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Comparison between sequential and simultaneous application of activated carbon with membrane bioreactor for trace organic contaminant removal

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HIGHLIGHTS

- >95% removal of all trace organics was achieved by MBR–GAC and PAC–MBR initially.
- Gradual drop in removal of some hydrophilic compounds occurred in both systems.
- Known persistent compound carbamazepine showed high removal in both systems.
- Charged compounds fenoprop and diclofenac showed high persistence in both systems.
- PAC–MBR outperformed MBR–GAC in terms of adsorbent consumption.

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ABSTRACT

The removal efficiency of 22 selected trace organic contaminants by sequential application of granular activated carbon (GAC) and simultaneous application of powdered activated carbon (PAC) with membrane bioreactor (MBR) was compared in this study. Both sequential application of GAC following MBR treatment (MBR–GAC) and simultaneous application of PAC within MBR (PAC–MBR) achieved improved removal (over 95%) of seven hydrophilic and biologically persistent compounds, which were less efficiently removed by MBR-only treatment (negligible to 70%). However, gradual breakthrough of these compounds occurred over an extended operation period. Charged compounds, particularly, fenoprop and diclofenac, demonstrated the fastest breakthrough (complete and 50–70%, in MBR–GAC and PAC–MBR, respectively). Based on a simple comparison from the long-term performance stability and activated carbon usage points of view, PAC–MBR appears to be a better option than MBR–GAC treatment.

1. Introduction

In view of the potential adverse effects of trace organic contaminants on human health and that of other biota, numerous studies have been devoted for their removal from wastewater by membrane bioreactors (MBRs). The reported data have demonstrated better and/or more stable removal of trace organic contaminants of moderate to high biodegradability and/or significant hydrophobicity by MBRs as compared to conventional activated sludge (CAS) processes. However, significant variations in removal of hydrophilic and biologically persistent compounds by MBR have been noted in several recent studies (Bernhard et al., 2006; Visvanathan et al., 2005). Besides biological processes, adsorption onto powdered activated carbon (PAC) or granular activated carbon (GAC) can also be used to efficiently remove trace organic contaminants from water (Ternes et al., 2002). However, limited adsorption of ionic compounds, particularly of those containing electron-withdrawing functional groups, has been reported (Ternes et al., 2002). In this connection, the concept of combined processes such as coupling of MBR with PAC/GAC has been explored (Li et al., 2011; Lipp et al., 2012; Nguyen et al., 2012). Activated carbon adsorption in conjunction with an MBR can be applied in two different configurations: (i) direct addition of PAC into MBR (PAC–MBR), and (ii) post-treatment of MBR permeate by passing it through a GAC column (MBR–GAC) or by dosing of PAC. It is

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