THE FUTURE OF RO

Increase Production & Uptime with Fouling-Immune Technology

ZwitterCo

OVERVIEW

Reverse osmosis (RO) membranes have been revolutionary technology in water treatment and are a cornerstone in industrial applications. However, despite their crucial role, traditional RO membranes are still prone to issues like **organic fouling** and **biofouling.**

Despite membrane manufacturers' efforts to tackle biological and organic fouling with resistant RO elements for decades, the reliability of water treatment systems continues to suffer.

Now, an era of new membrane chemistry has finally arrived. ZwitterCo has developed an advanced RO membrane that uses zwitterionic chemistry to solve irreversible fouling challenges. This innovative membrane technology ensures **reduced cleaning frequency, which means less downtime, longer membrane life, and lower costs.**

ZwitterCo is not reinventing the wheel – just making it *better*.

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CHAPTER 1

Identifying Problems with RO Membranes

RO undeniably plays an essential role, not only in industrial water treatment, but also in protecting the environment and promoting sustainability. RO technology aids in conserving water, a resource that is becoming increasingly scarce in many parts of the world. By removing contaminants, RO systems purify water and minimize waste generated, contributing to the overall sustainability of water resources.

RO membranes are integral to achieving broader goals of environmental protection, resource conservation, and promoting sustainable industrial practices.

By ensuring that water and wastewater are treated efficiently and effectively, RO helps maintain the balance of our ecosystems while supporting economic growth and development.

> Water is not just a nice-to-have sustainability goal – ***it's a license to operate.***

PROBLEM #1 - FOULING

One of the biggest challenges with RO systems is **membrane fouling.**

While RO membranes may be chemically cleaned to combat fouling and recover performance, **cleaning accelerates the deterioration of RO membranes, requiring regular replacements, causing significant operational burdens, and driving up operational costs.**

ORGANIC FOULING

One of the main challenges is organic fouling, which occurs when there is a build-up of natural organic matter in the water that adheres to the surface of the RO membrane, reducing its efficiency. This build-up leads to a decrease in operational flux and an increase in pressure drop across the membrane. Organic fouling not only diminishes the performance of RO systems but also shortens the lifespan of the membranes.

BIOFOULING

Biofouling is another significant hurdle that involves the growth of bacteria or other microorganisms on the RO membrane. Biofouling is particularly problematic because it can lead to the development of biofilms, which are resistant to standard cleanings and can significantly impair water flow and purification efficiency.

Both organic and biofouling issues increase the need for more frequent chemical cleanings, which cause membrane degradation, resulting in a decline in performance and consequently, more frequent membrane replacements. If you are replacing your membrane every two years or more frequently, or cleaning at least once a month, expenses can add up quickly.

PROBLEM #2 - FREQUENT MEMBRANE REPLACEMENTS

Every cleaning cycle chips away at the lifespan of your membranes, requiring you to replace your membranes more often. Whether planned or unplanned, the cost of new RO membranes can negatively impact budget. Frequent replacements not only increase overall costs but also contribute to additional downtime associated with installing and commissioning new membranes. Because each replacement cycle requires taking the system offline and halting production, frequent replacements often disrupt operations and lead to lost productivity on top of additional expenses.

The cost of frequently replacing membranes extends beyond the price of purchasing new membranes. There are also costs involved in the installation and setup process. Each time you install new membranes, you're increasing labor costs and redirecting resources to ensure the system is up and running smoothly as soon as possible.

Overall, the frequent need to replace membranes can strain your maintenance schedule and resources.

Planning and executing these replacements requires careful coordination to minimize disruption, but even with the best planning, there is always an unavoidable period of downtime.

PROBLEM #3 - DOWNTIME FROM CLEANING

Frequent membrane cleaning, while necessary to maintain system performance, tends to heavily increase overall expenses. With each cleaning cycle requiring a temporary system shutdown, downtime costs from membrane cleaning can detrimentally affect operations.

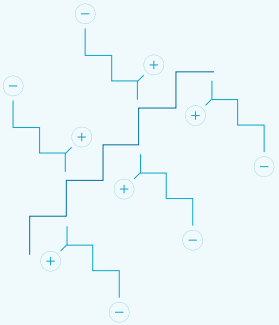
Each time your system goes offline for a cleaning cycle, it's not producing purified water, which translates directly to lost productivity. This lost productivity can quickly add up, especially if your facility operates on tight schedules. Frequent periods of system downtime make it more difficult to meet production volume targets, impacting downstream processes and ultimately your bottom line.

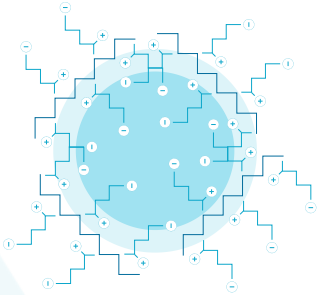
System upsets, such as sudden fouling or unexpected spikes in contamination, can also worsen these issues, creating additional or longer periods of unplanned downtime. These upsets not only increase the frequency of necessary cleanings but can also lead to emergency maintenance situations that further disrupt your operations.

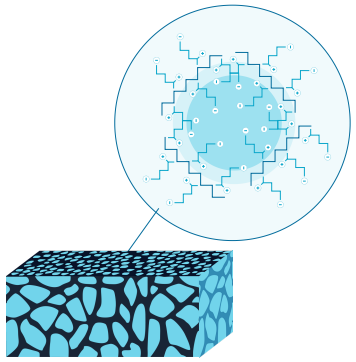
If you are replacing your membrane every two years or more frequently, or cleaning at least once a month, expenses can add up quickly. Along with increased expenses, the downtime from cleaning and maintenance can disrupt production schedules and impact overall productivity.

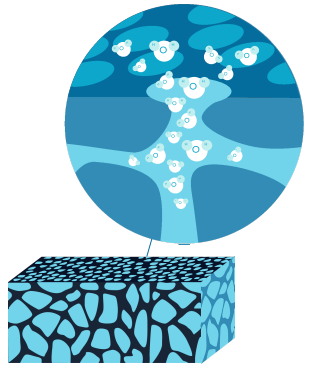
CHAPTER 2

Why ZwitterCo Membranes Are Different









POSITIVE & NEGATIVE CHARGES

First, zwitterions attract to water molecules, displacing or repelling organic compounds.

PROPRIETARY CO-POLYMERS

Co-polymers bind zwitterions with hydrophobic molecules for stability, preventing wearing away over time.

FOULING IMMUNITY

Zwitterions create water-loving channels, ensuring immunity to fouling internally and externally.

CLEAN PERMEATE

Zwitterionic channels retain contaminants and produce clean water and can operate for years at full capacity.

THE SCIENCE

ZwitterCo has set new standards in the membrane industry with its innovative zwitterionic technology. By integrating the technology with **proven commercial brackish water membranes,** ZwitterCo RO addresses the critical and persistent issue of irreversible organic fouling - making it a thing of the past.

A zwitterion is simply a small organic molecule that carries both positive and negative charges, which balance each other out, resulting in a molecule that is net neutral. In 2013, researchers at Tufts University made a breakthrough, discovering that specialized copolymers combining hydrophilic zwitterionic monomers with hydrophobic monomers could yield stable materials with the astonishing ability to form self-assembled pore structures.

Being extremely hydrophilic, the zwitterions are central to ZwitterCo's membrane technology, as they create water-loving channels that prevent organic compounds from adhering to the membrane surface, significantly enhancing fouling resistance.

OPERATIONAL BENEFITS

ZwitterCo membranes offer unparalleled organic fouling resistance, reducing the frequency of high pH chemical cleaning by up to 90%. This means longer operational periods without the need for shutdowns and maintenance, enhancing overall system efficiency.

ECONOMIC BENEFITS

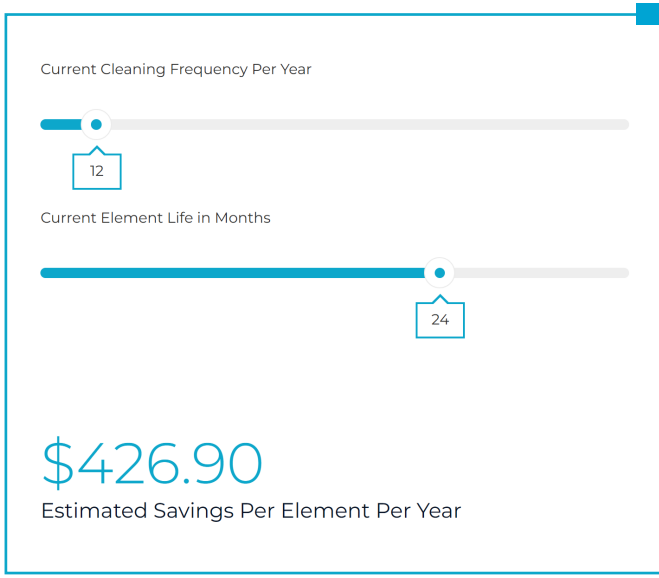
The economic advantages of ZwitterCo RO membranes are substantial long-term. By reducing cleaning frequency by up to 90%, ZwitterCo RO elements may also last at least twice as long as conventional RO elements, reducing element replacements and lowering overall operating costs.

Not only can ZwitterCo RO membranes reduce your overall operating expenses (OPEX) by 50% over four years, but they are also designed to be drop-in replacements, offering a no-risk opportunity for users to upgrade their system and lower costs without additional capital expenditure (CAPEX).

SUSTAINABILITY BENEFITS

Designed to offer stable performance even in high-fouling streams, ZwitterCo membranes can be fully restored with a simple water flush or mild cleaning. This results in at least twice the membrane life, which keeps OPEX costs low, minimizes waste, and reduces chemical usage.

Additionally, the longer element life helps reduce the number of used elements ending up in landfills, ensuring long-term performance with minimal environmental impact.



An industrial water treatment system using 150 x 8040 RO elements could reduce annual costs by $426.90 per element.

90%

Reduce cleaning cycles by up to 90% with ZwitterCo.

CHAPTER 3

Industry & Feedwater Examples

POWER GENERATION: SURFACE WATER

Because power plants require large quantities of water for their processes, the plants are often built near surface water sources such as rivers, lakes, and oceans. Meeting water quality and volume requirements in a power plant is vital for effective operation, so RO membrane elements are often used to remove impurities for boiler make-up water.

Surface waters typically contain higher concentrations of impurities like suspended solids, organics, and dissolved salts (e.g., calcium, magnesium, silica, etc.), all of which must be removed before sending the make-up water to boilers for heating. Because of this, make-up water is first pretreated to remove floating and suspended materials, then treated by reverse osmosis membrane elements to remove dissolved organics and salts.

Due to the high organic and biological content found in surface waters, many existing RO systems treating boiler make-up water struggle with biological or organic fouling challenges, resulting in a rapid decline in RO system performance. To restore performance, the system is shut down to perform chemical cleanings. The more fouling the feed stream, the more frequently cleaning is performed, which results in excessive system downtime.

Power plants treating surface water with existing RO systems could reduce their cleaning frequency by **up to 90%** with ZwitterCo RO—**a no-risk, drop-in replacement.**

LANDFILL: LEACHATE

Leachate is a wastewater formed when water filters through landfill waste. When water comes in contact with buried wastes, it leaches, or draws out, chemicals and pollutants from the waste, resulting in a mixture that contains heavy metals, color, and various inorganic and organic components.

Due to its high toxicity, landfill leachate must be treated to meet discharge regulations or hauled to a municipal wastewater treatment plant for treatment. Because landfill leachate often contains high levels of ammonia, many sites use a two-pass RO system to meet discharge limits.

The first pass stage typically uses seawater RO membranes because they can handle the higher pressures needed to overcome the high osmotic pressure caused by the high salt content. The permeate from the first pass then goes to the second pass RO, using either seawater or brackish water RO membranes.

Because landfill leachate often has high levels of organic material (like TOC, COD, or BOD), the first pass RO membranes regularly suffer from organic fouling. This means the membranes must be cleaned every few days and fully replaced every six-to-twelve months. This frequent maintenance is not only costly but also time-consuming, preventing operators from focusing on other critical tasks.

In two-pass systems, high-pressure ZwitterCo RO elements could **reduce cleaning frequency and extend element life** while still operating at similar conditions.

CHEMICAL PLANTS & REFINERIES: WASTEWATER & PROCESS WATER

Chemical plants and refineries use RO systems to treat various streams, including surface waters, industrial process waters, and wastewaters.

Within industrial water and wastewater, another issue arises: oil. Oil is an organic component that leads to RO membrane fouling, increasing membrane cleaning and replacement frequency.

Chemical processing plants and refineries dealing with process waters that contain Total Organic Carbon (TOC) often experience significant organic fouling as well. This results in more frequent RO cleanings and short membrane lifespans, leading to high operational costs.

Chemical plants and refineries using RO systems to treat their process water and wastewater containing oil can benefit from **reduced cleaning, longer membrane life, and decreased OPEX** when switching to ZwitterCo RO.

FOOD & BEVERAGE: MBR EFFLUENT

Outside of municipal wastewater treatment, the food processing industry is one of the largest users of membrane bioreactors (MBRs) to treat wastewater. MBRs are used to remove the bulk of suspended solids and organic material found in wastewater, but the MBR effluent still contains organic materials.

This effluent is often sent to a reverse osmosis (RO) system for further polishing, but due to the level of organics, these RO systems typically require cleaning every one-to-four weeks. With each cleaning, the membrane deteriorates more, leading to frequent membrane replacements.

In the beverage industry, surface waters are commonly treated using activated carbon beds to remove organic matter and improve taste or color. However, these carbon beds can become breeding grounds for bacteria, particularly in warm weather, leading to biofouling issues with the RO membranes.

Because activated carbon doesn't remove dissolved solids, RO membranes are used afterwards to further polish the water. The bacteria from the carbon beds is consequently sent into the RO system, causing biofouling. This results in *even more* frequent cleanings, increasing maintenance costs and reducing the lifespan of the RO membranes.

Understanding the unique fouling challenges in various industries is crucial. These challenges highlight the necessity for a change in the RO membrane industry - **and that change is *finally here*.**

CHAPTER 4

Real Life Example

In the United States, a power plant treating river water for boiler make-up in the Pacific Northwest has been struggling with persistent maintenance issues and frequent downtime. The facility relies on RO systems to produce the necessary high-quality boiler make-up water.

Dealing with persistant fouling issues and the conducting of chemical cleanings at least once a month, they turned to ZwitterCo for a solution.

> Our process would not be **profitable or possible** without ZwitterCo membranes.
>
> Dr. Kondrad Miller
> *VP, Manufacturing, Science, & Technology,* Solugen

CONSISTENT IN UPSTREAM UPSET

Shortly after the installation, the plant experienced an unplanned upset: an accidental overdose of coagulant upstream of the RO system. This event caused a significant increase in the Silt Density Index (SDI) of the feed water, spiking from 0.932 to 4.97, which posed a severe challenge to the RO membranes.

Despite the coagulant, the ZwitterCo RO elements were **unaffected**, continuing to produce stable permeate flow and seeing a **minimal increase in pressure drop.**

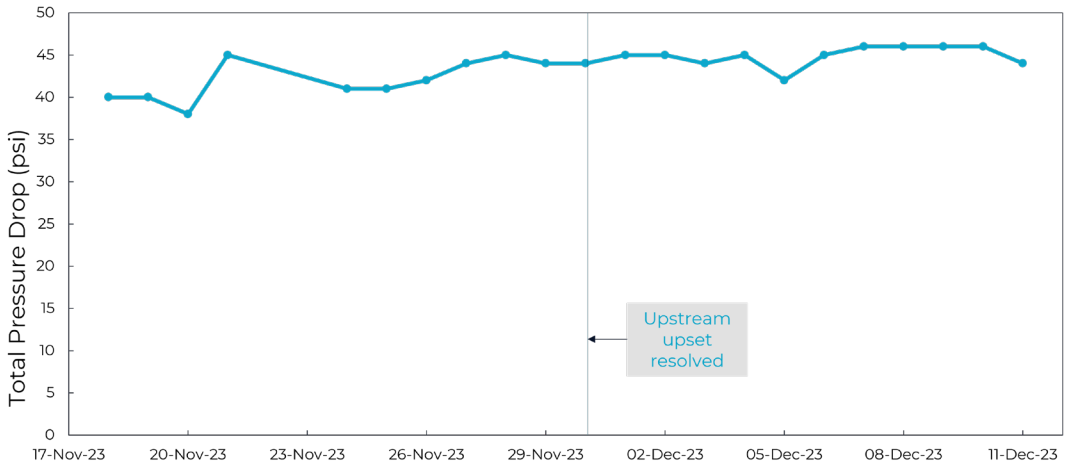


Figure 1: ZwitterCo RO elements demonstrated stable performance (minimal increase in pressure drop) during and after the increase in feed SDI due to the upstream upset.

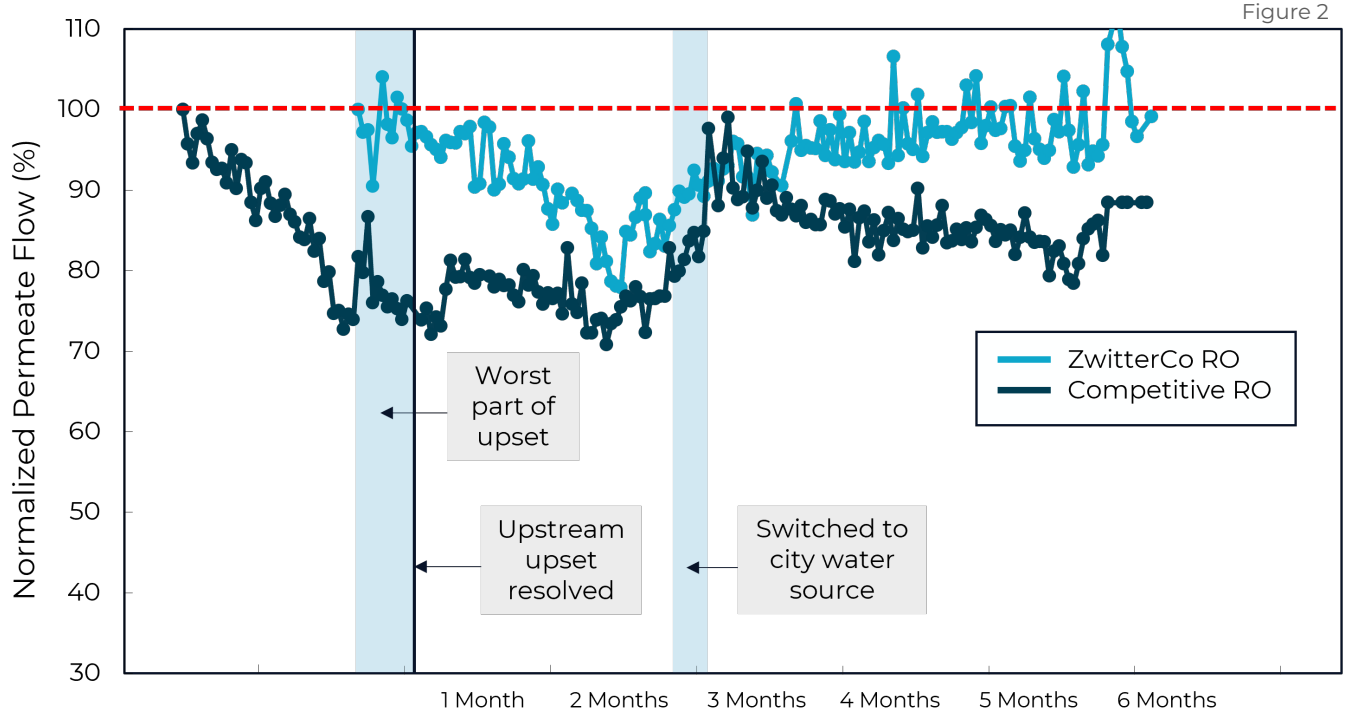
Due to their consistent performance, the ZwitterCo RO elements **did not require any chemical cleaning**, offering the power plant reliable operation and **zero system downtime** (Figure 1). This incident highlighted the vulnerability of conventional RO systems to upstream upsets and underscored the need for more resilient solutions.

LESS CLEANING NEEDED

Over the first six months of operation at the power generation plant, the first stage of the train housing conventional fouling-resistant RO elements repeatedly showed significant performance decline, with permeate flow dropping noticeably after start-up (Figure 2).

Because of this, the plant had to shut down and clean these elements four separate times in an effort to restore membrane performance. Despite these cleanings, the conventional RO elements have not fully recovered performance.

Figure 2



The ZwitterCo RO elements, on the other hand, demonstrated more stable performance and continue to operate at similar permeate flows as they did at start-up. At the time of writing, the installation had been operating without needing a chemical cleaning for more than six months.

CHAPTER 5

Pricing and Availability

Both ZwitterCo RO High Rejection and Low Energy elements are generally available from stock or with very competitive lead times to meet customer requirements.

While the value delivered from lower cleaning costs, more uptime, and longer membrane life justifies a price 2-3 times that of a conventional RO membrane, ZwitterCo offers special pricing and terms for new users. Our goal is to make it easy for users to **see the performance benefits for themselves.** We not only help new adopters benefit from special pricing, but also offer tier 1 technical/ operational support and direct access to our product team.

To learn more about getting started, click here.

Learn More

CONCLUSION

The introduction and adoption of new membrane chemistry is critical to make real change in the water industry, and as we often say – *every industry is a water industry*. This new era of membrane technology will enhance efficiency, sustainability, and cost-effectiveness, setting a new standard for water treatment and reuse.

ZwitterCo's innovative membranes are at the forefront of this change, offering solutions that are not only more effective but also more resilient. If you are interested in discovering how much your operation could save by switching to ZwitterCo membranes, we invite you to use our savings calculator or contact us directly for more information.

ADDITIONAL RESOURCES

APPLICATION BRIEF - DOWNTIME DUE TO CLEANING

APPLICATION BRIEF - DOWNTIME DUE TO UPSTREAM UPSETS

ABOUT ZWITTERCO

ZwitterCo has developed a breakthrough in materials science, a new class of zwitterionic membranes that are immune to irreversible organic fouling, making it practical and affordable to treat challenging water and wastewater. Our mission is to provide industries with the tools to create clean water from every source, whether it involves accessing novel sources of water, shoring up distressed assets, or enabling onsite wastewater reuse. The company has been recognized as Breakthrough Technology Company of the Year at the Global Water Summit and by the Department of Energy and the National Science Foundation as a leader in clean water technologies.

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