effective in removing total organic carbon (TOC) from low strength synthetic wastewater [9]. According to Gur-Reznik et al. [10], GAC pre-treatments in pilot scale columns resulted in 80–90% dissolved organic matter (DOM) removal from membrane bioreactor (MBR) effluents, which in turn stabilized membrane

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