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# Testing of DuPont™ B-Free™ technology in Arabic Gulf water at Sharjah Electricity & Water Authority (SEWA) Hamriyah Desalination Plant

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**ABSTRACT**

Increasing water and power demand in the Middle East requires that desalination plants maximize overall efficiency and operate on the lowest production. Despite the extended pretreatment in the Hamriyah plant, the deteriorating quality of seawater over the last years, the heavy marine biological growth and the extended red tide have imposed serious challenges for seawater reverse osmosis (SWRO) operation. Sharjah Electricity & Water Authority (SEWA) aims to achieve the best long-term performance and reliability to maximize plant availability throughout the year. DuPont™ B-Free™ creates an instant and sustained biostatic environment for the downstream RO operations and is resilient to upstream upsets. This pretreatment will allow water production to be maintained during all regular variations in seawater quality throughout the seasons and in future. A demo unit was installed and commissioned on-site to demonstrate the reduction in fouling potential achieved thanks to DuPont™ B-Free™ pre-treatment technology. This long-term test has shown significant improvements in SWRO operation and the mitigation of biofouling potential. These results are translated into reduced energy consumption, reduced chemical cleaning, and upgraded system reliability.

*Keywords:* Biofouling; Reverse osmosis; Media; Bacteria; Desalination

## 1. Introduction

### 1.1. Biofouling

Biofouling is the most challenging type of fouling to manage in reverse osmosis (RO) systems due to the propensity of microorganisms to multiply rapidly in the non-sterile environments of commercial plants [1]. Microorganisms preferentially colonize the membrane feed spacer and, to a lesser extent, the membrane surface, generating biofilms on these surfaces. Bacterial biofilm formation is initiated by the attachment of free-floating bacteria to the surface [2]. The biofilm matrix, comprised of extracellular polymeric substances (EPS), is a sticky and hydrated mixture of carbohydrates and proteins, immobilizing and supporting microbial cells as they grow [3]. EPS enables microbial cell attachment to both the membrane and feed spacer surfaces, further contributing to biofilm formation and gradual clogging of the feed-concentrate channel. This results in the reduction of the channel's void space leading to an increase in water resistance and an exponential pressure drop [4], thus reducing the efficiency of the reverse osmosis module and increasing energy consumption. EPS also provides considerable mechanical and chemical stability to bacteria, making biofilms challenging to clean [5].

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*1.2. Methods to mitigate biofouling*

Polyamide-based membranes are sensitive to oxidizing agents, such as chlorine, which significantly limits the use of chemicals for preventing bacterial growth in feed water [6]. Furthermore, conventional pretreatment methods, such as coagulation, flocculation, ultrafiltration, or cartridge filters, are inefficient at removing biofouling potential from feed water [7].

Once biofilms have accumulated on the surfaces of RO systems, they are notoriously challenging to prevent and remove [8]. Chemical cleaners can hydrolyze the polysaccharides and proteins from the EPS matrix to disperse fouling layers. However, the efficacy of cleaning methods for biofouling is limited, even under harsh conditions [9]. However, the harsh cleaning of biofouling is insufficient and would result in the rapid regrowth of biofilms after each CIP [10].

One alternative for combating bacterial growth is metabolic inactivation, which involves in-line water treatment before it reaches the RO modules to minimize the risk of biofilm regrowth. Physical and chemical inactivation are the two available options [11]. Biocidal agents are effective in preventing biofouling formation. However, most used biocides, such as hypochlorite and chloramines, are oxidizing compounds that are harmful to polyamide membranes over time. Only non-oxidizing biocides effectively control bacterial activity without harming thin-film composite RO membranes. However, it is important to consider the severe environmental and health risks associated with biocides when deciding on their implementation.

*1.3. New biofouling free technology*

DuPont™ B-Free™ is a pre-treatment technology that aims to alleviate the limitations of currently available methods for preventing reverse osmosis biofouling. It provides a compact, efficient, chemical-free, and robust solution to the problem. This vessel-based technology eliminates the harmful effects of biofouling, while creating an instant and sustained biostatic environment for downstream RO operations [12]. Unlike traditional methods, DuPont™ B-Free™ does not require chemicals during its operation and can resist upstream upsets. The technology employs three different media, each with a specific purpose in the process, as depicted in Fig. 1.

The biostatic environment is established by combining three synergic mechanisms:

- Biological: Bulk nutrients removal by biomass.
- Filtration: Barrier against biomass carry-over.
- Chemical: Phosphate polishing to create bio-static environment.

During normal operation, the system is maintained through backwashing, using only water and air, making it a sustainable, chemical-free solution against biofouling (Fig. 2). The maintenance interval is influenced by the growth rate of the biomass and the linear velocity applied for filtration. Backwashing is triggered by an increase in head loss over the media bed, caused by the accumulation of biomass in the free void fraction of the media or visual observation of the stratum height, if a sight-glass is available.

## 2. Methods

The study was conducted in SEWA Hamriyah Desalination Plant (90,000 m³/d) located at Sharjah region (United Arab Emirates). It uses ultrafiltrate sea water from

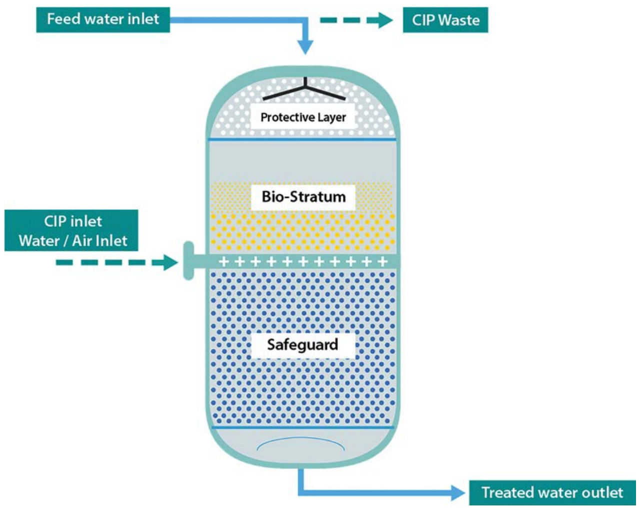


Fig. 1. Vessel layout.

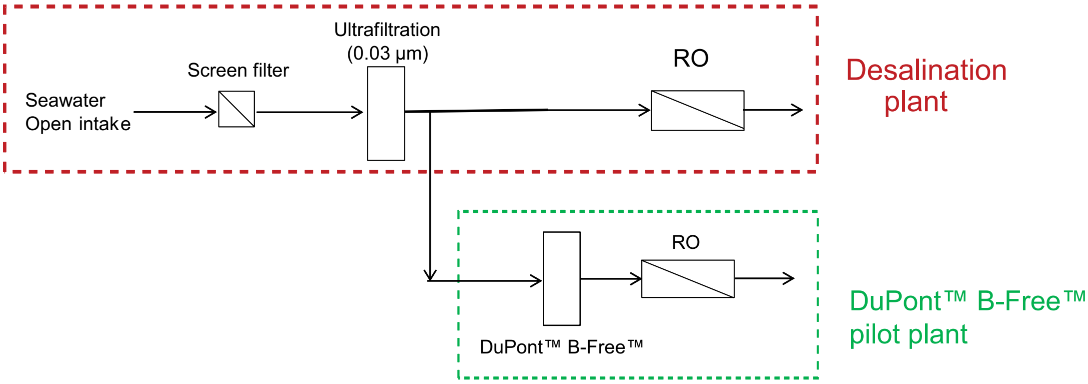


Fig. 2. Pilot plant set-up.

an open intake as feed source and has been suffering from biofouling problems in the RO. To resolve the biofouling challenges, a pilot plant was deployed to test the novel pre-treatment technology – DuPont™ B-Free™ designed to eliminate the effects of biofouling in the RO system.

DuPont™ B-Free™ biofouling prevention performance was evaluated by comparing reverse osmosis element installed in B-Free™ pilot plant to reverse osmosis elements from desalination plant as control (Fig. 2). The pilot plant is operated with same RO type, feed water and operating conditions as the large desalination plant, to allow comparison.

A constant pressure drop over time indicates that biofilm is not developing within the RO module. Desalination plant was operated without DuPont™ B-Free™ technology and its pressure drop trend was used to quantify the number of chemical cleanings prevented and assessing the biofouling prevention achieved by the pre-treatment. After operation, a detailed visual inspection of RO was completed to confirm operational results in pilot plant.

The glass fiber-reinforced-polymer composites (GFRP) vessel used to operate DuPont™ B-Free™ has an inner diameter of 1,000 mm and the feed flow is 13 $m^3/h$. The bed height is 80 cm, corresponding to 630 L of media.

The open intake seawater used as feed water to the desalination plant has undergone an extensive pre-treatment. Because of the dissolved nutrients that remain present, however, the feedwater still has high biofouling potential once reaching the RO system, leading to biofilm build-up and a corresponding rapid pressure drop (Table 1).

## 3. Results

During the extensive trial (nearly 1 y), the biofouling prevention achieved with DuPont™ B-Free™ for the cartridge filter and reverse osmosis elements was evaluated by comparing the performance of pilot plant to the desalination plant one.

During piloting several backwashes were performed to restore the pressure drop of the DuPont™ B-Free™ system. As can be observed in Fig. 3, the backwash protocol with water and air was effective in restoring performance without the need to use chemical cleanings.

The dP trigger used was around 0.85 bar. After the backwash, the amount of water treated before reaching the dP trigger once more can be used as a means of evaluating its effectiveness. DuPont™ B-Free™ can treat more than 2,000 $m^3$ of raw water before a backwash is required. Considering these results and water requirements during backwashes, average water recovery has been 99.4%.

Biofouling impacts reverse osmosis operations severely, causing a rapid increase in pressure drop (dP). The desalination plant suffers from high chemical cleaning (CIP) frequency with an average CIP rate of 27 chemical cleaning per year.

Table 1
Feed water properties

| | |
|---|---|
| TDS (mg/L) | 41,700 |
| K (mg/L) | 510 |
| Na (mg/L) | 13,200 |
| Mg (mg/L) | 1,300 |
| Ca (mg/L) | 400 |
| $HCO_3$ (mg/L) | 170 |
| Cl (mg/L) | 22,800 |
| $SO_4$ (mg/L) | 3,200 |
| Boron (mg/L) | 4 |
| pH | 6.8 |

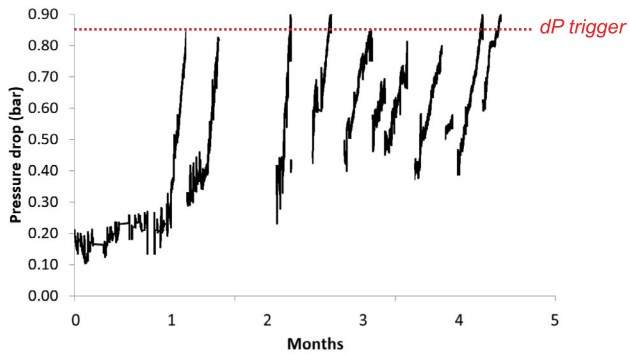


Fig. 3. Backwash overview during operation.

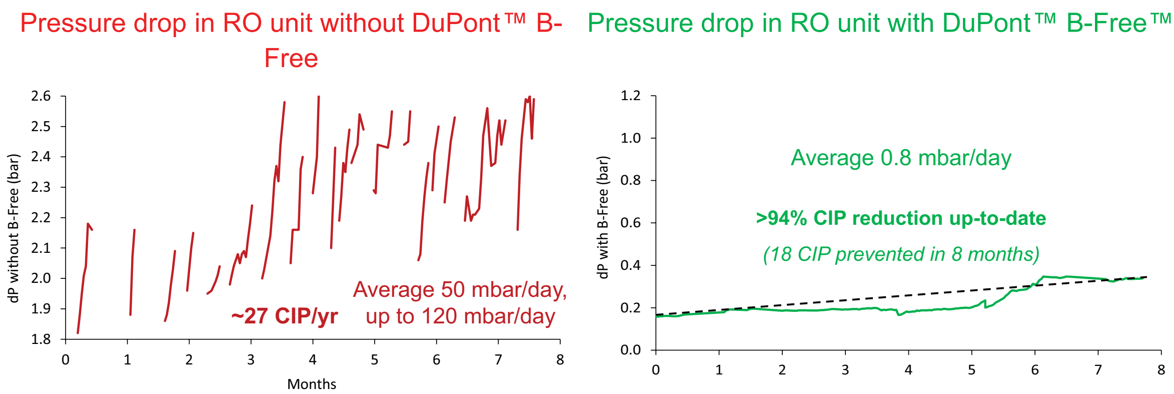


Fig. 4. Cartridge filter pressure drop evolution in seawater test.

In contrast, DuPont™ B-Free™ pre-treatment in the pilot plant creates an instant and sustained biostatic environment for the downstream RO operations and is resilient to upstream upsets. In a period of eight months, an equivalent of 18 chemical cleanings would have been required in the desalination plant, compared to the stable operation in the RO operated with DuPont™ B-Free™ (Fig. 4). The average increase in the pilot plant was only 0.8 mbar/d.

## 4. Conclusions

DuPont™ B-Free™ pre-treatment technology for biofouling prevention in RO is a novel vessel-based media technology that provides instant and sustained biofouling protection. It has been validated using seawater at a commercial desalination plant with industrial-size elements. For nearly 1 y of piloting, it provided stable operation, neutralizing the high biofouling present in the feed water.

Moreover, DuPont™ B-Free™ is compact and easy to operate, with only air and water cleaning, eliminating the need for chemicals.



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