

# APPLICATION OF POWDERED ACTIVATED CARBON IN MEMBRANE FILTRATION INVESTIGATION OF DIFFERENT CARBON DOSAGE MODES

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## Introduction

The implementation of low pressure membrane processes such as micro- and ultrafiltration (MF and UF) in drinking water treatment has grown exponentially the last 20 years.

Since the separation mechanism of these membranes is size exclusion, they do not remove dissolved substances like synthetic organic chemicals (SOCs). The combination of powdered activated carbon (PAC) with membrane filtration is a simple and cost-effective way to remove them. In such a hybrid process PAC is added to the filtration feed to adsorb the SOC and the carbon particles are separated afterwards by the membrane itself. The main advantage is that the PAC dose can be optimized according to the raw water quality. Furthermore, the hybrid process increases the SOC removing capacity of low pressure membranes to a level comparable to nanofiltration (NF) and reverse osmosis (RO) membranes, utilizing less energy due to the higher permeability.

The objective of this master thesis was to investigate the SOC removal efficiency for different PAC dosing procedures in porous membrane filtration processes, focusing on utilizing the lower energy demanding dead-end mode and low carbon contact time. The short contact time was chosen specifically because it provides the advantage of dosing the PAC directly into the pipe, thus avoiding the need of an additional tank.

## Methods

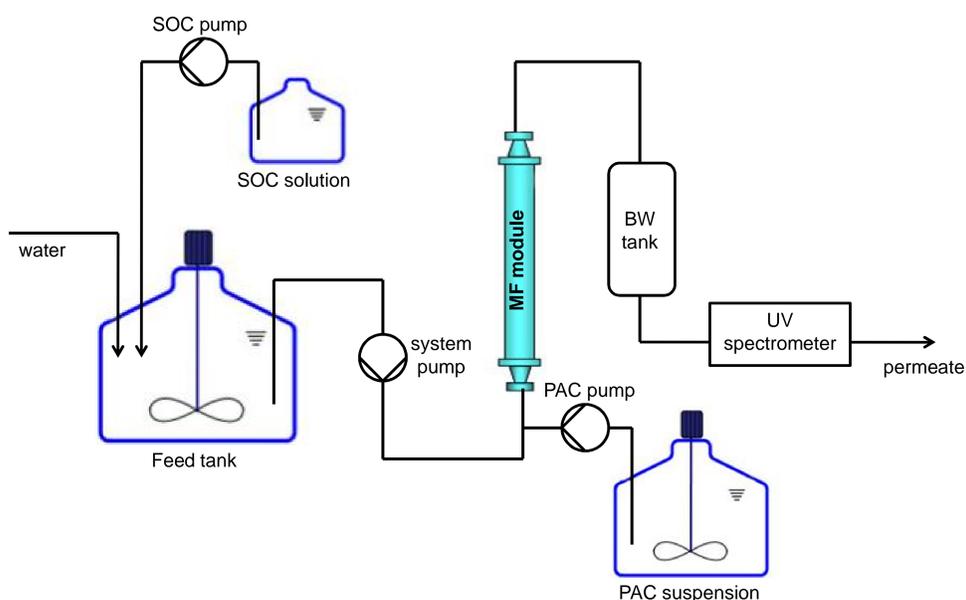


Fig. 1: Schematic of the set-up for the PAC/MF experiments

For the experiments PAC of small particle size was injected into a bench-scale MF system using continuous, multi-pulse and single-pulse dosing procedures. Tap water spiked with a single SOC was used as feed and the permeate quality was monitored by UV spectroscopy. With this set-up it was possible to observe the variations in SOC removal over time during the filtration cycles and link them to the PAC dosing mode. Furthermore, batch kinetic tests were performed to obtain information on the loading capacity of the PAC and breakthrough curves were recorded to determine the influence of the membrane in the adsorption process.

The tested compounds were *p*-nitrophenol (PNP), carbamazepine (CBZ) and diclofenac (DFC).

## Results & Conclusion

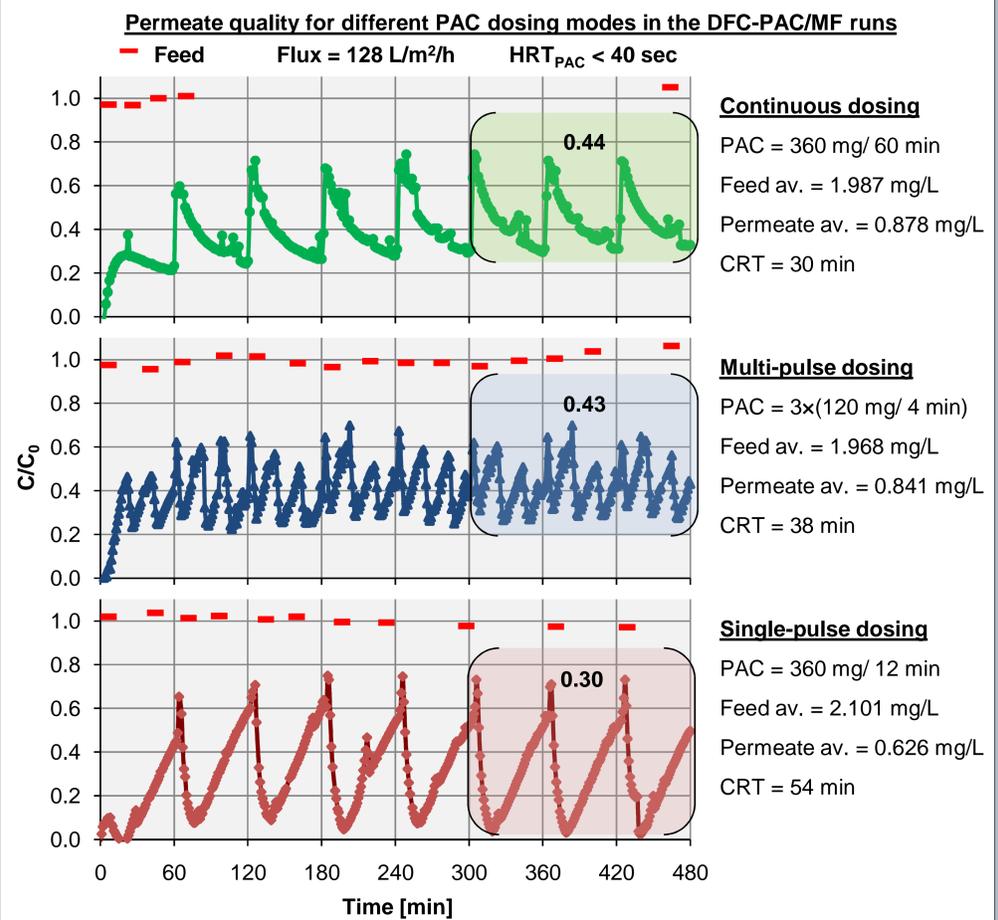


Fig. 2: Permeate quality for the PAC/MF runs with 2 mg/L DFC and 10 mg/L PAC. The  $C/C_0$  average is displayed in brackets. HRT = Hydraulic retention time, CRT = Average carbon residence time in the filtration module

PNP and CBZ showed a slight adsorption on the membrane material. The most likely explanation for this phenomenon is a hydrogen bond interaction between the PVDF membrane and these molecules. The highest averaged removal of the tested SOC in the PAC/MF system was achieved when the activated carbon was dosed in single-pulse mode with 84 %, 68 % and 70 % removal for PNP, CBZ and DFC. The improvement compared to the continuous dosing mode was 6 %, 2 % and 13 %, respectively. No significant difference showed the results for continuous and multi-pulse dosing modes in the respective cases of PNP and DFC, while for CBZ the continuous dosing mode performed 6 % better than the multi-pulse dosing mode. With a PAC residence time in the module of 54 minutes for the single-pulse mode, the PAC loadings were better or at least similar compared to the loadings after 60 minutes contact time in batch kinetic tests.

## About me

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