HOD™ UV Chemical-Free Solution for Desalination Plants

Chlorine and SMBS replacement in seawater desalination plants with Atlantium HOD™ UV

Atlantium Technologies has successfully completed its full-scale case study in northern Chile, proving once again the efficiency of its HOD™ UV technology for biofouling control on reverse osmosis membranes.

The study has been carried out in the sulfuric acid production plant NORACID, in Mejillones, Chile, for more than 10 months with extremely successful results.

Introduction:

A frequent practice in seawater desalination plants is the initial chlorination to prevent microbiological colonization on reverse osmosis membranes, trying to avoid "biofouling", one of the most common problems that damage their performance: decreasing in flow and quality of the RO permeate, increasing differential pressure, resulting in more frequent chemical cleaning, and shortened RO lifetime. Due to its oxidizing nature, chlorine attacks the RO membrane polymers, so pre-RO dechlorination is required, which is usually carried out by in-line dosing of sodium metabisulfite. This procedure often promotes and increases the formation of biofilm. Atlantium developed an alternative treatment approach that minimizes the membrane biofouling potential, minimizing anaerobic and aerobic bacterial growth, and protects RO membranes and other sensitive equipment without the use of chemicals.

Development:

Recent studies propose a comprehensive approach to minimize the formation of bio-fouling considering all the factors involved in its formation and growth by evaluating the "potential for bacterial growth" according to:

- Microbiology: microorganisms total count
- The extracellular polymeric substances (EPS)
- Presence of available nutrients for bacteria, expressed as "assimilable organic carbon - AOCs".

Not all organic carbon compounds present in water are assimilable by bacteria. Only a fraction of it can be biodegraded, which is of main interest as they enhance microbiological proliferation.

Chlorination-Dechlorination

A side effect of chlorination is the oxidation of dissolved organic matter increasing the "assimilable" organic fraction, increasing the "potential for bacterial growth". Doses as small as 0.5 ppm of free chlorine can increase up to 80% the assimilable carbon content (Maria Kennedy, IHE Delft).

Additionally, the dosage of a chlorine scavenger such as sodium metabisulfite, which is usually dosed in excess, simultaneously absorbs the dissolved oxygen, generating an environment favorable to the development of anaerobic microorganisms, according to Figure 1.

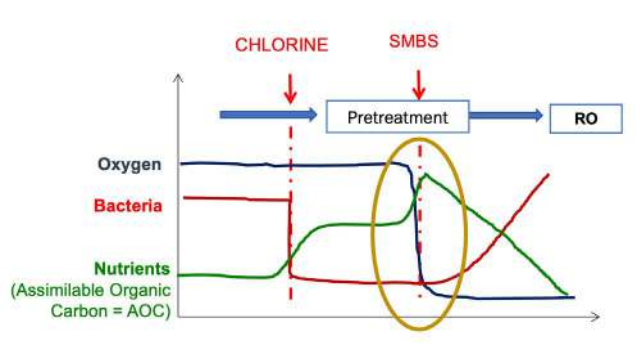


Figure 1: Evolution of concentrations at different stages of pretreatment

Application of medium-pressure HOD™ UV

The biofilm is constituted of 80-85% of macromolecules segregated by microorganisms for their protection and growth: the Extracellular Polymeric Substances (EPS.), so an accurate strategy to control biofouling must prioritize EPSs minimization. UV radiation is used in relatively low doses and has a minor or no effect on the content of degradable organic matter. It has been widely proven that the use of medium-pressure (MP) lamps achieves cell inactivation, inhibiting repair mechanisms and simultaneously affecting vital functions like EPS secretion driving to reducing biovolume and making biofilm more porous.

The results obtained show that the HOD™ MP UV strongly impacts the RO membranes' surface biofilm characteristics, meaning more constancy in the flow and consequently an improvement in plant performance

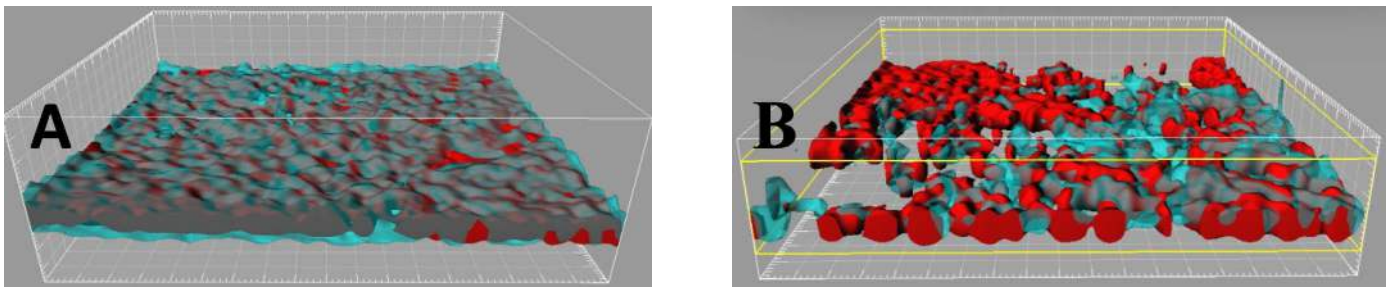


Figure 2: Confocal laser microscopy (CLSM) of biofilms with and without UV pretreatment

- (A) Biological contamination layer without UV pretreatment.
- (B) Biological contamination layer with Total EPS biomass (transparent light blue) and microorganisms (red), after UV pretreatment.

The content of EPS in the biofilm on the membrane that received the water irradiated with HOD™ UV was much lower in comparison to the membrane that did not receive this pretreatment.

The application of UV radiation for biofouling control allows several benefits in desalination plants:

1. Maintaining flow at lower operating pressure = energy savings.
2. Fewer CIP processes are required allowing longer membrane useful life.
3. Increasing the duration between microfiltration cartridges replacement.
4. Allow replacing existing chlorination or biocides.

NORACID seawater desalination plant, Mejillones, Chile: Replacement of chlorine and SMBS by HOD™ UV system

Noracid produces 720,000 tons/year of sulfuric acid for mining activity in the area and uses demineralized water to feed its high-pressure boilers (electricity generation). The seawater desalination plant presented several performance problems:

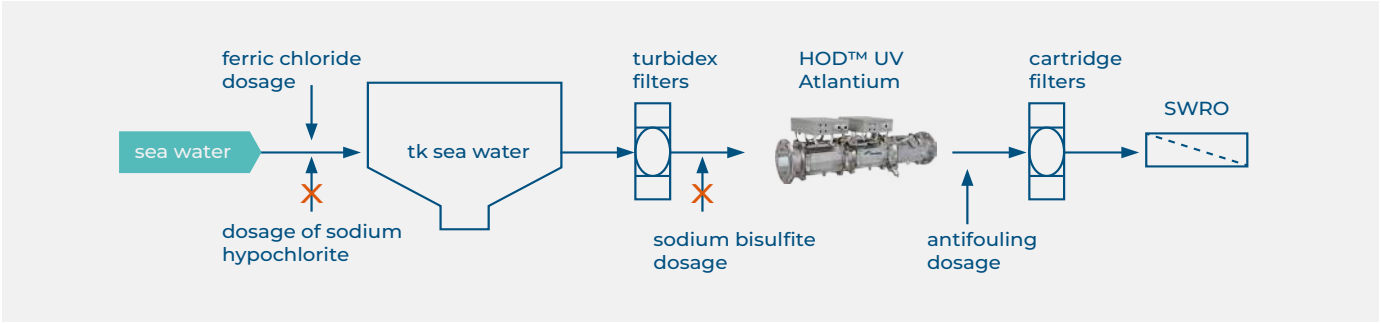
RO Permeate Flow:	30-35 m^3/hr
Membrane service life :	2 years
Cartridges replacement :	Every 4 days average
CIPs frequency :	Every 13-30 days
Chlorine dosage:	2 ppm
MSBS dosage:	20 ppm
Ferric Chloride dosage:	3 ppm

Figure 3: Installation skid HOD™ UV with RZ163-11 HP, 2.3 kW equipment

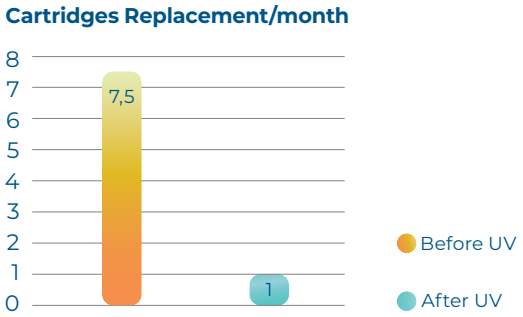
On July 2022, a skid containing an Atlantium RZ 163-11 system with one 1.7 kW medium pressure lamp was installed, vertical mounting, as shown in Figure 3. Since its installation there has been notable performance improvements.

1. Chlorine dosing stopped and consequently dechlorination with SMBS dosing was also stopped.
2. The dose of Ferric Chloride was gradually reduced, operating satisfactorily with only 0.5 ppm as there was no interaction with the other chemical reagents such as Chlorine.

In this way, the system was operated according to the following diagram:



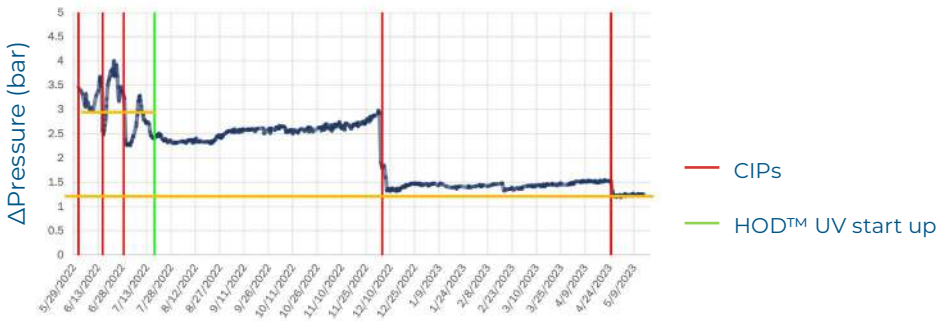
The benefits in terms of extending cartridge life and increasing the time between chemical cleanings were quickly verified, by reducing biofouling as can be seen in the graphs below relative to microfiltration cartridges replacement and the feed-brine pressure difference (delta P):



Transmembrane pressure differential (ΔP) :

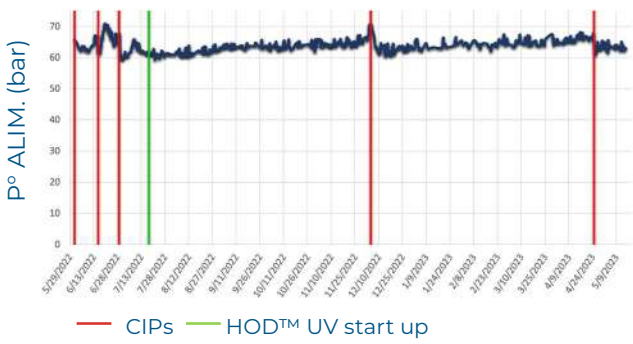
It achieved the lowest post - CIP ΔP (> 20 psi), which was never seen before. This means the changes in biofilm structure (less EPS) make CIP more effective, cleaning membranes more deeply, and even better, after the second CIP.

Differential Pressure

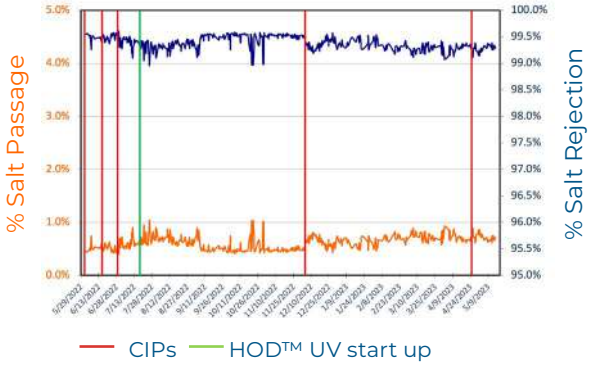


Other graphs on plant performance:

Feed pressure



Salt rejection %



Savings in OPEX from the installation of the HOD™ UV

Chemicals:

1. Chlorination/dechlorination removal (SMBS) previously used for biofouling control.
2. Reduction of coagulant dose, due to change in water characteristics after avoiding previous chlorination and related side reactions.
3. CIP: CIP reduced from once every 13 days to once every more than 5 months.
4. Greater removal of biofilm, which is evidenced by the smaller transmembrane pressure difference.
5. Fewer chemical residue measurements and consumption of analytical reagents.

Performance improvement and service life extension

The differential pressure shows a significant constancy for

155 days

During this time the RO permeate flow rate and conductivity were maintained operating at lower feed pressure

Savings in OPEX from the installation of HOD™ UV

Moreover, once a CIP was performed after 5 months with HOD™ UV pretreatment, **the differential pressure fell like never before**

Consequently, energy consumption per m^3 produced shows a reduction > **3%**

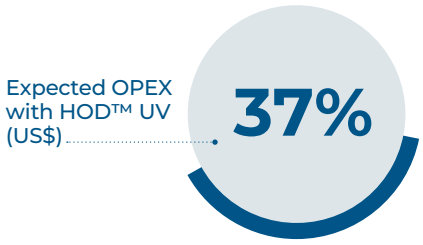
Drastic decrease in chemical cleanings should mean a significant extension of RO membrane life

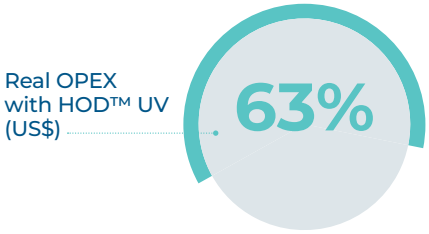
Optimization of operation and maintenance:

1. Increased plant operational availiability due to fewer events (cartridge replacements, CIP, etc.)
2. No more time and safety risks due to chemical transfer and handling
3. Reduces labor apent changing microfiltration cartridges and chemical cleaning
4. Eliminates maintenance of metering pupms
5. Reduction of physicochemical control of residuals

Annual Operating Cost Comparison => Return on Investment			
Item	**without HOD™ UV (US$)**	**Expected OPEX with HOD™ UV (US$)**	**Real OPEX with HOD™ UV (US$)**
Chemicals	21,918.60	3,207.60	534.60
Membrane Cleaning	18,240.00	13,680.00	6,768.00
Microfiltration cartridges	18,264.00	13,698.00	2,401.92
Membrane lifetime (partial replacements) estimated	21,056.00	14,739.20	14,739.20
Indirect OPEX	6,000.00	3,000.00	1,440.00
UV lamps	-	4,000.00	4,000.00
Technical Assistance (bimonthly visit)	-	1,920.00	1,920.00
Total Operating Cost (year)	85,478.60	54,244.80	31,803.72
OPEX savings per year		31,233.80	53,674.88

Percentage of savings





Conclusions:

The comparison of operating results shows the economic advantage of implementing this pre-treatment with a very clear ROI. Moreover, they have exceeded our initial expectations, being even more to NORACID. Additionally, there are qualitative advantages such as:

1. The performance of the desalination plant has improved significantly, and is highly valued by the client, who can minimize attention on it and can concentrate more on its "core business".
2. Totally friendly to the environment as there are no undesired residuals and allows the elimination or minimization of chemicals.
3. In line with the UN 2020 targets: "to achieve environmentally proper management of chemicals....., in accordance with internationally agreed milestones, and significantly reduce their release into **air, water, and soil to minimize their negative effects on human health and the environment"**

In summary, configuring the best available solution in terms of efficiency and environmental care guarantees the adequate pretreatment of seawater desalination plants.