Hybrid membrane bioreactor- powdered activated carbon (MBR-PAC) process for wastewater treatment

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Keywords: MBR; PAC; Biofilm; QCM-D

Short Introduction

The goal of this study was to evaluate performance of a membrane bioreactor (MBR), using powdered activated carbon (PAC) suspended in the mixed liquor suspended solids (MLSS) which entails adsorption-desorption-biodegradation processes. This MBR-PAC hybrid process provides a synergistic behavior as a solution for membrane biofouling in the MBR: The adsorption-desorption-biodegradation characteristics of the MBR-PAC reactor improve the stability of acclimated microbial community for biodegradation of recalcitrant organic compounds that can also acquire strong membrane fouling capabilities. The main hypotheses were that the MBR-PAC process would provide the MBR with higher microbial activity, stronger capacity to cope with certain shock loads of organic pollutants, and an alternative media for adsorption of organic foulants to the membrane surface, and as such, the presence of PAC may sequester organic fouling.

Material and Methods

Two pilot-scale reactors were operated, one reactor was supplemented with suspended PAC and one was operated under similar conditions, without PAC. The feed to the reactors was comprised of synthetic-, domestic-, and olive oil mill-wastewater. The MBR operational parameters were registered daily, along with biological oxygen demand (BOD) and dissolved organic carbon (DOC) analyses that were measured weekly. The affinity of the main MBR components - the soluble microbial products (SMP) and extracellular polymeric substances (EPS) extracted from the MLSS - for a surface simulating ultrafiltration (UF) membrane (polyether sulfone (PES)) was determined using a quartz crystal microbalance with dissipation monitoring (QCM-D). Also, autopsies of the membranes were conducted at the end of the MBR operation.

Results and Discussion

The working hypothesis that supplementing the MBR with PAC would improve performance due to adsorption of certain foulants followed by their continuous desorption and biodegradation, was contradicted by the results of this study. Permeate flux and membrane permeability decreased faster in the MBR supplemented with PAC compared to the control reactor. Interestingly, the SMP and EPS originating from the PAC supplemented reactor were found to be more adhesive to the QCM-D sensor coated with PES. Notably, the SMP fraction, originated from the PAC reactor, which was collected towards the end of the reactor's operation, was found to have higher

affinity to the PES-coated sensor mimicking the membrane surface. The autopsies results showed that the EPS from the biofilm on the membrane surface from the PAC reactor, had a bigger amount of polysaccharides, DOC and proteins compared to the control reactor. Furthermore, batch filtration of SMP solutions originating from the two MBRs through disks of UF membranes, corroborated the finding of reduced performance of the PAC supplemented MBR: a higher decline in membrane permeability was observed for the SMP of the PAC supplemented system. According to these effects of PAC on membrane fouling as well as affinity of the SMP fraction to a membrane mimetic surface, it seems that the addition of PAC to the MBR alters the distribution and type of organic compounds in the reactor. This effect of the PAC will be studied in the future and the reasons for the consequent reduction in membrane performance will be delineated. Probably, the activated carbon selects for certain refractory adsorbents, which remain in the aqueous phase and more significantly adsorb to the membrane and enhance fouling.

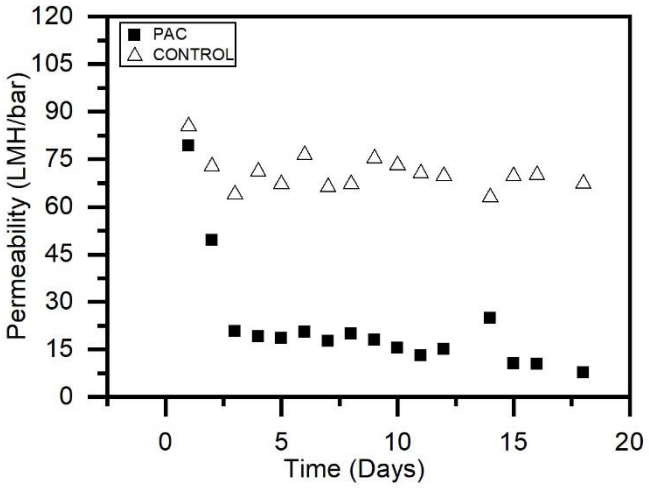


Figure 1. Permeability of the membranes in MBR-PAC and the control (w/o PAC) during the different experiments

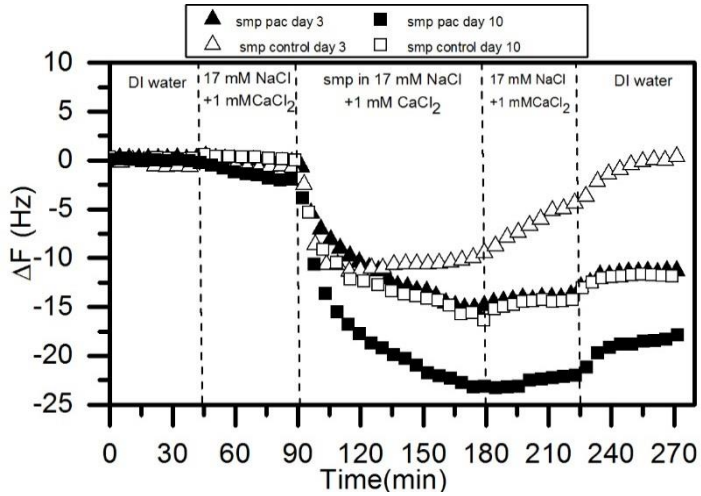


Figure 2. Adherence properties of SMP, extracted from the MBR, after runs with and w/o PAC provided as frequency shifts during SMP adhesion to PES coated QCM-D sensors. A background solution with ionic strength of 20 mM (17 mM NaCl + 1 mM CaCl2) was supplemented with SMP from MBR at 20 mg DOC/l was injected to an E4 QCM-D parallel flow cells (Q-Sense, SWEDEN) at a flow rate of 100 μl/min.