Abstract

A possible way to meet the increasing demands on the effluent quality of conventional wastewater treatment plants is low-pressure membrane filtration like microfiltration or ultrafiltration. One of the reasons for a limited use of this technology is the fouling of the membranes, which decreases the efficiency of the process. Macromolecular organic substances, so-called biopolymers (BP), are suspected as main causes of membrane fouling. The exact composition of BP, the mechanisms of fouling as well as effective prevention strategies of membrane fouling are still widely unexplored.

Using an enzymatic digestion, the current study showed that a part of the macromolecular organic fraction are proteins. Based on this finding, fouling by proteins in laboratory membrane filtration tests with the model protein bovine serum albumin (BSA) was investigated. Matrix assisted laser desorption/ionization-time of flight-mass spectrometry (MALDI-TOF-MS), a modern but unusual analytical procedure in this research field, was used to analyze the deposition of BSA directly on the membrane. It was demonstrated that the BSA molecules form agglomerates on the membrane during filtration. These agglomerates are considerably larger than the membrane pores and cause additional filtration resistance. It could be shown that with a backwash of the membrane these BSA-agglomerates can be largely removed. Individual protein molecules, however, can block or constrict the membrane pores and thus cause hydraulically irreversible fouling.

Besides these fundamental studies on the fouling of low-pressure membranes by proteins also more practical research on fouling of secondary effluent was done in this work. In laboratory test and further in long-term experiments on pilot installations, the impact of a targeted treatment of secondary effluent by ozonation and coagulation on the fouling of low-pressure membranes was investigated. For narrow ultrafiltration membranes (pore size of 20 - 50 nm), the sole coagulation proved as the most effective way to reduce membrane fouling. An additional ozonation before coagulation ensures a lower total filtration resistance, but produces highly hydraulically irreversible membrane fouling. By size-exclusion-chromatography it could be shown that ozonation of BP produces transformation products (TP), which range in size of the membrane pores. These TP are responsible for blocking of the membrane pores or irreversible inpore fouling. In contrast, tests with membranes of a pore size bigger than 50 nm show that the TP can pass through the membrane almost unhindered. In this case, an additional ozonation leads to significantly improved filtration properties.