Removal of human adenovirus 40 in membrane bioreactors: Roles of membrane pore size, fouling, pressure relaxation and membrane cleaning.

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Abstract

Virus removal in membrane bioreactors is of concern since membrane pore size can be larger than the size of certain viruses. In the present work, human adenovirus 40 (HAdV 40) removal experiments were carried out using PVDF ultra- and microfiltration membranes with nominal pore sizes of 0.04 μm and 0.45 μm simulating membranes commonly used in full scale MBRs.

In the first part of the study, HAdV40 removal from model feeds was explored to elucidate individual and combined impacts of dissolved and particulate foulants on membrane fouling and virus removal [1]. Membrane fouling by SiO_2 colloids led to 1.2 log decrease in the removal of HAdV 40 by 0.04 μm membranes but had much smaller effect (δLRV=0.2) on virus removal by the microfilters. The decreased removal was attributed to the cake-enhanced accumulation of viruses at the membrane surface. In contrast, fouling by humic acid significantly enhanced virus removal by 0.04 μm membranes (δLRV=0.8) but not by 0.45 μm membranes (Figure 1). The trend can be explained by intrapore fouling and pore blocking by humic acid. When membranes were challenged by virus-seeded feeds containing both humic acid and suspended SiO_2, the reductions in virus removal for 0.04 μm and 0.45 μm membranes were 0.04 log and 0.53 log, respectively. The overall removal appeared to be a superposition of contributions due to individual feed components fouling the membrane.

In the second part of the study, we applied pressure relaxation and permeate backwash to 0.45 μm microfilters in a submerged MBR treating synthetic wastewater [2]. The experimental variables included durations of the filtration ($t_{\Delta P>0}$), pressure relaxation ($t_{\Delta P=0}$) and backwash ($t_{\Delta P<0}$) stages. Both pressure relaxation and permeate backwash led to significant reductions in virus removal (Figure 2). For the same value of $t_{\Delta P>0}/t_{\Delta P=0}$, longer filtration/relaxation cycles (i.e. larger $t_{\Delta P} + t_{\Delta P=0}$) led to higher transmembrane pressure (ΔP) but did not have a significant impact on virus removal. A shorter backwash ($t_{\Delta P<0}$ = 10 min) at a higher flow rate (Q= 40 mL/min) resulted in more substantial decreases in ΔP and virus removal than a longer backwash ($t_{\Delta P<0}$ = 20 min) at a lower flow rate (Q = 20 mL/min) even though the backwash volume ($Qt_{\Delta P<0}$) was the same. Virus removal returned to pre-cleaning levels within 16 h after backwash was applied. Moderate to strong correlations (R^2 = 0.63 to 0.94) were found between ΔP and virus removal (Figure 3).

References

1. Yin, Z.; Tarabara, V.; Xagoraraki, I. Human adenovirus removal by hollow fiber membranes: Effect of membrane fouling by suspended and dissolved matter. J. Membr. Sci. 2015, 482, 120–127.
2. Yin, Z.; Tarabara, V.; Xagoraraki, I. Effect of pressure relaxation and membrane backwash on adenovirus removal in a membrane bioreactor. Water Res. 2016, 88, 750–757.

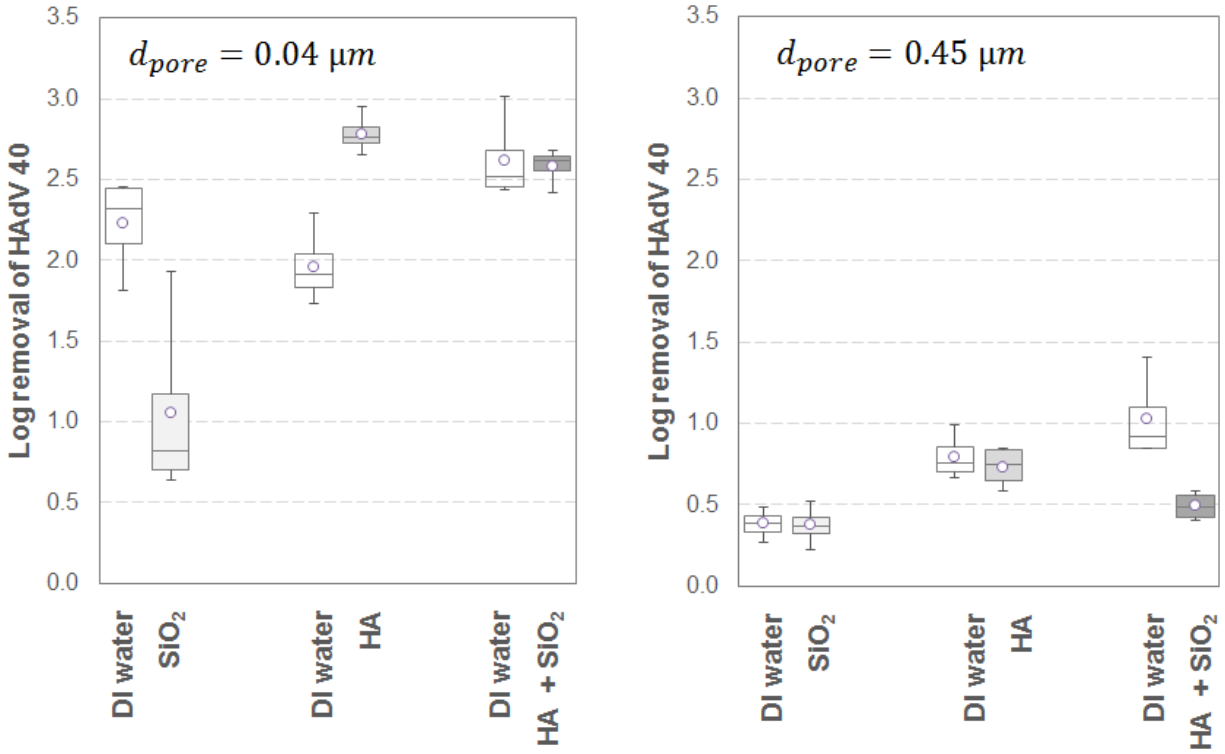


Figure 1: Comparison of HAdV 40 removal from DI water, suspension of SiO_2 microspheres, solution of humic acid, and SiO_2/HA mixture by two membranes of different nominal pore sizes: 0.04 µm, and 0.45 µm [1].

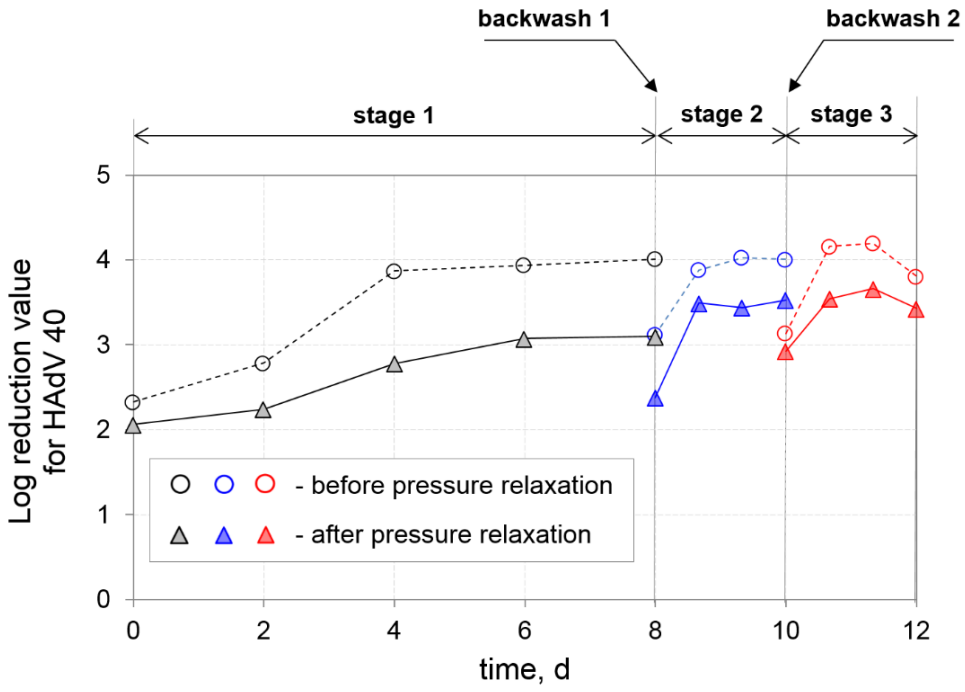


Figure 2: Effects of pressure relaxation and backwash on the removal of HAdV 40 in a submerged MBR [2]. Pressure relaxation format: $t_{\Delta P>0}/t_{\Delta P=0}$ = 25 min / 5 min.

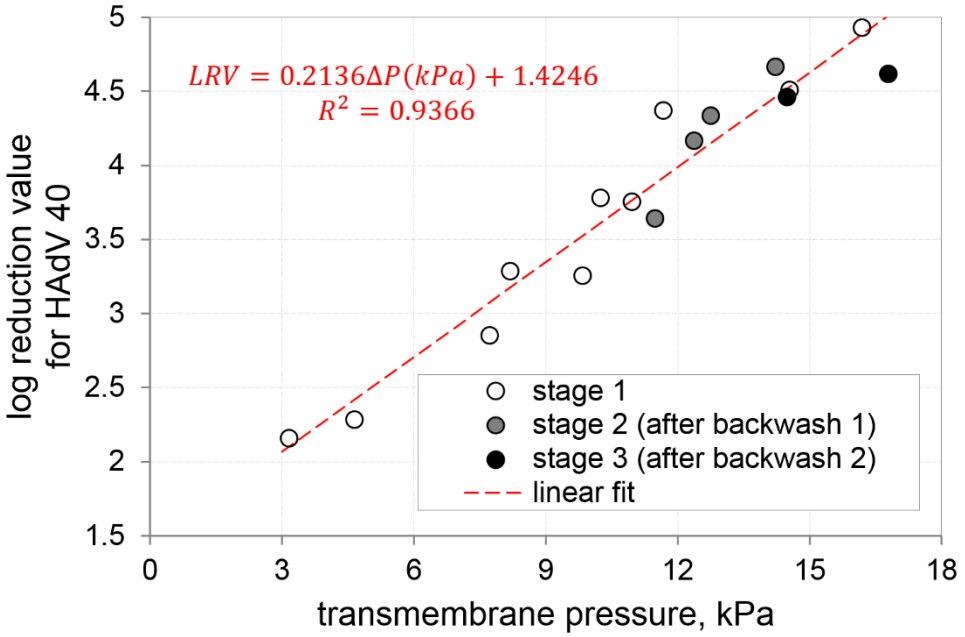


Figure 3: Correlation between HAdV 40 removal and transmembrane pressure in MBR [2]. Pressure relaxation format: $t_{\Delta P>0}/t_{\Delta P=0}$ = 50 min / 10 min.