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The power of Medium Pressure UV technology to combat Biofouling and boost Membrane performance

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Biofouling, the accumulation of microorganisms, extracellular polymeric substances (EPS), and organic materials on membrane surfaces, poses a significant challenge in membrane-based water treatment systems. It adversely affects performance, leads to increased operational costs, and shortens the lifespan of membranes, particularly in seawater reverse osmosis (SWRO) applications.

Biofouling in membrane systems results in many issues, including increased differential pressure (dP), which necessitates frequent clean-in-place (CIP) interventions, heightens energy consumption, and ultimately contributes to membrane degradation. Statistical analysis from a study by Chesters et al. (2011) revealed that biofouling caused approximately 28% of membrane failures. Additionally, when considering related factors like scale formation, biofouling accounts for nearly 80% of failures in SWRO systems (Figure 1). These failures necessitate costly repairs, replacements, and downtime, influencing the operational efficiency of water treatment facilities.

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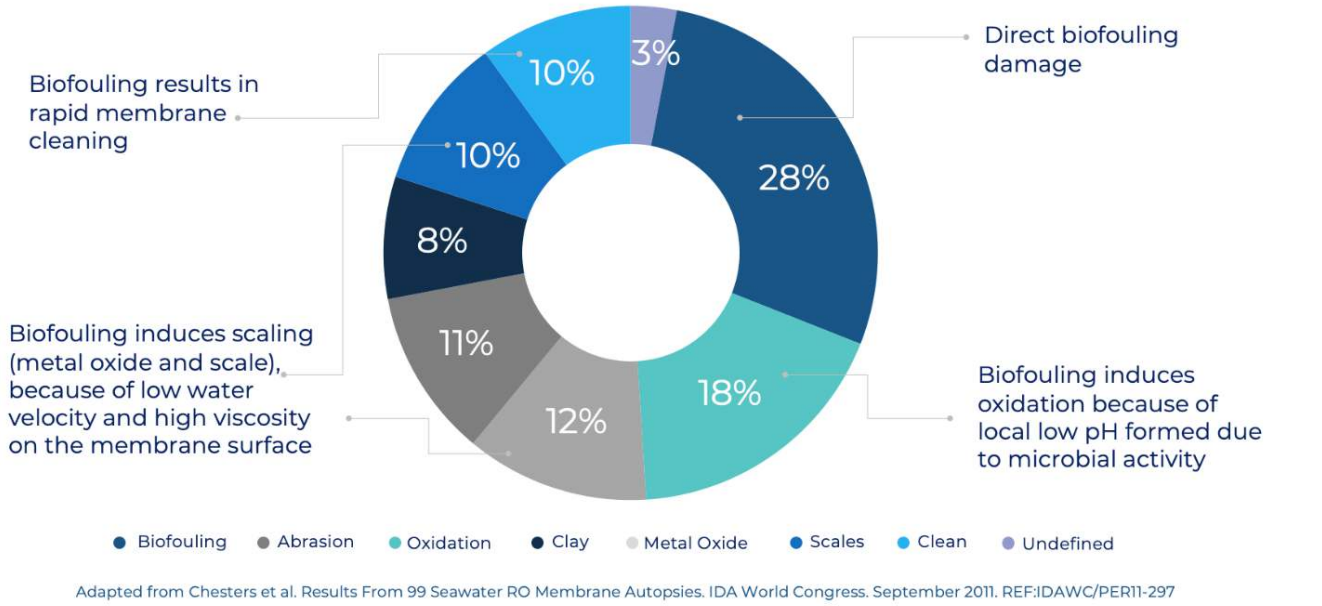

Figure 1. Biofouling is the Major Cause for SWRO Membrane Failures

Limitations of Conventional Biofouling Control Methods

Current methods to prevent biofouling, such as chemical biocides, don't always reduce the biofouling potential. These methods are costly and potentially harmful to the public and the environment. The use of biocides, particularly chlorine, in RO desalination is widely practiced despite documented evidence that although biocides may be advantageous in controlling microbial counts in the water, in some cases, they can exacerbate biofouling of the membranes (Al-Abri et al, 2019).

As an alternative treatment approach to traditional biocides, ultraviolet disinfection, specifically medium-pressure ultraviolet (MP-UV), is a viable disinfection method applicable to RO desalination (Al-Abri et al., 2019; Harif et al., 2011; Marconnet et al., 2011; Munshi et al., 2005; and Otaki et al., 1998) and biofouling protection for membranes.

The MP-UV technology, typically installed after the sodium bisulfite (SBS) injection and before the RO, limits biofouling development because of the ability to keep optimal growth conditions low and minimize bacteria formation.

UV Lamp Technologies and Biofouling Protection for Membranes

UV technology is a physical process that generates wavelengths of UV light, measured in nanometers (nm). UV light, generated by both low-pressure (LP) monochromatic lamps and MP polychromatic lamps, is germicidal and proven to deactivate the DNA of microorganisms like bacteria, viruses, and other pathogens, disrupting their ability to multiply.

All LP-UV lamps provide monochromatic light at a single wavelength of 253.7 nm while MP-UV lamps provide polychromatic UV light within the 200–415 nm wavelength range.

The broad germicidal spectrum of MP-UV lamps is better suited for treating the accumulation of microorganisms, EPS, and AOC on membrane surfaces. Additionally, MP-UV lamps can more readily damage the repair mechanism (photo or dark repair) inherent in microorganisms, preventing possible repair and biofouling downflow of the UV treatment system.

Different studies have supported the effectiveness of MP-UV lamps compared to LP-UV lamps, showing that the needed UV dose from an MP-UV spectrum, compared to the LP-UV spectrum, for achieving the same log inactivation is lower in the MP-UV lamps (Linden et al, 2007).

MP-UV System Configuration

The MP-UV technology is designed in series with a dual sensor configuration (Figure 2). A dedicated UV lamp intensity sensor is used per lamp. The MP-UV system measures three critical parameters, including ultraviolet transmittance (UVT), flow rate, and UV lamp intensity (kW), in real time to maintain a specified UV dose/energy. The MP-UV system automatically adjusts lamp power when conditions fluctuate so that the minimum required dose set by the user is guaranteed to be delivered.

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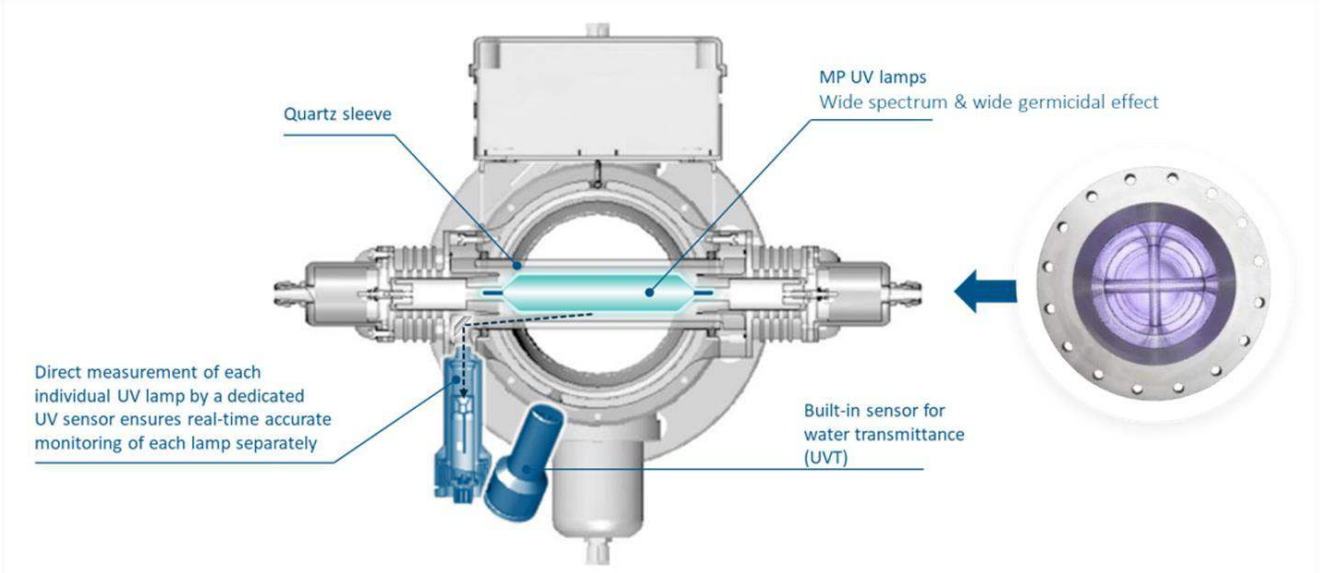

Figure 2. MP-UV System Configuration

Case Studies Demonstrating MP-UV Effectiveness

Operational data shows the MP-UV technology enhances membrane performance and prolongs membrane life. The technology minimizes the membrane biofouling potential, limits bacterial growth, and protects RO membranes and other sensitive equipment without chemicals. Two case studies have been provided; additional application details and data are available in the MTC 2025 paper.

First, a 100,000 m^3/day seawater desalination facility for drinking water experienced significant operational improvements, including a 50% decrease in CIP frequency and a 65% decrease in micron filter replacement events, leading to 4.8% and 7.7% cost savings, respectively. Membrane performance also improved; there was a 21% decrease in post-CIP dP and an 8.2% increase in membrane permeate flow with the MP-UV technology (Figure 3).

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Figure 3. Seawater Desalination Facility With MP-UV Installed

Second, using MP-UV technology, a 1,000 m^3/day water facility at a mining site eliminated the use of chlorination and dechlorination chemicals. Additionally, the frequency of CIP decreased from every 13-30 days to once every five months, the post-CIP dP reduced from 2.5 to 1.25 Bar, there a greater than 80% savings on cartridge filters, and membrane cleaning expenses decreased more than 60%.

Conclusion

The operational improvements and OPEX savings demonstrated in the case studies highlight the significant potential of MP-UV technology in enhancing membrane performance, reducing maintenance requirements, and promoting sustainable water treatment practices. MP-UV technology presents a promising and effective alternative to traditional biocides for preventing biofouling in RO membrane systems. The technology minimizes biofouling potential and contributes to RO membrane systems' overall operational efficiency and longevity, making it a valuable and environmentally friendly solution.

About the Author

Ytzhak Rozenberg - CTO for Atlantium Technologies leading a multidisciplinary R&D team in the development of ‘green’ solutions for municipal and industrial applications based on Atlantium’s proprietary HOD™ (Hydro-Optic Disinfection) system. For more than 30 years, Ytzhak has transformed optics-based technologies into products in the bio-medical, military, and industrial consumer goods markets. Ytzhak holds a B.Sc. in Mechanical Engineering from the Technion Institute of Technology in Israel. Co-authors include Amichai Felder, Vice President of Process and Innovation for Atlantium Technologies, and Assaf Lowenthal PhD, Senior Scientist for Atlantium Technologies.