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Characterization of nanoparticulate fouling and breakthrough during low-pressure membrane filtration

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ABSTRACT

Low-pressure membranes suffer from particulate, organic and biological fouling during operation. In order to elucidate the impact of nanoparticles on membrane fouling, experiments were carried out with a small membrane test unit operated with artificial and natural waters. Both microfiltration (MF) and ultrafiltration (UF) membranes were used. Artificial waters were made from ultra pure water spiked with polystyrene or magnetite nanoparticles with sizes between 20 and 250 nm in varying particle concentrations. During the filtration tests the permeability decreased with time indicating a blocking of the membrane pores by nanoparticles. During the filtration of small particles (20–30 nm) the permeability dropped to a significantly lower level than during filtration of larger particles (100–250 nm). Under the tested conditions the nanoparticle concentration seemed to have no influence. In natural waters particulate fouling tended to be overlapped by other fouling processes such as organic fouling. With the test unit the fouling potential of raw waters could be characterized within a short period of time whereas the nanoparticles in the feed waters were characterized by a special analysis based on Laser-induced Breakdown Detection (LIBD). With this highly sensitive quantification method it was possible to determine both nanoparticle size (down to 10 nm in diameter) and concentration (down to a few ng/L) in the feed and the filtrate. In the filtrates of the MF membrane operated with spiked feed waters, nanoparticles were detected indicating their breakthrough. Comparatively, under similar conditions the UF membrane showed a very high retention of such nanoparticles.

Keywords: Laser-induced breakdown detection (LIBD); Nanoparticles; Particle analysis; Particulate fouling; Ultrafiltration

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