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# A simple in-situ biofouling analyses in desalination plants

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**Abstract:** A study was conducted to develop an in-situ method for assessing the biofouling potential of seawater and pre-treated seawater used in reverse osmosis systems. Measurements of assimilable organic carbon (AOC) and the standard fouling index using ultrafiltration membrane were performed and compared. The pre-treatment methods evaluated included dual media filtration (DMF) with flocculation and a submerged membrane adsorption bioreactor (SMABR). A linear correlation was observed between AOC concentrations and the standard blocking index (Ks) derived from MFI-UF10. This finding showed that standard fouling test can be employed as an in-situ tool in desalination plants to provide an early indication of AOC, a key precursor to biofouling.

**Keywords**: biofouling; desalination; early detection.

Early detection of biofouling allows for timely preventive measures, such as physical and chemical membrane cleaning, which minimizes chemical usage, reduces downtime, and lowers the risk of biofouling and membrane replacement frequency. Membrane cleaning at an early stage of biofouling significantly improves efficiency and reduces operational costs, including a 10% decrease in annual membrane replacement and chemical expenses, as well as up to a 5% reduction in energy costs (Vrouwenvelder et al., 2011).

Most seawater reverse osmosis (SWRO) plants currently rely on the silt density index (SDI) to estimate the quality of pre-treated seawater in RO fouling. However, SDI is primarily effective in predicting particulate fouling potential and does not adequately assess the risk of organic or biofouling.

Assimilable organic carbon (AOC) measurement is a superior method for evaluating biofouling potential. While accurate, existing methods for AOC measurement are labour-intensive and time-consuming, requiring 1–3 days to complete. Jeong et al. (2022) introduced a luminescence-based approach using *Vibrio fischeri* derived from seawater, offering a faster and highly sensitive alternative. However, this technique necessitates advanced microbiological procedure and is not practical for in-situ applications.

To address these limitations, this research developed a simple, in-situ method for continuously monitoring biofouling using a biofouling index to represent AOC levels. This approach eliminates the need for chemicals and can be adopted in desalination plants.

**Experimental Methodology:** Fouling index is normally measured using a lab-scale membrane filtration setup (Fig. 1). The pressure is kept constant. The total resistance was evaluated based on the membrane resistance model, which relates resistance to either the volume of filtrate or the duration of filtration.

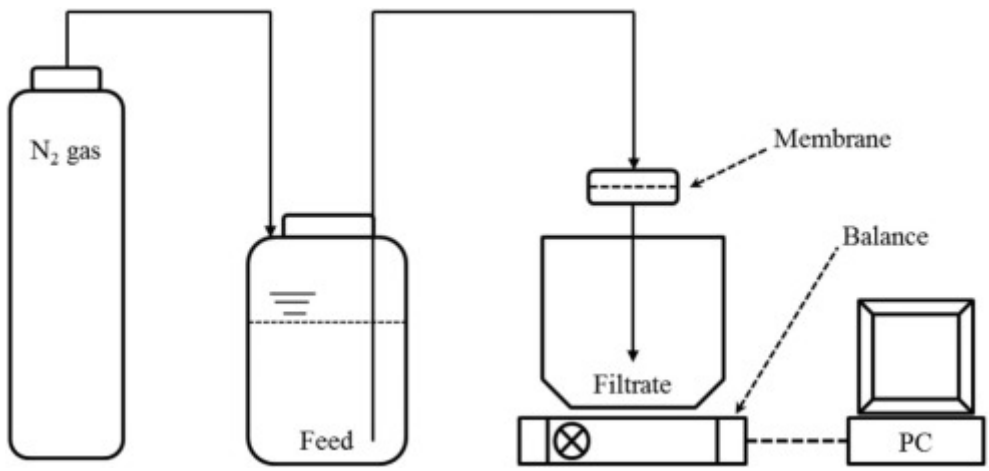


**Figure 1.** Fouling index measurement set-up.

**Results:** Traditional fouling indicators like the silt density index (SDI) and the modified fouling index based on microfiltration membranes (MFI-MF) often fall short in accurately predicting biofouling due to their inability to account for fouling caused by adsorption of organics. To address this, Jeong et al. (2015) proposed using ultrafiltration (UF) membranes with smaller pore size to better represent biofouling potential. Since organic molecules in water are typically lower than the pore size of UF membranes, they tend to adsorb onto the membrane surface or within its pores. The fouling index was measured using a hydrophilic membranes made of poly-ether-sulfone (PES) with an MWCO of 10 kDa, fabricated by NADIR®RM. The UF membrane demonstrated a pure water flux exceeding 150 L/m²h at 3 bar. Manufacturer data indicated a retention rate for PVP K17 of 63–85%, while lab measurements showed a zeta potential of −13 ± 1 mV (at pH 7) and a contact angle of 44 ± 5°. Preliminary testing with UF membranes of 5, 10, and 20 kDa MWCOs revealed that the 10 kDa membrane exhibited a linear fouling pattern over time, making it the most suitable choice. Consequently, the 10 kDa membranes was selected in this study. Both raw and treated seawater underwent a pressure of 2.0 bar (207 ± 3 kPa) using nitrogen gas forfouling measurements.
Standard or pore blocking index ($K_s$) was calculated from the following equation.

$$t/(V/A) = 1/ J_0 + K_s /2 \qquad \text{(Eq 1)}$$

here t is the time of filtration, V is the total filtrate volume, A is the filtration area (0.001735 m2), $J_0$ is the initial filtration rate, and $K_s$ is the standard or pore blocking index.

A linear relationship between $t/(V/A)$ and $t$ indicated pore blocking behaviour. The pore blocking occurs when particles stick onto the membrane pores, gradually reducing their effective diameter.

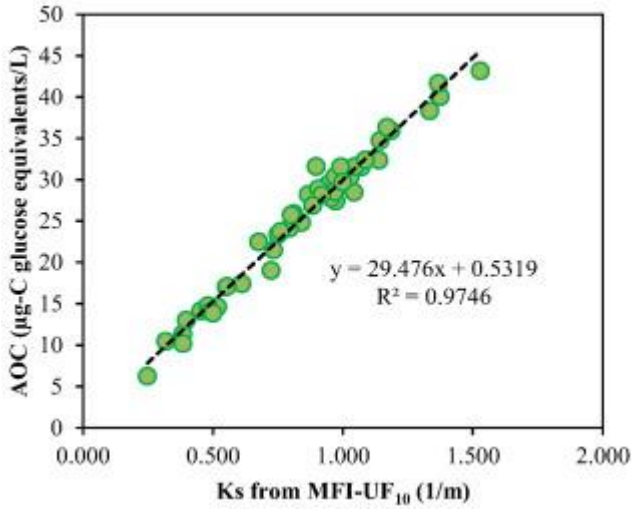


**Figure 1.2** Relationship between Ks value obtained from Equation 1 and AOC of the pre-treated seawater.

Further methodological details and data are available in Jeong and Vigneswaran (2015). The findings showed that the pore blocking index (Ks) derived from Equation 1exhibited a strong correlation with the AOC concentration in pre-treated seawater (Figure 2). This suggests that the MFI-UF10 rig can serve as a reliable method to represent relative biofouling levels.

The MFI-UF10 test is compatible with desalination plants, as it can be conducted using the same setup as the silt density index (SDI) test, which is widely used in such facilities. The only modification required is the replacement of the membrane with a UF 10 kDa membrane.

**Conclusion:** Jeong and Vigneswaran (2015) observed a strong linear correlation between Ks values and AOC concentrations in pre-treated seawater, suggesting that Ks can serve as an initial indicator of AOC. This makes standard/pore fouling rig (Figure 1) a representative tool for the early detection of biofouling in desalination plants, offering a faster alternative to traditional AOC analyses, which are time-intensive and require specialized microbiological and chemical laboratories.

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