Removal of Colloidal Particles through Online Monitoring to Lower Membrane Fouling

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There is an increased emphasis on indirect and direct potable reuse (IPR/DPR) in recent years in order to meet the future water demand and increase water security. Microfiltration (MF) and ultrafiltration (UF) membranes are integral components of most IPR/DPR processes. However, fouling of these membranes results in increased energy demand, increased cleaning, and membrane replacement frequency. Recent studies have shown that MF/UF membrane fouling is largely due to deposition of feed water colloidal nanoparticles (typically <200 nm) inside the membrane pores (pore plugging).

Currently, no techniques are available to directly measure colloidal particles in the feed water, which will facilitate appropriate pretreatment to remove these particles and prevent their deposition in membrane pores. Surrogate techniques such as measurement of turbidity or organic content are sometimes used for monitoring “foulant” levels in the feed water. These techniques do not correlate well with the levels of colloidal particles and hence, lead to ineffective fouling control. Because of these limitations many utilities do not pretreat the feed water prior to MF/UF membrane treatment.

Orange County Water District and Kennedy Jenks are collaborating on a field demonstration of a real-time monitoring technology that measures the colloidal particles concentration and size distribution in the feed water. This approach has the potential to facilitate pretreatment via coagulation or other means for enhanced removal of these particles. This technology, Nanoparticles Tracking Analysis (NTA) by Malvern Instruments, uses a light scattering technique to detect colloidal size particles.

The project work consisted of i) monitoring and measurement of diurnal changes in colloidal particles profile (concentration and size distribution) in membrane feed water using NTA, ii) determination of the relationship between colloidal particle profile and optimum coagulant dose for fouling reduction through bench scale studies, iii) integration of a feed-forward loop-based chemical feed system that delivers coagulant dose based on feed water colloidal particles profile and iv) performance of cost-benefit analyses for implementation of this technology. Two MF pilot units fitted with polypropylene membrane elements (typical pore size ~200 nm), one operating as control and another receiving coagulant (commercial poly-aluminum chloride), were operated in parallel to demonstrate the efficiency of the proposed technology in reducing membrane fouling. The overall results of the project indicated that

i) diurnal variations existed in colloidal particles profile in the feed water, and the colloidal particle concentration during the peak period were approximately four to five times higher than that during the period when the levels of colloidal particles were the lowest,

ii) the algorithm developed through bench scale testing was effective in optimizing coagulant dosing, and

iii) the fouling potential, measure in terms of transmembrane pressure, for the coagulant dosed pilot was only 27% of the control pilot after six weeks of operation. Further, the controlled release of coagulants, based on colloidal particles profile resulted in minimal bleeding of aluminum (or polymer) in the membrane permeate.

In summary, the data indicated that monitoring and removal of colloidal particles using NTA technology was very effective in minimizing MF membrane fouling.

Kennedy Jenks