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ScienceDirect
Desalination 222 (2008) 59–65
DESALINATION
www.elsevier.com/locate/desal

UF/MF as RO pre-treatment: the real benefit

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Received 16 January 2007; accepted 30 January 2007

Abstract

Ultrafiltration (UF) and microfiltration (MF) are theoretically the best pre-treatment upstream reverse osmosis, removing from the feed water most of the potential elements responsible of desalinating membranes fouling such as particles, turbidity, bacteria and large molecular weight organic maters. Those clarification membranes reduce also significantly the silt density index below 3 (100%) [1–6] and generally below 2. Many papers present results about the efficiency of UF/MF regarding clarification efficiency.

UF/MF can be an economical option for RO pre-treatment. Several evaluations of the cost of UF/MF upstream RO demonstrate the interest of this pre-treatment technology on average to bad water qualities, compared to a double filtration steps conventional pre-treatment. In that case, and on a long-term operation basis, the treatment line is economically viable [7]. However, UF/MF remains more costly than a single filtration on mono or multimedia filter: UF/MF is not economically applicable on the best water quality to pre-treat.

Nevertheless, UF/MF technology has some limits. If this technology is economically viable on average to bad water qualities, UF/MF direct filtration can overpass the technical limits of the process, generating the need of frequent cleanings. In that case, the RO fouling is moved upstream to the pre-treatment stage. Moreover, the clarification membranes, with cut off generally higher than 100,000 kd, do not remove the smaller organic matter molecules responsible of the biofouling development on RO membranes. In this situation, it is very difficult to demonstrate the real technical advantage of UF/MF on the RO operation, since this demonstration needs a long-term study (more than one year depending on the application) with side-by-side technologies to compare, and the results appear to be site specific.

Solution of this double problem, UF/MF fouling on average to bad surface seawater and biodegradable organic matters removal, can be found in the treatment line, enhancing the UF/MF treatment by adding a pre-coagulation/settling of flotation. The benefits of this association of technologies are multiples, as it was developed for the treatment on surface water one decade ago for drinking water production. Moreover, the benefit of the coagulation/separation on the design (filtration flux) and operation (frequency of cleaning, membrane life duration) can significantly improve the economical balance of the process. It also allows a definitive advantage

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Presented at the conference on Desalination and the Environment. Sponsored by the European Desalination Society and Center for Research and Technology Hellas (CERTH), Sani Resort, Halkidiki, Greece, April 22–25, 2007.

0011-9164/06/$– See front matter
doi:10.1016/j.desal.2007.01.129

concerning RO membrane fouling and its related impact on cleaning frequency, RO membrane replacement and plant availability.

Keywords: Seawater; Desalination; Direct filtration; Ultrafiltration; Membrane; Pre-treatment; Technical and economical study

1. UF/MF pre-treatment upstream RO: the theoretical BAT

1.1. Objectives definition

RO membranes are very sensitive to foulant materials such as colloids, inorganic scale and biofilm development (biofouling).

The silt density index (SDI according to ASTM) is a useful tool for particle evaluation and, by extension, membrane fouling (extended SDI). The suppliers of RO membranes typically require the SDI_{15} of the feed water to be less than 5, and in fact generally recommend that the SDI_{15} should be less than 3 (DOW, Hydranautics, Toray spec.).

If this parameter is well recognized to quantify particles and NOM in some extend, unfortunately, SDI is not a sufficient parameter to characterize the RO behaviour on a given water.

Pre-treatment must also reduce the organic matters load to reduce both adsorption (fouling) and bacteria growth (biofouling) (Fig. 1).

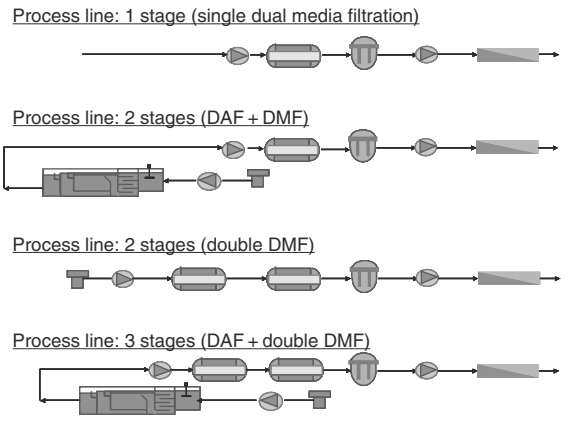

Fig. 1. Conventional treatment line with direct filtration or with coagulation pre-treatment.

1.2. Pre-treatment technologies

Looking at the pre-treatment technologies available for the clarification of seawater upstream RO, a quick and easy classification gives the following:

- Conventional pre-treatment using direct filtration: conventional pre-treatment design (disinfection, coagulation/flocculation clarification, multimedia and cartridge filters) has been widely used at seawater RO plants for removal of excess turbidity and suspended solids, and to meet stringent standards for membrane feed water quality, specified in terms of SDI.
- Pre-clarification by membrane: ultrafiltration (UF) and microfiltration (MF) with in-out or out-in membranes and immerged or pressurized systems. Those technologies are well known on clarification of continental water for drinking water or process water production. Concerning particles removal, efficiency is nearly 100% for both UF and MF technologies. This concerns turbidity, TSS and algae. The efficiency regarding dissolved compounds such as NOM is much more limited, with removal rate ranging 5%, and mainly concerning the largest molecules. In terms of design, and membrane fouling control, UF and MF are always protected by a screen from 500 to 50 μm according to the membrane supplier. It can be necessary to add a coagulation/settling of flotation for the treatment of very bad water quality, to improve the permeate water quality feeding the RO or to optimize the design (filtration flux increase and membrane surface reduction, cleaning frequency reduction, membrane life increase).
- Coagulation and settling: considered as "the pre-treatment of the pre-treatment," located