



# **Technical Position Paper**

## **Chlorination in RO Seawater Supply Lines and Pretreatment Processes**

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## Introduction

Hydranautics seawater elements have been used in a variety of plants around the world. The total capacity of treated water from these plants as of 2008 exceeds 1.7 million cubic meters per day. Extensive plant data has shown that the membranes can reliably produce a high quality of product water. However, some plants have shown higher fouling rates, which is most often associated with the feed water quality and the type of pretreatment. A variety of pretreatment processes can be used, including beachwell filtration, coagulation and clarification, sand or multi-media filtration, cartridge filtration, microfiltration, and ultrafiltration. Many of these pretreatment processes utilize chlorination to control problems associated with biogrowth. Additionally, many sites will use chlorine to control biogrowth formation in the supply lines as well. Polyamide RO membranes, however, are degraded by chlorine. Hydranautics requires that no (0.00 ppm) free chlorine is introduced into the RO system. If chlorination is used, chemicals must be added before the RO system, with sufficient mix time, to neutralize the chlorine and ensure the RO feed is chlorine free.

Although chlorine effectively controls biogrowth in the pipe or process equipment, many plants find that there can be significant biofouling in the vessels and on the RO membrane itself. This phenomenon is due to the ability of bacteria to grow again, once the chlorine is removed. Biofouling of the membrane can lead to more plant down-time, higher operating cost due to higher feed pressures, higher chemical cleaning costs, shorter membrane life, and degradation of permeate quality.

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## Current Studies

Recent research has provided a new perspective on the cause and control of biofouling in seawater RO systems. One such paper by Saeed, Jamaluddin, and Tisan<sup>1</sup> studied the selection of an optimal coagulation dosing point, the selection of the dechlorination dosing point in the system, and the termination of the chlorination/dechlorination process. In general, the studies show that the chlorination step prevents biogrowth and retards biofilm formation in the pipe and equipment as long as the free chlorine is present; however, the regrowth of bacteria was found to

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<sup>1</sup> "Biofouling in a Seawater Reverse Osmosis Plant on the Red Sea Coast, Saudi Arabia" by M.O. Saeed, A.T. Jamaluddin, I.A. Tisan, Proceedings of the IDA World Congress on Desalination, San Diego, CA, Volume II, Pages 207-221, 1999.

be very rapid immediately after dechlorination. This indicates that all bacteria are not killed by chlorination. The bacterial growth rate was actually found to be higher immediately after chlorination/dechlorination compared to raw, unchlorinated water. This was attributed to the surviving bacteria feeding on the new nutrients from the chlorine degraded organic material.<sup>2</sup> The study also showed that as nutrients in the feedwater are consumed, the bacteria growth rate will decrease due to lack of nutrients. For example, higher biofilm formation rate was seen immediately after the dechlorination step, compared to positions much further along in the process. Thus, dechlorination should be done **as far from the membranes as possible**, while still ensuring biofouling control of critical equipment. There were some advantages when chlorination/dechlorination was not used, including slower biofilm formation on the membrane. This actually resulted in 33% lower pressure drop in the RO system compared to the operation with chlorination/dechlorination. They concluded that chlorination enhances bacterial growth, and thus the possibility of biofilm formation in the RO system. However the authors had concern about biofilm formation in the intake lines and indicated that some chlorination of intake lines would likely be required.

The rate of biogrowth for a given water can vary, depending on water temperature, organic nutrients available, feedwater pH and other factors. Thus, the use of continuous chlorination/dechlorination, intermittent chlorination/dechlorination or no chlorination can each be used, although the success will depend on the site. Some sites have found that weekly or biweekly use of chlorination could control biogrowth at the intake<sup>3</sup>, while others have operated more successfully without chlorination.<sup>4</sup>

## Hydranautics Experience

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Hydranautics has SWC1 and SWC3 seawater RO elements operating at plants that do not use chlorination/dechlorination in the pretreatment process. These plants in Southern Europe and the Mediterranean region have not had significant problems with biofouling. In some cases the non-chlorination strategy has improved performance. In the past Hydranautics built and operated

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<sup>2</sup> "Biofouling Status of the Saline Water Conversion Corporation (SWCC) Reverse Osmosis (RO) Plants in the Kingdom of Saudi Arabia, A Consultancy Report", by H. Winters, 23, 1994.

<sup>3</sup> A. Hamida and I. Moch Jr., The International Desalination and Water Reuse Quarterly, 6/3 (1996) 40-44.

<sup>4</sup> "New Technology to control Biofouling", I. Moch Jr., A. Ben Hamida, H. Pohland, Proceedings of the IDA World Congress on Desalination, Abu Dhabi, UAE, Vol. IV, 59-72, Nov. 18-24, 1995.

<sup>5</sup> "Operating results and economics of single stage and two stage large size seawater RO systems", S. Kremen, M. Wilf and P. Laverty, Desalination, 82 (1991) 15 - 30.

commercial seawater plants<sup>5</sup> which, operated successfully without continuous chlorination. The approach was to include feed chlorination equipment in the RO system design but apply chlorination only when required. The requirement for chlorination was determined by monitoring system operation for signs of biofouling. The signs include: an increase of bacterial population along the system, an increase of trans-membrane pressure differentials, and/or an appearance of bacterial slime on the internal wetted surfaces. Biofouling at the initial stages can be controlled by intermittent chlorination of the feed water supply lines *or* disinfection of the *whole system* with non oxidizing *biocide*. Long term experience using the above method of pretreatment indicates that such approach is effective in mitigating fouling rate and also reduces potential danger of membrane damage due to exposure to strong oxidants.

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## Summary

- Biofouling is enhanced by higher water temperatures, higher organic compound concentrations, and degradation of organic compounds to bio-assimable material by chlorination.
- The use of intermittent chlorination/dechlorination or no chlorination is a technically sound alternative for many seawater RO plants. This has been used successfully at plants with Hydranautics' products.
- Selection of a chlorination/dechlorination process needs to be assessed independently for each site. Systems which require continuous or intermittent chlorination, should move the dechlorination step as far from the membranes as is feasible.
- Removal of bacterial nutrient sources will minimize biogrowth and fouling of the membrane. Effective coagulation and filtration are important to achieve this for high organic laden waters.
- Customers who use chlorination/dechlorination must ensure that the chlorine concentration of the feed water to the RO membrane does not exceed 0.00 ppm of free chlorine. The information contained in this document is for technical reference only. Hydranautics does not warranty the performance of the system regarding the use or non-use of chlorination/dechlorination processes.